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Injunction Frameworks and the Licensing of Standard-Essential Patents

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Injunction Frameworks and the Licensing of Standard-Essential Patents*

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Abstract

We develop a licensing-litigation model to analyze how different injunction frameworks affect bargaining behavior, equilibrium royalties, and litigation outcomes in standard-essential patent (SEP) disputes. Motivated by recent developments in German case law, we compare two legal frameworks that differ only in whether the patent holder's licensing offer conditions the availability of injunctive relief. We show that removing the patent holder's offer from the injunction analysis raises equilibrium royalties and the risk of patent hold-up when courts are sufficiently imprecise in assessing FRAND compliance; when courts are predictable, the two frameworks coincide. Higher royalties arise because SEP holders make more aggressive, non-FRAND, licensing offers, while implementers respond with higher counteroffers to reduce the risk of an injunction. The same mechanism, however, can reduce the incidence of injunctions, so injunction frequency is an imperfect measure of hold-up. Whether the higher royalties raise or lower welfare depends on where the socially optimal royalty lies relative to the rates the two frameworks produce.

Key words: bargaining, FRAND, hold-up, injunction, legal uncertainty, licensing negotiations, litigation, standard-essential patents (SEP)

JEL classification: C78, K21, K41, L24, O31, O34

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1 Introduction

In 2020, German regional courts issued Germany-wide sales bans on Mercedes-Benz vehicles for infringing cellular standard-essential patents (SEPs) held by Nokia and Sharp.[1] For the first time, a major automaker had been enjoined over standard-essential patents, extending SEP disputes from smartphones into the automotive industry. The threat of an injunction strengthens the patent holder's hand in licensing negotiations with the implementer, even when standard-setting organizations require SEP holders to commit to fair, reasonable, and non-discriminatory (FRAND) licensing terms (Lemley, 2002; Chiao et al., 2007). A long-standing concern is that SEP holders exploit this threat to extract royalties above FRAND levels.[2]

The Mercedes-Benz cases exposed a widening gap between two legal approaches to SEP injunctions in Europe. In 2015, the European Court of Justice established the benchmark *symmetric framework* in *Huawei v. ZTE*: An injunction requires that the SEP holder's license offer be FRAND while the implementer's counteroffer is not.[3] German courts, among the most important venues for SEP enforcement globally,[4] departed from this standard by granting injunctions based solely on the implementer's non-FRAND counteroffer, regardless of the patent holder's initial offer. Both *eBay v. MercExchange* in the United States and *Huawei v. ZTE* in Europe narrowed access to SEP injunctions. The *amended framework* pursued in some judgments of German Courts and the recently established Unified Patent Court pushes in the opposite direction. We ask how its ex-

[1] *Nokia v. Daimler*, Regional Court of Mannheim, 2 O 34/19, judgment of 18 August 2020; *Sharp v. Daimler*, Regional Court of Munich, 7 O 8818/19, judgment of 10 September 2020.

[2] For background on patent hold-up concerns, see Farrell et al. (2007), Lemley and Shapiro (2005), and Schmalensee (2009). For the role of FRAND commitments in standard-setting, see Lemley (2002) and Lerner and Tirole (2015); for a survey, see Layne-Farrar (2017).

[3] This framework is symmetric in that no injunction is issued if the offer and the counteroffer are either both found FRAND or both found non-FRAND. The European approach differs from that in the U.S., where *eBay Inc. v. MercExchange, L.L.C.*, 547 U.S. 388 (2006), replaced the presumption of injunctive relief with a four-factor equitable test. Under *eBay*, SEP injunctions are rare because FRAND-committed patent holders can typically be compensated through damages, as the Federal Circuit held in *Apple Inc. v. Motorola, Inc.*, 757 F.3d 1286 (Fed. Cir. 2014). The European framework, by contrast, treats injunctions as available in principle and conditions their denial on the parties' negotiation conduct.

[4] Three specialized courts in Düsseldorf, Munich, and Mannheim handle the vast majority of European patent disputes, and their rulings shape licensing negotiations well beyond Europe. See Cremers et al. (2017) for a cross-country comparison of patent litigation across major European jurisdictions and Lehmann-Hasemeyer and Morell (2025) for evidence on the concentration of cases in these three courts.

pansion affects equilibrium royalty rates, injunction rates, and welfare in SEP licensing negotiations.

We develop a game-theoretic model of licensing negotiations between a standard-essential patent holder and an implementer. The patent holder makes an initial offer; the implementer either accepts or counters; the patent holder then accepts the counteroffer or takes the case to court. Two features distinguish our model. First, the court assesses FRAND not as a single rate but as a *corridor*, that is, a band of royalty rates it considers acceptable, with a width that captures the court's FRAND tolerance. Second, the location of this band is uncertain, and heterogeneous courts differ in their prior view of where FRAND lies. The parties do not know the court's position when they make their offers. This *court noise* is a key driver of our results.[5]

Litigation proceeds in two steps: The court first decides on an injunction, then determines damages. The time lag between these steps creates an imbalance of bargaining power. An implementer facing an injunction typically incurs prohibitively high costs from halted production and is pressed to settle on the patent holder's terms.[6] The two legal frameworks differ in a single but critical element: When *both* the offer and the counteroffer are non-FRAND, the *symmetric framework* (following *Huawei v. ZTE*) denies an injunction (because the patent holder's offer was also deficient), while the *amended framework* grants one (because the implementer's counteroffer alone triggers it).

We find three main results. First, when court noise is sufficiently high, the amended framework produces non-FRAND equilibrium royalty rates that strictly exceed those of the symmetric framework. The mechanism operates on both sides of the negotiation: The patent holder makes more aggressive offers (because her offers no longer affect the injunction decision), and the implementer responds with more cautious counteroffers (because a non-FRAND counteroffer now triggers an injunction with certainty). By

[5]This notion of a FRAND corridor follows judicial practice. For instance, *Sisvel v. Haier*, Higher Regional Court Düsseldorf, I-15 U 66/15, notice of 17 November 2016, Rn. 13. It deviates from assumptions in earlier work, such as Langus et al. (2013). We discuss interpretations of the optimal FRAND rate in Section 5.

[6]This timing assumption distinguishes our model from Ratliff and Rubinfeld (2013), who assume negotiations precede rather than follow the injunction decision.

contrast, the two frameworks yield identical equilibrium royalty rates when court noise is sufficiently low. For low noise, both parties make offers near the FRAND corridor, so the situation in which the two frameworks differ is not triggered. Second, despite easier access to injunctions, the amended framework can produce *lower* equilibrium injunction rates for intermediate levels of court noise. The implementer's cautious counteroffers preempt the injunction, a *chilling effect*. Only for high noise do injunction rates in the amended framework exceed those in the symmetric framework. The injunction rate is therefore not monotone in the underlying royalty distortion, implying that injunction-rate data alone cannot identify a framework's effect on royalties. Third, whether expanding injunction access raises or lowers welfare depends on where the socially optimal royalty lies relative to the midpoint of the expected royalties the two frameworks produce. The amended framework improves welfare when the optimum lies above that midpoint, and the symmetric framework when it lies below. At the benchmark where the court's average FRAND determination is itself socially optimal, the ranking depends on court noise. The amended framework can welfare-dominate for moderate court noise (over a relatively narrow parameter range that disappears as judicial tolerance tightens), where its royalty remains closer to the optimum. For sufficiently high court noise, the symmetric framework dominates the amended framework.

Our results contribute to several strands of the literature. First, we introduce two features absent from prior models of SEP injunctions: the FRAND corridor (capturing judicial tolerance) and a formal comparison of two institutional frameworks that differ in whether the patent holder's offer matters for the injunction decision. Prior work on injunctions and royalty rates treats FRAND as a single rate (Shapiro, 2010; Lemley and Shapiro, 2007; Ratliff and Rubinfeld, 2013);[7] Choi (2016) and Langus et al. (2013) model SEP injunctions directly but retain the single-rate assumption, and Bourreau et al. (2023) model SEP licensing with costly enforcement but abstract from framework differences.

[7]Different from our model, Ratliff and Rubinfeld (2013) assume implementers can resort to court-determined license terms as a fallback, which eliminates the injunction threat from negotiations. In German practice, no such fallback exists: The European Court of Justice foresees court-determined FRAND rates only if both parties agree, and German courts have held that counteroffers proposing such a determination are not automatically FRAND.

The corridor drives the comparison: A model with a single FRAND rate collapses the two frameworks into identical outcomes, foreclosing the comparison by construction.

Second, we shed light on the interaction of institutional frameworks and court capabilities. A central concern in the SEP literature is that patent holders exploit injunctions to extract royalties above FRAND levels, a phenomenon known as *patent hold-up* (Lemley and Shapiro, 2005; Farrell et al., 2007). In our model, hold-up is, on average, precluded by courts under the symmetric framework, but arises under the amended framework when court noise exceeds a threshold set by the FRAND corridor width. Below that threshold, both parties' offers are disciplined by the court, and broader injunction access leaves equilibrium royalties unchanged.[8] The framework choice is therefore more critical for less predictable courts (that is, those with lower experience, precision, or specialization), not only because of lower precision of the courts' findings *ex post* but also because SEP holders anticipate less predictable rulings *ex ante*, inducing less tempered offers.[9]

Third, we show that expanding access to injunctions can *lower* the issuance rate. A more credible injunction threat leads the implementer to make cautious counteroffers that preempt the injunction, making it more readily available yet less frequently exercised. This is a *chilling effect*. The result speaks to a growing empirical literature that reads injunction grant and filing rates as evidence of how injunction regimes shape licensing and enforcement (Seaman, 2016; Contreras et al., 2017; Mezzanotti and Simcoe, 2019; Mezzanotti, 2021). Yet observed litigation outcomes are a selected sample of the underlying disputes (Priest and Klein, 1984): In our model, the injunction rate is determined by the parties' equilibrium offers, so a larger royalty distortion need not surface as a higher injunction rate, and the absence of a measurable change in injunctions is not evidence that expanded access has no effect. Ratliff and Rubinfeld (2013) conclude

[8] A counterargument in the SEP literature holds that implementers delay or withhold payment during the licensing process, known as *patent hold-out* (Llobet and Padilla, 2023a; Love and Helmers, 2023). Our model does not include the frictions that generate hold-out. Both the symmetric and amended frameworks effectively address the risk of hold-out, as injunctions are issued under both if the SEP holder's offer is found to be FRAND and no counteroffer is made.

[9] This is an *ex ante* analog to Galasso and Schankerman (2010), who find that reduced uncertainty about court outcomes accelerates the settlement of patent disputes *ex post*. It bears on the policy debate over court specialization in patent enforcement (see Lanjouw and Lerner, 2001; Schankerman and Scotchmer, 2001; Amir et al., 2014; Dornis, 2020; Schwartz and Sepe, 2024; Lehmann-Hasemeyer and Morell, 2025).

that injunctions do not distort royalties when the implementer retains a court-determined fallback; we find that even when injunctions do distort royalties, the distortion need not appear in injunction rates, while the settlement royalties that would reveal it are typically confidential, an observational equivalence that complicates empirical identification.

Last, our analysis speaks directly to ongoing policy developments. The European Commission's *amicus curiae* brief in *VoiceAge v. HMD* at the Munich Higher Regional Court endorsed a strict, sequential reading of the *Huawei v. ZTE* steps, consistent with the symmetric framework.[10] The European Unified Patent Court's first substantive FRAND rulings diverged on whether the patent holder's own offer should condition the injunction. In *Panasonic v. Oppo*, the Mannheim Local Division followed the *Huawei v. ZTE* negotiation program, assessing both the patent holder's offer and the implementer's counteroffer for FRAND compliance, an approach consistent with the symmetric framework.[11] In *Huawei v. Netgear*, by contrast, the Munich Local Division focused on the implementer's failure to engage constructively (rejecting the offer without a substantiated counteroffer and withholding company-specific licensing data) without conditioning the injunction on the patent holder's own FRAND compliance, an approach closer to the amended framework.[12] In January 2026, the German Federal Court of Justice confirmed this direction in *FRAND-Einwand III*, holding that the implementer's obligations are independent of the patent holder's conduct.[13] Our model formalizes the channel at the center of this disagreement: Expanding injunction availability beyond the symmetric framework may increase equilibrium royalties to non-FRAND levels. When the court's average FRAND determination is itself socially optimal, the symmetric framework tends to welfare-dominate the amended framework (with the ranking non-monotone in court noise). When that is not the case, we derive the conditions that determine the welfare comparison between the two frameworks.

[10]The Commission had earlier proposed an EU SEP Regulation establishing out-of-court FRAND determination procedures (COM(2023) 232 final, 27 April 2023), withdrawn 6 October 2025 (OJ C/2025/5423).

[11]UPC, Mannheim Local Division, UPC_CFI_210/2023, judgment of 22 November 2024.

[12]UPC, Munich Local Division, UPC_CFI_9/2023, judgment of 18 December 2024.

[13]*FRAND-Einwand III* (*VoiceAge v. HMD*), German Federal Court of Justice (BGH), KZR 10/25, judgment of 27 January 2026.

The paper proceeds as follows. Section 2 describes the symmetric framework (following *Huawei v. ZTE*) and recent departures by German courts (amended framework). Section 3 introduces the model of licensing negotiations in the shadow of litigation. Section 4 derives the equilibrium for both litigation frameworks. Section 5 compares the frameworks' equilibrium injunction rates and the welfare implications. Section 6 concludes. All proofs and auxiliary results are in the appendix.

2 Institutional Sources of Litigation Frameworks

This section describes the two litigation frameworks that structure our analysis: the symmetric framework established by the European Court of Justice in *Huawei v. ZTE* and the amended framework adopted by several German courts, which effectively expanded a patent holder's access to injunctions.

2.1 Symmetric Framework Following Huawei v. ZTE

In its *Motorola* case in 2014, the European Commission clarified that injunctions should be available only under very narrow circumstances.[14] It held that Motorola's seeking and enforcement of an injunction against Apple constituted an abuse of a dominant position in violation of EU antitrust laws. The case eventually led to the landmark judgment in *Huawei v. ZTE* by the European Court of Justice (ECJ) in 2015.[15]

In that case, Huawei, the owner of a portfolio of SEPs for the 4G standard, offered to license certain SEPs to ZTE. ZTE rejected the offer, and Huawei sought an injunction to prohibit ZTE from using the SEPs in question. ZTE argued that Huawei's offer was not FRAND and that the court should not grant an injunction until a FRAND royalty rate had been determined. The German court referred the case to the ECJ for a

[14] European Commission, Case AT.39985 – Motorola – Enforcement of GPRS Standard Essential Patents, Commission Decision of 29 April 2014.

[15] Case C-170/13, EU:C:2015:477, judgment of 16 July 2015. Larouche and Zingales (2014) made the academic case for CJEU intervention before the judgment issued, arguing that the court should establish presumptions governing when SEP holders may seek injunctions.

Table 1: Injunctions in Different Litigation Frameworks

Panel (a): Symmetric Litigation Framework

SEP holder P's offer	Implementer L's counteroffer	
	r_L **is FRAND**	r_L **is non-FRAND**
r_P **is FRAND**	No injunction	Injunction
r_P **is non-FRAND**	No injunction	*No injunction*

Panel (b): Amended Litigation Framework

SEP holder P's offer	Implementer L's counteroffer	
	r_L **is FRAND**	r_L **is non-FRAND**
r_P **is FRAND**	No injunction	Injunction
r_P **is non-FRAND**	No injunction	*Injunction*

Notes: Panel (a) summarizes the court's injunction decision for any offer-counteroffer combination under the symmetric framework (following *Huawei v. ZTE*). Panel (b) summarizes the court's injunction decision for any offer-counteroffer combination in the amended framework introduced by German courts. The two litigation frameworks differ in the non-FRAND/non-FRAND combination (in italics).

preliminary ruling on the conditions under which an injunction may be granted and on how to determine whether a license offer is FRAND.

The ECJ held that it is abusive for an SEP holder to seek an injunction against an implementer who has taken steps to negotiate a FRAND license under a framework specified by the court (i.e., the implementer has shown a willingness to negotiate in good faith). Under this framework, the SEP holder must first present the alleged infringer with a specific, written license offer on FRAND terms. If the alleged infringer does not accept that offer, the court should still deny an injunction, provided the implementer has promptly submitted, in writing, a specific counteroffer on FRAND terms to the SEP holder.

The *Huawei v. ZTE* judgment, therefore, warrants an injunction *only if* the SEP holder's offer is found to be FRAND and the implementer's counteroffer is not (that is, the implementer has shown "unwillingness"). We summarize the symmetric framework in panel (a) of Table 1 where r_P and r_L (either FRAND or not) stand for the SEP holder's offer and the implementer's counteroffer, respectively.

2.2 Recent Departures: The Amended Framework

In several recent rulings, German courts have adopted a different interpretation of the ECJ's decision in *Huawei v. ZTE*, departing from its benchmark framework.[16] They found that an implementer's non-FRAND counteroffer may in and of itself be an indication of "unwillingness." They held that such a counteroffer, therefore, warrants the award of an injunction regardless of the FRAND status of the SEP holder's initial offer. Under such an amended framework, a court may grant an injunction even if the SEP holder's offer was non-FRAND. We summarize the amended framework in panel (b) of Table 1.

Four key cases exemplify the amended framework. *Nokia v. Daimler* (in Mannheim) and *Sharp v. Daimler* (in Munich) involve disputes between holders of cellular SEP portfolios and the automaker over connectivity patents; *LG v. TCL* (in Mannheim) involves LG's SEPs for 4G/LTE standards asserted against a mobile device manufacturer; and in *FRAND-Einwand III* (*VoiceAge v. HMD*), the German Federal Court of Justice confirmed the amended framework at the highest level, holding that the implementer must submit a counteroffer and engage actively and constructively even when the patent holder's initial offer is non-FRAND.[17]

However, not all German courts moved in the same direction. In *Bildrekonstruierung*, the Düsseldorf Court rejected the Mannheim and Munich approach of assessing willingness based on the content of the counteroffer, instead evaluating the implementer's overall negotiation conduct and the licensing request itself.[18] This conduct-focused standard is more favorable to the implementer than the strict counteroffer scrutiny applied by Mannheim and Munich, creating a divergence among Germany's principal patent courts (see Banasevic and Bobowiec, 2023).

With the partial exception of *Bildrekonstruierung*, the above cases have in common that, under their amended framework, a court ought to grant an injunction in situations

[16] Banasevic and Bobowiec (2023) provide an extensive assessment. The courts in question (Mannheim, Munich, and Düsseldorf) handle virtually all German patent cases and actively compete for filings (Lehmann-Hasemeyer and Morell, 2025; Bechtold et al., 2019).

[17] *Nokia v. Daimler*: Regional Court of Mannheim, 2 O 34/19, judgment of 18 August 2020. *Sharp v. Daimler*: Regional Court of Munich, 7 O 8818/19, judgment of 10 September 2020. *LG v. TCL*: Regional Court of Mannheim, 2 O 131/19, judgment of 2 March 2021. *FRAND-Einwand III* (*VoiceAge v. HMD*): German Federal Court of Justice (BGH), KZR 10/25, judgment of 27 January 2026.

[18] *Bildrekonstruierung*: Regional Court of Düsseldorf, 4c O 42/20, judgment of 21 December 2021.

in which the symmetric framework would not do so, namely when both the patent holder's offer and the implementer's counteroffer are non-FRAND (see Table 1). This extension of injunction access shifts bargaining power toward the patent holder and weakens the implementer's position. In the symmetric framework, a counteroffer by the implementer that is found to be non-FRAND implies an injunction *with less than certainty*, that is, only when the patent holder's offer is found FRAND. In the amended framework, conversely, a non-FRAND counteroffer triggers an injunction *with certainty*, because the FRAND status of the patent holder's offer is irrelevant to the court's decision.

3 Model

We propose a simple model of SEP licensing negotiations between the holder of a standard-essential patent and the implementer of a standard in a downstream product market. Licensing negotiations are in the shadow of two distinct litigation regimes that differ in their rules for granting injunctions (Table 1). The framework follows the tradition of bargaining in the shadow of the law (Mnookin and Kornhauser, 1979): Equilibrium offers are shaped by the anticipated court outcome, here by which party's offer quality triggers an injunction. The classic models of litigation and settlement turn on uncertainty about the merits of the dispute, which governs whether the parties settle or go to trial (Bebchuk, 1984; Crampes and Langinier, 2002). Our uncertainty is different in kind: It concerns where the court locates the FRAND corridor and distorts equilibrium offers and royalty rates, even though the parties settle on the equilibrium path.[19]

3.1 License Offers and Counteroffers

A patent holder P and an implementer (the prospective licensee) L bargain over a percentage royalty rate r. The implementer is active in a downstream market; the patent holder is not vertically integrated (and specializes in the upstream technology market).

[19]The same litigation-threat discipline drives recent models of royalty bargaining, in which the prospect of a validity challenge moderates the rates licensors can sustain (Llobet and Padilla, 2023b) and outside options derived from a subsequent litigation game shape negotiated royalties (Griem and Inderst, 2022). On legal uncertainty as a constraint on patentee market power, see Ayres and Klemperer (1999).

We make three assumptions to keep the model simple and emphasize the effects of variations in the litigation framework on licensing negotiations. First, the implementer's marginal production costs are zero. Second, we assume away any pricing effects of the royalty and normalize the implementer's downstream revenues over the product life cycle to one (that is, royalty rates do not affect the size of the pie to be shared). This fixed-pie assumption shuts down any pass-through or output effects and isolates the channel of interest: how the litigation framework shapes equilibrium offers and royalties. Third, the royalty base equals the implementer's overall revenues. With these product-market assumptions, the parties' payoffs are $\pi_P = r$ for the patent holder P and $\pi_L = 1 - r$ for the implementer L.

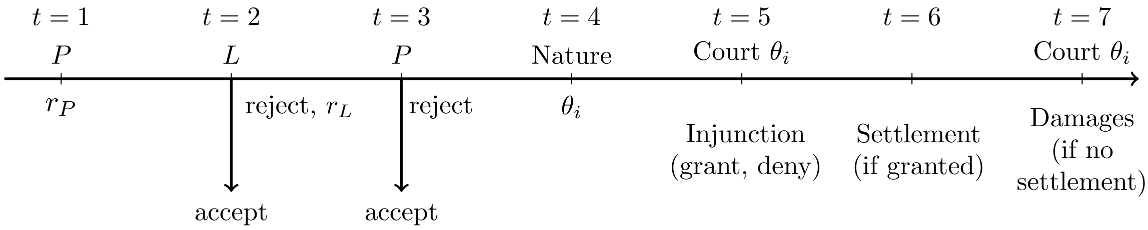
We assume a simple bargaining protocol that follows the procedure outlined in the *Huawei v. ZTE* decision: The patent holder P makes an *offer* r_P in $t = 1$. If L accepts the offer in $t = 2$, r_P is implemented, and the game ends. If L rejects the offer in $t = 2$, she can make a *counteroffer* r_L. If P accepts the counteroffer in $t = 3$, r_L is implemented, and the game ends. If P rejects the counteroffer, the case goes to court for litigation (at zero cost) and settlement negotiations. We depict the timeline of our model in Figure 1. We make explicit the following assumptions about the parties' offers:

Assumption 1. *Offer and counteroffer are within the unit interval:* $r_P \in [0, 1]$ *and* $r_L \in [0, 1]$.

Assumption 2. *The implementer's counteroffer does not exceed the patent holder's offer:* $r_L \leq r_P$.

Both assumptions simplify our analysis without much loss of generality. First, any violation of Assumption 1 violates an implicit participation constraint since we do not allow for any side payment (or any non-linearities in the licensing contract). Second, any counteroffer that exceeds the initial offer, $r_L > r_P$, in violation of Assumption 2, is strictly dominated by a lower counteroffer. We confirm this in the formal proofs of our results.

Figure 1: SEP Licensing and Litigation



Notes: The figure depicts the timeline of the licensing game between a standard-essential patent holder P and a standard implementer L in the shadow of litigation. If the court grants an injunction at $t = 5$, the parties settle at r_P at $t = 6$; if denied, no settlement surplus exists, and the court determines damages at $t = 7$.

3.2 Injunctions and Settlement

Litigation is a two-step process. In the first step (in $t = 5$ in Figure 1), the court assesses whether the offer and counteroffer are FRAND and decides to grant or deny an injunction. It does so after observing its type θ_i in $t = 4$. In the second step (in $t = 7$), the court determines the final damages.[20]

For settlement negotiations, we assume a simple bargaining protocol: The patent holder can make a take-it-or-leave-it offer. We assume that she is still bound by her original offer r_P. This assumption captures the self-limiting logic of the FRAND commitment: Demanding a higher rate after the injunction would undermine the FRAND compliance that justified it.

When the court grants an injunction, we further assume the implicit time cost to the implementer is prohibitively high, so that the prospective damages decision (step 2 of litigation) is not the relevant outside option for the bargaining procedure. Instead, the implementer's value of the outside option (the expected damages minus the opportunity costs of waiting for litigation) is sufficiently low to render it unattractive relative to

[20]The patent holder first requests an injunction, and the court determines the level of damages only after it has found that the implementer, and alleged infringer, owes damages. This modeling approach mirrors the situation, for instance, in German litigation, where the injunction decision typically precedes the final damages award by a significant time lag (see Cotter, 2013).

accepting r_P in settlement negotiations.[21] As a result, the parties will settle on a royalty rate equal to the patent holder's initial offer, r_P.[22]

When the court denies the patent holder's injunction request, the implementer is not forced to stop producing and selling its product and can therefore afford to wait for the court's decision on damages (the implicit cost of time does not arise). Settlement negotiations, if they take place, follow the same procedure but will yield the expected litigation result as bargaining outcome.[23]

3.3 FRAND Corridor and Court Noise

The court's injunction decision depends on the respective litigation framework and whether the parties have made FRAND or non-FRAND offers and counteroffers. A patent holder's offer is FRAND if it is not too high, $r_P \leq \overline{r}$, whereas an implementer's counteroffer is FRAND if it is not too low, $r_L \geq \underline{r}$. We assume heterogeneous courts that differ (i) in their prior view of what a FRAND royalty rate ought to be and (ii) in their tolerance for deviations from that view.

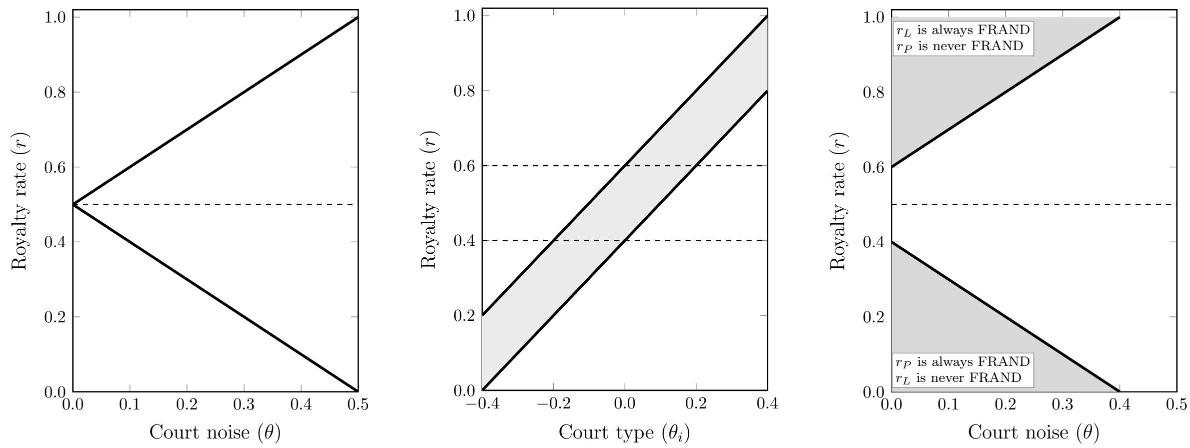
A court views royalty rates as FRAND if they fall within a band $[\underline{r}, \overline{r}]$ with width 2δ centered around a midpoint. This width parameter δ captures the court's *FRAND tolerance*. We assume the location of the band is stochastic with the midpoint equal to $1/2 + \theta_i$ where $\theta_i \sim U[-\theta, \theta]$ is the court's type realized in $t = 4$. Whenever we use the subscript i, we refer to this realization of the court's type. The parameter θ without the subscript denotes the spread of the distribution, capturing the degree of uncertainty about the court's type (or court noise) when the parties make their offers and counteroffers.

[21] This contrasts with the patent hold-out literature, in which prospective licensees gain from delay, strategically withholding payment to reduce royalties at the patent holder's expense (Love and Helmers, 2023; Llobet and Padilla, 2023a).

[22] The baseline assumes the patent holder is bound by her initial offer. More generally, with a post-injunction bargaining weight $\alpha \in (0, 1]$, the settlement royalty is $\alpha r_P + (1 - \alpha)(1/2 + \theta_i) \leq r_P$, which moderates the patent holder's incentive to inflate her offer. The amended framework still yields strictly higher equilibrium royalties than the symmetric framework for any $\alpha > 0$, with the gap increasing in α and vanishing at $\alpha = 0$, so the baseline ($\alpha = 1$) provides an upper bound on the royalty distortion. The derivation is available upon request.

[23] Because of zero litigation costs, there is no bargaining surplus the parties can generate. As both parties can fall back on the expected litigation outcome as their respective outside option, a settlement will mimic that outcome, regardless of which side makes the take-it-or-leave-it offer.

Figure 2: Courts' FRAND Assessments



Notes: The LHS panel depicts the range of the court's FRAND assessment for a given noise term θ (with $\delta = 0$). The center panel depicts the corridor of FRAND royalty rates for a given court realization θ_i (for $\delta = 1/10$). The RHS panel depicts the areas for which r_L and r_P are always and never FRAND (for $\delta = 1/10$).

Assumption 3. *The court's FRAND tolerance δ and noise θ are such that $\delta + \theta < 1/2$.*

This assumption ensures that the lower bound $\underline{r}(\theta_i) := 1/2 + \theta_i - \delta > 0$ of the corridor is always positive, and the upper bound $\overline{r}(\theta_i) := 1/2 + \theta_i + \delta < 1$ is always less than one.

Definition 1. *An offer by P is FRAND if $r_P \leq 1/2 + \theta_i + \delta = \overline{r}(\theta_i)$. A counteroffer by L is FRAND if $r_L \geq 1/2 + \theta_i - \delta = \underline{r}(\theta_i)$.*

We assume the parties know the band's fixed width 2δ but not its location (that is, the prior view) when they make their offers and counteroffers.[24] Both parties observe each other's offers; the model has no private information between the parties. The only uncertainty is the court's type θ_i, which is common knowledge as a distribution until it is realized at $t = 4$. There is therefore no role for signaling.[25]

Figure 2 illustrates FRAND assessments. The LHS panel depicts the range of the court's FRAND assessment for a given noise term θ (with $\delta = 0$). As θ increases, the

[24] The contract theory literature identifies uncertainty over court interpretation as an independent source of contracting failure; Schwartz and Sepe (2024) formalize this mechanism in a related setting.

[25] The parameter θ has a natural institutional interpretation: It measures the dispersion of possible court views about the FRAND midpoint when parties make their offers. Lower θ corresponds to more predictable courts, whether because of greater judicial experience, established precedent, or a narrower range of plausible FRAND rates. Because the corridor midpoint is centered at the normalized FRAND rate $1/2$, θ and δ measure deviations relative to that rate rather than absolute royalty levels: $\theta = 1/10$ corresponds to court views dispersed by up to $\pm 20\%$ around the underlying FRAND rate.

dispersion of potential court assessments increases. The center panel depicts the band $\left[\underline{r}(\theta_i), \overline{r}(\theta_i)\right]$ of FRAND royalty rates for a given court realization θ_i (for $\delta = {}^1\!/_{10}$). The RHS panel depicts the areas for which r_L and r_P are always and never FRAND (for $\delta = {}^1\!/_{10}$). The upper bound is $\overline{r}(\theta)$ and the lower bound is $\underline{r}(-\theta)$.

3.4 Litigation Outcomes

The parties' offers result in four possible combinations: FF (both are FRAND), FN (r_P is FRAND and r_L is non-FRAND), NF (r_P is non-FRAND and r_L is FRAND), and NN (neither is FRAND). These combinations affect the court's decision on the injunction (step 1 of litigation) and its decision on damages (step 2 of litigation) differently. For each framework and each of the four combinations, we summarize the royalty rate eventually obtained in Table 2.

Both litigation frameworks are identical in three (of four) combinations. First, when the implementer's counteroffer is FRAND (outcomes FF and NF), the court always denies an injunction, and the patent holder has to accept the counteroffer r_L regardless of the original offer. Second, when the implementer's counteroffer is non-FRAND, and the patent holder's offer is FRAND (outcome FN), the court always rejects the counteroffer and grants an injunction. Assuming a prohibitively high cost of time for the implementer, the damages decision is not binding as the parties will settle on r_P (given our bargaining protocol for settlement negotiations).

The two frameworks differ in the consequences of outcome NN (when both parties' offers are non-FRAND). Courts will grant an injunction only in the amended litigation framework, inducing settlement negotiations that result in a royalty rate of r_P. In the symmetric framework, by contrast, courts deny an injunction. Because neither offer was FRAND, the court has to determine the appropriate royalty rate. We assume that this court-compelled royalty rate is at the midpoint of the court's FRAND corridor, that is, ${}^1\!/_2 + \theta_i$, the court's best estimate of the FRAND rate given its signal, with an expected value equal to ${}^1\!/_2$.[26]

[26] We present the detailed derivations of the expected payoffs from litigation in Appendix A.

Table 2: Outcomes under Different Frameworks

(a) Symmetric Framework			(b) Amended Framework		
	r_L: **F**	r_L: **N**		r_L: **F**	r_L: **N**
r_P: **F**	r_L	r_P	r_P: **F**	r_L	r_P
r_P: **N**	r_L	$1/2 + \theta_i$	r_P: **N**	r_L	r_P

Notes: The table summarizes the litigation outcomes for the symmetric litigation framework under *Huawei v. ZTE* (in panel (a)) and the amended litigation framework (in panel (b)). Following Definition 1, **F** stands for a FRAND (counter)offer, and **N** stands for a non-FRAND (counter)offer.

4 Equilibrium Analysis

In this section, we characterize the subgame-perfect equilibria of our licensing-litigation game. We begin our analysis with the scenario of zero FRAND tolerance with $\delta = 0$ (Section 4.1) before moving on to our full-model analysis with $\delta > 0$ (Section 4.2). The model with zero FRAND tolerance provides intuition for when and why higher equilibrium royalties are obtained under the amended framework. While FRAND tolerance introduces additional effects, the overarching intuition for higher royalties remains intact.

4.1 Benchmark Without FRAND Tolerance

We first derive the equilibrium outcome under the symmetric litigation framework. Without FRAND tolerance and $\delta = 0$, Assumption 3 simplifies to $\theta < 1/2$. Moreover, the critical thresholds for FRAND in Definition 1 are $\overline{r}(\theta_i) = \underline{r}(\theta_i) = 1/2 + \theta_i$. Anticipating the patent holder's decision in $t = 3$ to accept or reject, the implementer never accepts the initial offer by the patent holder but instead makes a counteroffer $r_L^*(r_P)$ in $t = 2$. The patent holder, anticipating this counteroffer, makes an initial offer r_P^* in $t = 1$. In Proposition 1, we summarize the equilibrium outcome of this litigation game.

Proposition 1. *Let $\delta = 0$. The equilibrium in the symmetric framework is characterized as follows:*

1. *The patent holder's offer r_P^* and the implementer's counteroffer r_L^* are*

$$r_P^* = \frac{1+2\theta}{2} \quad \text{and} \quad r_L^* = \frac{1-2\theta}{2}.$$

2. *The equilibrium royalty rate is $r^* = 1/2$.*

3. *The implementer rejects all offers by the patent holder, and the patent holder rejects all counteroffers. The case enters the litigation stage, and the court-determined damages define the equilibrium royalty rate.*

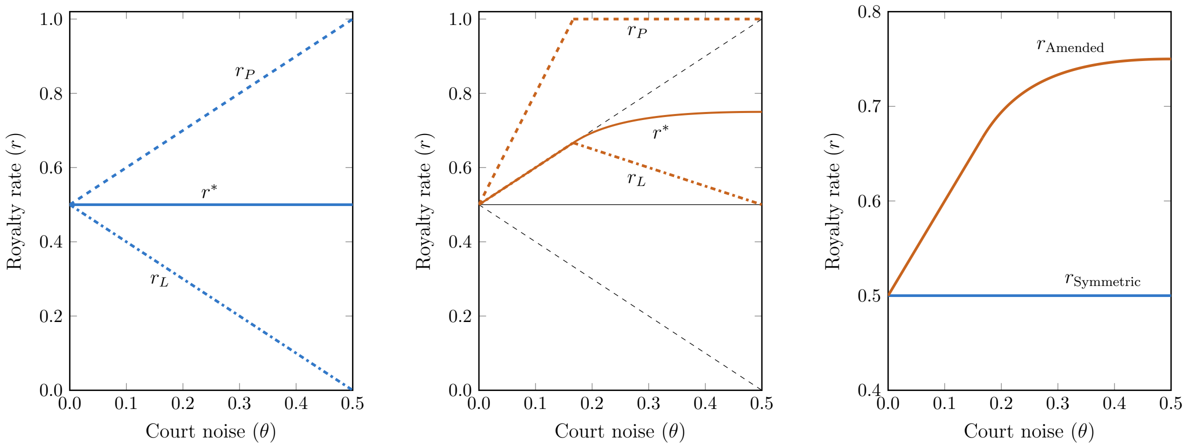
Notes on the proof: In Lemma B.1 in Appendix B, we show that for any counteroffer r_L lower than a threshold, the patent holder prefers litigation (by rejecting r_L) because r_L is the worst-case outcome of litigation. The formal proof of the proposition is relegated to Appendix C. Q.E.D.

Both parties' offers (on the equilibrium path) are at the respective extreme values of the court's range of FRAND assessments (that is, $r_L = \underline{r}(-\theta)$ and $r_P = \overline{r}(\theta)$). In the symmetric framework, the case enters litigation, and the offer and counteroffer are found non-FRAND with certainty, for all θ. The court therefore does not issue an injunction and proceeds to determine damages, but the parties settle on the expected damages award.[27] This benchmark does not hinge on the uniform distribution of court types: For any symmetric prior, both offers are found non-FRAND, and the equilibrium royalty equals the expected court estimate, $1/2$. We plot the parties' equilibrium strategies and the equilibrium royalty rate in the first panel of Figure 3.

Intuitively, it is optimal for the implementer to make a counteroffer at the lower end of the court's FRAND assessment range, because a higher counteroffer would not reduce the risk of an injunction. In equilibrium, the SEP holder's demand is at $\overline{r}(\theta)$, and therefore it will not be found FRAND with positive probability. A small increase in the implementer's counteroffer would mean that the counteroffer would be found FRAND with some probability, but in those circumstances where a slightly increased counteroffer

[27] This polarization result (both offers non-FRAND with probability one) is not an artifact of the uniform distribution. For any symmetric prior over court types, raising the counteroffer yields no first-order gain at the FRAND boundary, where the court's expected damages equal the marginal counteroffer, while it raises the payment over the range on which the counteroffer is already FRAND; the implementer's expected payment therefore increases in her counteroffer at a rate equal to the probability that it is found FRAND, independent of the density's shape, so she offers at the lower end of the support and the equilibrium royalty equals the expected court estimate, $1/2$. With unbounded support (for example, a normal prior), "with probability one" becomes "with high probability," leaving the no-injunction and $1/2$-royalty results unchanged.

Figure 3: Equilibrium Without FRAND Tolerance ($\delta = 0$)



(a) Symmetric Framework **(b)** Amended Framework **(c)** Equilibrium Royalties

Notes: The figure depicts the equilibrium outcomes for both litigation frameworks as a function of court noise θ. Panel (a) shows the patent holder's equilibrium offer r_P^* (dashed), the implementer's equilibrium counteroffer r_L^* (dot-dashed), and the expected equilibrium royalty r^* (solid) for the symmetric framework from Proposition 1 for $\delta = 0$. Panel (b) shows the corresponding equilibrium offers and expected royalty for the amended framework from Proposition 2. Panel (c) juxtaposes the equilibrium royalty rates from both frameworks.

would change the outcome of the court's assessment, the SEP holder's offer would be found non-FRAND and the court-determined damages following the extremely low equilibrium counteroffer would have led to an even lower payment by the implementer.[28] From the SEP holder's perspective, a similar reasoning applies: If the SEP holder demanded a royalty slightly below $\overline{r}(\theta)$, the implementer's counteroffer would remain unchanged. Such a reduction would lower the demanded royalties below the court-awarded damages if it changed the court's outcome, thereby reducing expected royalties.

We now turn to the equilibrium for the amended litigation framework. In Proposition 2, we characterize the equilibrium with the offer $\tilde{r}_P^*$ and counteroffer $\tilde{r}_L^*$ on the equilibrium path. For low θ, the royalty rate implied by the equilibrium is equal to the accepted implementer's counteroffer. For high values of θ, the patent holder rejects the offer, and the equilibrium royalty is the expected outcome from litigation and subsequent settlement negotiations. For high realizations of θ_i, the court will find the implementer's counteroffer is non-FRAND and issue an injunction.

[28] In the proof of Proposition 1, we show that larger deviations also would not increase the profit.

Proposition 2. *Let $\delta = 0$. The equilibrium in the amended framework is characterized as follows:*

1. *The patent holder's offer $\tilde{r}_P^*$ and the implementer's counteroffer $\tilde{r}_L^*$ are*

$$\tilde{r}_P^* = \begin{cases} \frac{1+6\theta}{2} & \text{if } \theta < 1/6 \\ 1 & \text{if } \theta \geq 1/6 \end{cases} \quad \text{and} \quad \tilde{r}_L^* = \begin{cases} \frac{1+2\theta}{2} & \text{if } \theta < 1/6 \\ \frac{3-2\theta}{4} & \text{if } \theta \geq 1/6 \end{cases} \tag{1}$$

2. *The equilibrium royalty rate is*

$$\tilde{r}^* = \begin{cases} \frac{1+2\theta}{2} & \text{if } \theta < 1/6 \\ \frac{7}{8} - \frac{1+4\theta^2}{32\theta} & \text{if } \theta \geq 1/6 \end{cases} \tag{2}$$

3. *The implementer rejects all offers by the patent holder. For $\theta < 1/6$, the patent holder accepts the implementer's counteroffer; for $\theta \geq 1/6$, the patent holder rejects the counteroffer, the case enters the litigation stage, and the equilibrium royalty rate is the expected outcome of settlement negotiations.*

Notes on the proof: In Lemma B.2, we summarize the implementer's counteroffer r_L; in Lemma B.3, we characterize the patent holder's initial offer r_P. The formal proof of the proposition is relegated to Appendix C. Q.E.D.

We depict the equilibrium outcomes in the second panel of Figure 3. The equilibrium offer $\tilde{r}_P^*$ increases in court noise θ and hits the upper bound of allowable offers, $r_P = 1$, at $\theta = 1/6$. For values of θ below this threshold, her offer is always above and increases faster than the FRAND threshold $\bar{r}(\theta) = 1/2 + \theta$, implying a probability of a FRAND offer that is equal to zero. Because the court grants injunctions regardless of the offer r_P, the patent holder can make excessive royalty offers at no cost.

The implementer's counteroffer following the patent holder's initial offer results from the implementer balancing the costs of a counteroffer being found non-FRAND against the probability of that outcome. In the amended framework, if the counteroffer r_L is FRAND, then litigation and settlement negotiations yield a royalty rate r_L. If instead

r_L is non-FRAND, then the royalty rate is r_P. The costs of a non-FRAND counteroffer, therefore, increase as the offer r_P increases. The implementer can reduce the probability of counteroffers being found non-FRAND by making higher counteroffers. This trade-off between costs and the probability of non-FRAND counteroffers widens the gap between r_P and r_L as court noise θ increases. For all $\theta \geq 1/6$, the offer is at the upper bound of the allowable range (Assumption 1), which holds the costs of a non-FRAND counteroffer constant. The implementer can now afford to make offers with higher non-FRAND probability: The equilibrium offer $\tilde{r}_L^*$ decreases in the court noise for sufficiently high values of θ.

Equilibrium offer and counteroffer, and the patent holder's decision to accept or reject the latter, determine the equilibrium royalty. It is increasing in θ but at a decreasing rate for higher values of θ. For low values of θ, the patent holder accepts r_L, and the royalty rate is equal to the implementer's counteroffer. For higher values of θ, the patent holder rejects the counteroffer, and the case proceeds to litigation. The expected royalty is then a weighted average of the two offers: r_L when the counteroffer is FRAND (for low realizations of θ_i) and r_P when the counteroffer is non-FRAND, and the court grants an injunction (for high realizations of θ_i).

We juxtapose the equilibrium royalty rates for litigation without FRAND tolerance derived under both frameworks in the third panel of Figure 3. The royalty rate in the symmetric framework is constant at the neutral rate of $1/2$. In the amended framework, by contrast, the equilibrium royalty rate is increasing in θ and always higher than the *Huawei v. ZTE* royalty rate for any $\theta > 0$.

4.2 Full Model With FRAND Corridor

We now turn to the analysis of our model with FRAND tolerance. We solve the game backward, as in the benchmark. The implementer never accepts the patent holder's initial offer; she makes a counteroffer $r_L^*(r_P)$ that trades off the cost of a non-FRAND counteroffer against the probability that it triggers an injunction. Anticipating this response, the patent holder chooses her offer r_P^*. These best responses, together with the patent holder's acceptance rule, give rise to the following equilibrium outcome:

Proposition 3. *Let $\theta > 0$ and $\delta > 0$. The equilibrium in the symmetric framework is characterized as follows:*

1. *The patent holder's offer r_P^* and the implementer's counteroffer r_L^* are*

$$r_P^* = \begin{cases} \frac{1+6\theta-2\delta}{2} & \text{if } \theta < \frac{2+\sqrt{2}}{4}\delta; \\ \frac{1-2\theta+2\left(1+\sqrt{2}\right)\delta}{2} & \text{if } \theta \in \left[\frac{2+\sqrt{2}}{4}\delta, \frac{1+\sqrt{2}}{2}\delta\right]; \\ \frac{1+2\theta}{2} & \text{if } \theta > \frac{1+\sqrt{2}}{2}\delta; \end{cases} \tag{3}$$

   and

$$r_L^* = \begin{cases} \frac{1+2\theta-2\delta}{2} & \text{if } \theta < \frac{2+\sqrt{2}}{4}\delta; \\ \frac{1-2\theta}{2} + \frac{\delta}{\sqrt{2}} \text{ or } \frac{1-2\theta}{2} & \text{if } \theta \in \left[\frac{2+\sqrt{2}}{4}\delta, \frac{1+\sqrt{2}}{2}\delta\right]; \\ \frac{1-2\theta}{2} & \text{if } \theta > \frac{1+\sqrt{2}}{2}\delta. \end{cases} \tag{4}$$

2. *The equilibrium royalty rate is*

$$r^* = \begin{cases} \frac{1+2\theta-2\delta}{2} & \text{if } \theta < \frac{2+\sqrt{2}}{4}\delta; \\ \frac{1-2\theta+2\left(1+\sqrt{2}\right)\delta}{2} - \frac{\left(3+2\sqrt{2}\right)\delta^2}{4\theta} & \text{if } \theta \in \left[\frac{2+\sqrt{2}}{4}\delta, \frac{1+\sqrt{2}}{2}\delta\right]; \\ \frac{1}{2} & \text{if } \theta > \frac{1+\sqrt{2}}{2}\delta. \end{cases} \tag{5}$$

3. *The implementer rejects all offers by the patent holder. For $\theta < \frac{2+\sqrt{2}}{4}\delta$, the patent holder accepts the implementer's counteroffer; for $\theta \geq \frac{2+\sqrt{2}}{4}\delta$, the patent holder rejects the counteroffer, the case enters the litigation stage, and the equilibrium royalty rate is the expected outcome of settlement negotiations.*

Notes on the proof: In Lemma B.4, we state the patent holder's acceptance rule (of the counteroffer); in Lemma B.5, we characterize the implementer's counteroffer; in Lemma B.6, we summarize the patent holder's initial offer. The formal proof of the proposition is relegated to Appendix C. Q.E.D.

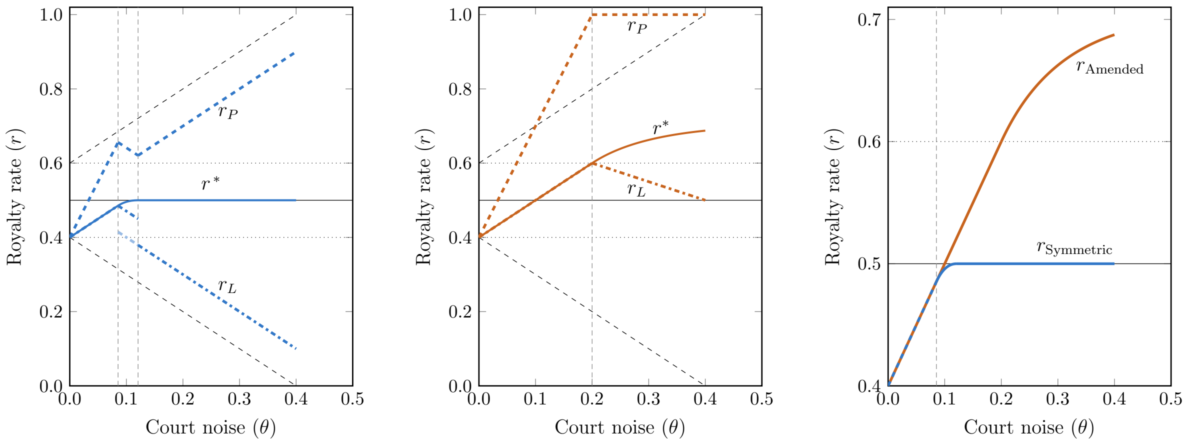
The symmetric-framework equilibrium has three regimes. Below an *equivalence threshold*, $\frac{2+\sqrt{2}}{4}\delta$, both parties' offers fall within the FRAND corridor, and no litigation occurs. Between $\frac{2+\sqrt{2}}{4}\delta$ and the *intermediate-regime threshold* $\frac{1+\sqrt{2}}{2}\delta$, an intermediate regime arises in which the implementer is indifferent between two counteroffers. Above the intermediate-regime threshold, the high-noise regime yields a constant royalty of $1/2$.

We plot the equilibrium offer and counteroffer for the symmetric framework in panel (a) of Figure 4. For high values of θ, we observe the same patterns as in the scenario without FRAND tolerance. The main and decisive difference between the equilibrium outcome for $\delta = 0$ (in Figure 3) and $\delta > 0$ (in Figure 4) is how the court's FRAND tolerance affects the parties' offer and counteroffer for low levels of court noise. In the limit case of $\theta = 0$, the implementer's counteroffer is at the lower end of the FRAND corridor (the counteroffer is FRAND with certainty). The patent holder, too, starts with low offers and increases offers as court noise increases. Because for very low θ, the offer is FRAND with (almost) certainty, the implementer must make cautious counteroffers to avoid triggering an injunction. These counteroffers trail the patent holder's offer, increasing as court noise rises.

We see the same offer-counteroffer pattern for the amended framework (panel (b) in Figure 4), but for a different reason. In the amended framework, a non-FRAND counteroffer triggers an injunction with certainty (by the nature of the litigation framework). In the symmetric framework, by contrast, a non-FRAND counteroffer triggers an injunction with close-to-certainty (for very low θ) because the offer is low and FRAND with close-to-certainty. As θ increases and the offer approaches the upper bound of the FRAND corridor, the probability that a non-FRAND counteroffer triggers an injunction decreases. With the probability of a non-FRAND offer high enough, the implementer no longer seeks to make a cautious counteroffer. As court noise increases, her counteroffer decreases.

The counteroffer exhibits a visible discontinuity at the intermediate-regime threshold ($\frac{1+\sqrt{2}}{2}\delta$). This discontinuity reflects the implementer's indifference between two counteroffers in the intermediate regime: the higher counteroffer $r_L^A = \frac{1-2\theta}{2} + \frac{\delta}{\sqrt{2}}$ (shown as the

Figure 4: Equilibrium With FRAND Tolerance



(a) Symmetric Framework **(b)** Amended Framework **(c)** Equilibrium Royalties

Notes: The figure depicts the equilibrium outcomes for both litigation frameworks as a function of court noise θ, for $\delta = {}^{1}/_{10}$. Panel (a) shows the patent holder's equilibrium offer r_P^* (dashed), the implementer's equilibrium counteroffer r_L^* (dot-dashed), and the expected equilibrium royalty r^* (solid) for the symmetric framework from Proposition 3. In the intermediate regime, the implementer is indifferent between two counteroffers; the lighter dot-dashed segment shows the alternative (lower) counteroffer. Panel (b) shows the corresponding equilibrium offers and expected royalty for the amended framework from Proposition 4. Panel (c) juxtaposes the equilibrium royalty rates from both frameworks. Vertical dashed lines mark the regime boundaries: the *equivalence threshold* $\frac{2+\sqrt{2}}{4}\delta$ and the *intermediate-regime threshold* $\frac{1+\sqrt{2}}{2}\delta$ in panel (a), the *litigation threshold* $\frac{1+2\delta}{6}$ in panel (b), and the *equivalence threshold* in panel (c).

upper dash-dot segment in panel (a)) and the lower counteroffer $r_L^B = \frac{1-2\theta}{2}$ (shown as the lighter dash-dot segment), which connects continuously to the high-noise counteroffer. Both counteroffers lead to litigation and yield the same expected royalty rate r^*; intermediate values between them are not equilibria. The patent holder's equilibrium offer in this regime places the implementer precisely at the threshold where neither counteroffer dominates the other.

We now turn to the equilibrium for the amended litigation framework. In Proposition 4, we summarize the equilibrium outcome, analogously to Proposition 2 without FRAND tolerance.

Proposition 4. *Let $\theta > 0$ and $\delta > 0$. The equilibrium in the amended framework is characterized as follows:*

1. *The patent holder's offer* $\tilde{r}_P^*$ *and the implementer's counteroffer* $\tilde{r}_L^*$ *are*

$$\tilde{r}_P^* = \begin{cases} \frac{1+6\theta-2\delta}{2} & \text{if } \theta < \frac{1+2\delta}{6} \\ 1 & \text{if } \theta \geq \frac{1+2\delta}{6} \end{cases} \quad \text{and} \quad \tilde{r}_L^* = \begin{cases} \frac{1+2\theta-2\delta}{2} & \text{if } \theta < \frac{1+2\delta}{6} \\ \frac{3-2(\theta+\delta)}{4} & \text{if } \theta \geq \frac{1+2\delta}{6} \end{cases} \tag{6}$$

2. *The equilibrium royalty rate is*

$$\tilde{r}^* = \begin{cases} \frac{1+2(\theta-\delta)}{2} & \text{if } \theta < \frac{1+2\delta}{6} \\ \frac{7}{8} - \frac{1+4\left(\delta+(\theta+\delta)^2\right)}{32\theta} & \text{if } \theta \geq \frac{1+2\delta}{6} \end{cases} \tag{7}$$

3. *The implementer rejects all offers by the patent holder. For* $\theta < \frac{1+2\delta}{6}$*, the patent holder accepts the implementer's counteroffer; for* $\theta \geq \frac{1+2\delta}{6}$*, the patent holder rejects the counteroffer, the case enters the litigation stage, and the equilibrium royalty rate is the expected outcome of settlement negotiations.*

Notes on the proof: In Lemma B.7, we characterize the implementer's counteroffer; in Lemma B.8, we summarize the patent holder's initial offer. The formal proof of the proposition is relegated to Appendix C. Q.E.D.

The amended-framework equilibrium has two regimes, separated by the *litigation threshold* $\frac{1+2\delta}{6}$. Below this threshold, the patent holder accepts the implementer's counteroffer, and no litigation occurs. Above it, the patent holder rejects the counteroffer, and the case proceeds to court.

We plot the equilibrium offer, counteroffer, and royalty rate $\tilde{r}^*$ in panel (b) of Figure 4. The royalty rates follow the same patterns as in the scenario without FRAND tolerance (in Figure 3). The two scenarios differ most visibly at $\theta = 0$, where offers coordinate at the lower bound of the FRAND corridor rather than at $1/2$; for all $\theta > 0$, the equilibrium expressions are shifted by δ. For low values of θ, the offer-counteroffer combinations are identical across the two frameworks. Once θ is high enough, and the offer in the symmetric framework is non-FRAND with sufficiently high probability, the patent holder switches to more moderate offers (to avoid jeopardizing an injunction) and the implementer to more aggressive ones. In the amended framework, there is no need for the patent holder to pace herself. Because the court's injunction decision does not depend on the offer, she can continue to increase it as court noise increases.

The third panel in Figure 4 depicts the equilibrium royalty rates from Propositions 3 and 4 as functions of court noise θ. From the propositions and figures, equilibrium royalty rates are weakly increasing as court noise θ increases. For low values of θ, equilibrium royalty rates strictly increase in court noise in both frameworks. Moreover, for low levels of court noise, the royalty rates do not differ. For higher values of θ, the royalty rate in the symmetric framework is constant but continues to increase in the amended framework.

Corollary 1. *For court noise below the equivalence threshold, $\theta \leq \frac{2+\sqrt{2}}{4}\delta$, the equilibrium royalty rates are identical in both frameworks. For θ above the equivalence threshold, the amended framework yields strictly higher equilibrium royalty rates than the symmetric framework.*

Easier access to injunctions under the amended framework yields higher equilibrium royalties than under the symmetric framework when court noise is high. For low levels of court noise, however, the less restrictive injunction regime in the amended framework does not result in higher royalty rates. The reason is that when court noise is low, both parties' equilibrium offers fall within the FRAND corridor under both frameworks. The single-cell difference (the NN cell in Table 1) is never triggered, and the two frameworks yield identical equilibrium royalties.

5 Effects on Litigation and Welfare

Propositions 3 and 4 in the previous section characterize the equilibria for both litigation frameworks. In this section, we derive injunction rates implied by equilibrium strategies and discuss the potential welfare implications of our results.

5.1 Injunction Rates

In both frameworks, for low court noise, the parties agree on licensing terms, as the patent holder accepts the implementer's counteroffer. For higher levels of court noise θ, however, the patent holder rejects the counteroffer and the parties enter litigation. In Step 1 of litigation (in $t = 5$), the court issues an injunction, following the legal framework laid out in Table 1; in Step 2 (in $t = 7$), the court determines damages. In between, the parties enter settlement negotiations. Litigation at Step 1 thus arises on the equilibrium path, not from a breakdown of settlement negotiations; our model accommodates both litigation and successful settlement in equilibrium.

The equilibrium outcomes in Propositions 3 and 4 imply injunction rates that capture the probability that a court issues an injunction given its realized estimate of the underlying FRAND rate, $1/2 + \theta_i$. We summarize these injunction rates in Proposition 5.

Proposition 5. *The probability of an injunction in the symmetric framework is*

$$I^* = \begin{cases} 0 & \text{if } \theta < \frac{2+\sqrt{2}}{4}\delta; \\ 1 - \frac{(2+\sqrt{2})\delta}{4\theta} & \text{if } \theta \in \left[\frac{2+\sqrt{2}}{4}\delta, \frac{1+\sqrt{2}}{2}\delta\right]; \\ \frac{\delta}{2\theta} & \text{if } \theta > \frac{1+\sqrt{2}}{2}\delta. \end{cases} \tag{8}$$

The probability of an injunction in the amended framework is

$$\tilde{I}^* = \begin{cases} 0 & \text{if } \theta < \frac{1+2\delta}{6}; \\ 1 - \frac{1+2\theta+2\delta}{8\theta} & \text{if } \theta \geq \frac{1+2\delta}{6}. \end{cases} \tag{9}$$

Notes on the proof: The formal derivation steps are relegated to Appendix C. Q.E.D.

We plot the injunction rates for the symmetric framework (panel (a)) and the amended framework (panel (b)) in Figure 5. In both frameworks, the injunction rates are zero for small values of θ when patent holders accept the implementers' respective counteroffers. For higher values of court noise, the injunction rates are strictly positive in both frameworks. The visible discontinuity in the symmetric framework's injunction rate (panel (a)) at the transition from the intermediate to the high court noise regime reflects the discrete shift in equilibrium offer strategies at that boundary. The relative ordering of the frameworks, however, varies with θ.

Corollary 2. *For $\theta < \frac{1+6\delta}{6}$, the injunction rate is weakly higher in the symmetric framework than in the amended framework. For θ above this crossover, the injunction rate is strictly higher in the amended framework.*

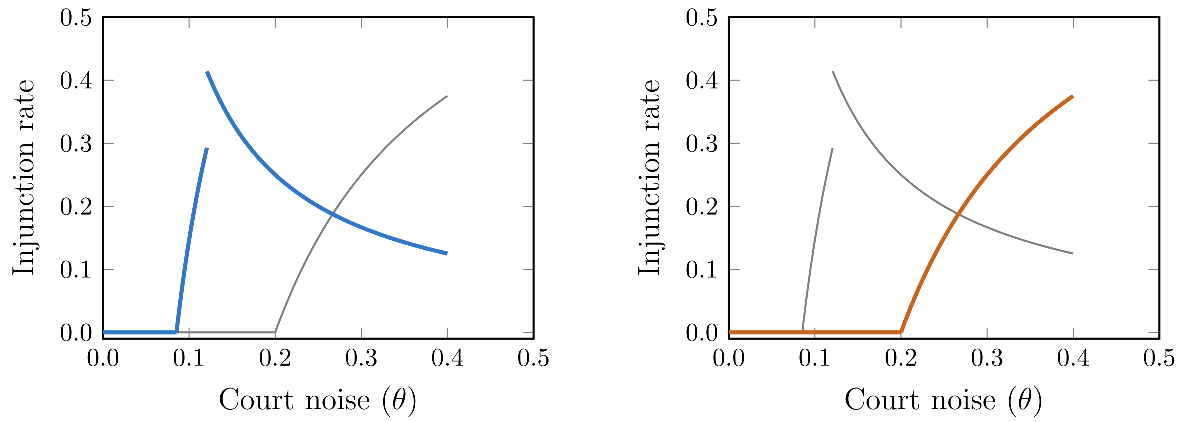
In equilibrium, easier access to injunctions *lowers* the injunction rate (that is, the equilibrium use of injunctions) for intermediate values of court noise. This pattern reflects the implementer's response: In the amended framework, she makes more cautious counteroffers than in the symmetric framework, so she does not trigger an injunction in the first place. We label this a *chilling effect*: The injunction is more readily available under the amended framework, yet less frequently exercised, because the increased risk of injunctions induces preemptive compliance on the counteroffer. For higher levels of court noise, counteroffers become more aggressive even under the amended framework, leading to higher injunction rates.

To make the effect concrete, consider $\delta = 1/10$. By Proposition 5, the two frameworks cross at $\theta = \frac{1+6\delta}{6} \approx 0.267$ (Corollary 2). At $\theta = 0.15$, the symmetric framework issues an injunction with probability $I^* = 1/3$, whereas the amended framework issues none ($\tilde{I}^* = 0$): The implementer's cautious counteroffer is accepted, and the case settles. At $\theta = 0.25$, both rates are positive, but the amended rate is still lower ($\tilde{I}^* = 0.15 < 0.20 = I^*$). Only past the crossover, at $\theta = 0.30$, does the ranking flip ($\tilde{I}^* = 0.25 > 0.17 = I^*$), as counteroffers turn aggressive under the amended framework. Whether real disputes fall within these ranges depends on the size of court uncertainty. Court-determined FRAND rates have varied widely across jurisdictions and methodologies and have diverged from patent-holder demands by large margins,[29] suggesting that θ can be large relative to δ, so the high-noise region in which the frameworks diverge is empirically relevant.

The injunction-rate pattern bears directly on empirical work. A growing empirical literature reads injunction grant and filing rates as a barometer of how injunction regimes shape licensing and enforcement (Seaman, 2016; Contreras et al., 2017; Mezzanotti and

[29] For example, in *Microsoft v. Motorola* the court-set RAND rate was roughly two orders of magnitude below the 2.25% of end-product price the patent holder had demanded (*Microsoft Corp. v. Motorola, Inc.*, No. C10-1823JLR, W.D. Wash., 25 April 2013). Comparable portfolio valuations have also diverged sharply across courts and methodologies (*Unwired Planet v. Huawei*, [2017] EWHC 711 (Pat), 5 April 2017; *TCL v. Ericsson*, No. SACV 14-341 JVS, C.D. Cal., 21 December 2017).

Figure 5: Injunction Rates



(a) Symmetric Framework

(b) Amended Framework

Notes: The figures depict the equilibrium injunction rates I^* and $\tilde{I}^*$ for $\delta = 1/10$ implied by the equilibrium for the symmetric framework (Proposition 3) in panel (a) (in blue) and the amended framework (Proposition 4) in panel (b) (in orange). In each panel, the gray line shows the injunction rate from the other framework for comparison.

Simcoe, 2019; Mezzanotti, 2021). Our analysis cautions against reading these rates at face value. The injunction rate is not a primitive of the legal regime but an equilibrium outcome, selected by the parties' offers (Priest and Klein, 1984): Under the amended framework, the implementer's cautious counteroffers can depress the injunction rate even as royalties rise. The absence of a higher injunction rate is therefore not evidence that the easier access under the amended framework is without effect.[30]

This wedge between the royalty distortion and the observed injunction rate creates an identification problem. Ratliff and Rubinfeld (2013) conclude that injunctions do not distort royalties when the implementer retains a court-determined fallback. We show that even when injunctions do distort royalties (as in our model, where no such fallback exists), the distortion need not manifest in elevated injunction rates. Two regimes can thus generate the same injunction rates while producing different royalties, and the royalty terms on which cases settle are typically confidential, so the observable record cannot identify the royalty effect of an injunction regime. What would identify it is the royalty level itself: The width of the FRAND corridor δ is informed by the range of rates courts

[30] The same selection operates where access to injunctions is narrowed rather than expanded: studying U.S. patent cases from 2000 to 2023, Acri (2024) finds that *eBay* sharply reduced the rate at which injunctions were *sought*, not only the rate at which they were granted, so injunction filings are themselves an equilibrium choice.

treat as FRAND, court noise θ by the dispersion of determined rates (or, given δ, by the injunction rate, since $I^* = \delta/2\theta$ in the high-noise regime), and the frequency of litigation relative to settlement by the prevailing regime. The obstacle is empirical, not conceptual: The rates that would reveal the distortion are rarely disclosed.

5.2 Welfare Implications

The preceding analysis establishes that the amended framework raises equilibrium royalties above the symmetric benchmark (and to non-FRAND levels) for sufficiently high court noise. Whether these higher royalties improve or reduce welfare depends on the relationship between the FRAND rate and the socially optimal royalty r^o, that is, the rate that maximizes total welfare accounting for both *ex ante* innovation incentives and *ex post* allocative efficiency. The socially optimal rate r^o may differ from the FRAND rate. The latter, normalized to $1/2$, is the rate the FRAND commitment and the courts treat as fair, the midpoint of the corridor that courts estimate with noise; the former is the rate that maximizes welfare. The same increase in the royalty rate can raise or lower welfare, depending on where r^o falls relative to the royalties the two frameworks produce.

Rather than resolving which benchmark applies, a question that depends on empirical magnitudes outside the model, we characterize the welfare comparison *as a function of* r^o. We assess welfare by the distance $|r - r^o|$ between the equilibrium royalty and this benchmark; any deviation from r^o, whether above or below, reduces welfare. By Propositions 3 and 4, the symmetric royalty never exceeds the FRAND midpoint ($r^* \leq 1/2$ for all θ), while the amended royalty is strictly higher above the equivalence threshold and exceeds the FRAND corridor ($\tilde{r}^* > 1/2 + \delta$ for $\theta > 2\delta$, with δ small), the sense in which the amended framework induces patent hold-up. Whether the amended framework's higher royalty moves toward or away from r^o, therefore, depends on where r^o sits relative to the midpoint between the two equilibrium royalties.

A starting point for the welfare analysis is that the FRAND rate already compensates innovation optimally, so that $r^o = 1/2$ and any royalty outside the FRAND corridor is a distortion. Other settings depart from this benchmark. Standardized technologies are typically one of many inputs into follow-on innovation and product development. In such a sequential innovation setting, the implementer is itself an innovator, and higher royalties deter its downstream R&D. The socially optimal rate then balances first- and second-generation innovation incentives (Scotchmer, 1991; Green and Scotchmer, 1995) and depends on the relative social values of the two innovations (see Chen and Sappington, 2018). A higher royalty helps the first-generation innovator but harms the second-generation innovator; the net effect is non-monotone in r.

Our welfare analysis also accommodates situations in which the midpoint of the FRAND corridor systematically differs from the socially optimal rate r^o. Because our model normalizes the downstream pie to one and abstracts from pass-through and output effects, the welfare ranking is a statement about royalty distortion relative to an exogenous benchmark, r^o, rather than a structural welfare result.[31] Proposition 6 characterizes the welfare comparison.

Proposition 6. *Suppose welfare is decreasing in $|r - r^o|$ for a socially optimal rate $r^o \geq 0$. For θ at or below the equivalence threshold, $\frac{2+\sqrt{2}}{4}\delta$, both frameworks yield identical welfare for any r^o. For θ above the equivalence threshold, the symmetric framework welfare-dominates the amended framework if and only if $r^o < \frac{\tilde{r}^*(\theta)+r^*(\theta)}{2}$.*

Figure 6 depicts the comparison in the (θ, r^o) plane for $\delta = 1/10$. The boundary $r^o = (\tilde{r}^* + r^*)/2$ rises with court noise and splits the plane: The amended framework welfare-dominates above it and the symmetric framework below it, while to the left of the equivalence threshold (the shaded region) the two coincide. The dotted line marks the benchmark $r^o = 1/2$, at which the court's average determination is itself socially optimal; the boundary crosses at $\theta^\dagger$. Because the boundary slopes upward, the range of court noise for which the symmetric framework welfare-dominates the amended framework shrinks as the socially optimal royalty rate r^o increases. The following corollary makes both observations precise.

[31] We expect the ranking to extend to a richer model in which deviations from r^o generate deadweight losses (through reduced downstream output as higher royalties pass through to consumer prices, reduced downstream investment, lower product variety, or diminished innovation incentives), but we do not formalize these channels here.

Corollary 3. *Above the equivalence threshold:*

(i) If $r^o = 1/2$ (the court's average determination is socially optimal), the welfare comparison is non-monotone in θ: The amended framework welfare-dominates for $\theta \in \left(\frac{2+\sqrt{2}}{4}\delta, \frac{4+3\sqrt{2}}{8}\delta\right)$, and the symmetric framework welfare-dominates for $\theta > \frac{4+3\sqrt{2}}{8}\delta$. The parameter space in which the symmetric framework dominates expands as the FRAND corridor narrows, and the symmetric framework dominates throughout in the limit case when courts apply no FRAND tolerance ($\delta \to 0$).

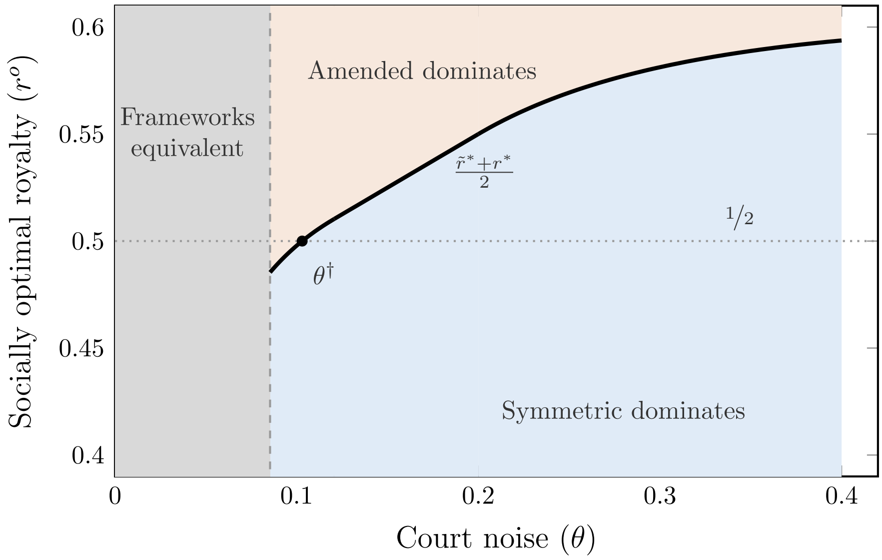
(ii) The crossover $\theta^\dagger(r^o)$ at which the welfare ranking switches is increasing in r^o: Higher socially optimal royalties favor the amended framework over a wider range of court noise. For r^o sufficiently large, the amended framework welfare-dominates for all θ above the equivalence threshold; for r^o sufficiently small, the symmetric framework welfare-dominates for all such θ.

Intuitively, just above the equivalence threshold the amended framework has not yet entered its hold-up regime, which begins only at $\theta > 2\delta$: The patent holder still accepts the counteroffer, so the amended royalty remains near $1/2$ and lies closer to the optimum than the weakly lower symmetric royalty; only at higher court noise does the amended royalty overshoot $1/2$ and cede the advantage to the symmetric framework.

At the natural benchmark where the court's average determination is itself socially optimal ($r^o = 1/2$), the symmetric framework dominates when noise is high (which is empirically plausible) because the amended royalty then overshoots the optimal level. The amended framework is preferred only for a narrow range of moderate noise just above the equivalence threshold (which disappears as the judicial tolerance narrows), where its royalty stays near $1/2$ while the symmetric royalty falls below it.

If the socially optimal rate systematically differs from the court-determined FRAND rate, the welfare implications depend on the direction of that divergence. If FRAND rates are systematically set below the socially optimal level, above-FRAND royalty rates under the amended framework could alleviate this bias. Conversely, if court-determined FRAND rates systematically exceed the socially optimal level, a further increase in equilibrium

Figure 6: Welfare Comparison by Socially Optimal Royalty



Notes: The figure illustrates Proposition 6 for $\delta = 1/10$. The solid curve plots the welfare boundary $r^o = (\tilde{r}^* + r^*)/2$ as a function of court noise θ. For a given θ, the amended framework welfare-dominates if the socially optimal royalty r^o lies above the boundary; the symmetric framework welfare-dominates if r^o lies below it. For θ below the equivalence threshold (gray region), both frameworks yield identical royalties and welfare. The dotted line at $r^o = 1/2$ marks the case in which the court's average determination is socially optimal, and the point $\theta^\dagger$ marks the crossover at which the welfare ranking switches in that case.

royalties under the amended framework would reduce welfare. Whether and to what extent court-determined FRAND rates differ from socially optimal rates is then ultimately an empirical question.

6 Conclusion

We present a simple licensing-litigation game between the owner of a standard-essential patent and an implementer of a standard in a downstream market. We model the licensing negotiations in line with the protocol set out in the *Huawei v. ZTE* judgment of the European Court of Justice (the *symmetric framework*), and account for recent deviations by German courts that have made it easier for patent holders to obtain injunctions (the *amended framework*). We show that expanding access to injunctions can yield higher equilibrium royalties when court uncertainty is sufficiently high. In the presence of low court uncertainty (for instance, a precise court with minor deviations from an *ex ante* neutral or optimal FRAND rate), expanded access does not affect the equilibrium outcome. The amended framework can also *lower* equilibrium injunction rates. Because the implementer responds with more cautious counteroffers, the injunction is granted less often, even though it is more readily available, a *chilling effect*. Only at high court uncertainty do injunction rates under the amended framework exceed those under the symmetric framework. The chilling effect carries an empirical caution: The absence of a higher injunction rate is not evidence that expanded access is without effect.

Whether the increase in royalties under the amended framework (for high court uncertainty) affects welfare depends on how the socially optimal royalty compares with the royalties the two frameworks yield. If court-determined FRAND rates are, on average, socially optimal, the symmetric framework welfare-dominates the amended framework when court noise is sufficiently high, whereas for moderate court noise, it is the other way around. The amended framework dominates over a relatively narrow parameter range, which shrinks as the FRAND corridor narrows and vanishes when courts apply no FRAND tolerance. Lastly, the framework does not affect welfare for low court uncertainty. More generally, our model allows for cases in which the midpoint of court-determined FRAND corridors is systematically biased upwards or downwards relative to the socially optimal royalty level. We identify the precise conditions under which expanded injunctions improve or worsen welfare, and we show that these conditions vary with court uncertainty.

The model comes with limitations. First, we abstract from litigation costs. Positive costs moderate offer polarization under both frameworks but do not alter the structural asymmetry that drives the comparison: The implementer bears injunction risk from a non-FRAND counteroffer regardless of the patent holder's offer under the amended framework, but only when the patent holder's offer is itself FRAND under the symmetric framework. Litigation costs would reduce the absolute magnitude of offer distortion; we expect them to leave its direction unchanged. Second, we treat the patent as unambiguously valid and essential. Introducing validity uncertainty would scale down the expected payoff from the injunction threat under both frameworks, but the amended framework's expanded scope of that threat is structural and should persist regardless of how litigation payoffs are discounted by validity risk. For high validity uncertainty, the two frameworks would converge as the injunction threat weakens under both. Third, we model a single bilateral negotiation rather than multi-patent portfolios or competing implementers; portfolio effects and downstream competition are left for future work.

As SEP disputes spread beyond telecommunications into automotive and the Internet of Things, the institutional design of injunction frameworks will remain a first-order policy question. Beyond SEP licensing, the mechanisms we identify may operate wherever a legal framework conditions the availability of coercive outside options on the quality of prior offers.

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APPENDIX

Injunction Rules and the Licensing of Standard-Essential Patents

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A Litigation Payoffs

This appendix derives the expected litigation payoffs that enter the equilibrium analysis of Section 4. Given the offer or counteroffer and the court's FRAND tolerance parameter, we define the critical thresholds for the noise term θ for FRAND (following Definition 1) as follows:

$$\theta_P(r_P) \;:=\; r_P - 1/2 - \delta \tag{A.1}$$

$$\theta_L(r_L) \;:=\; r_L - 1/2 + \delta \tag{A.2}$$

The patent holder's offer r_P is FRAND if $\theta_i \geq \theta_P(r_P)$, and the implementer's counteroffer is FRAND if $\theta_i \leq \theta_L(r_L)$. The parties' offer-counteroffer combination is then NF if the court noise term θ_i is less than the smaller one of these two thresholds, $\theta_i \leq \min\{\theta_P(r_P), \theta_L(r_L)\}$; analogously, the combination is FN if $\theta_i \geq \max\{\theta_P(r_P), \theta_L(r_L)\}$. For intermediate values of θ_i, we further distinguish between two cases:

1. In *Case 1*, let $r_P - r_L \geq 2\delta$ so that $\theta_L(r_L) \leq \theta_P(r_P)$. Then the offer-counteroffer combination is NN for $\theta_L(r_L) < \theta_i < \theta_P(r_P)$.

2. In *Case 2*, let $r_P - r_L < 2\delta$ so that $\theta_L(r_L) > \theta_P(r_P)$. Then the offer-counteroffer combination is FF for $\theta_P(r_P) < \theta_i < \theta_L(r_L)$.

Whether Case 1 or Case 2 applies is determined by the spread between the patent holder's offer and the implementer's counteroffer relative to the width of the FRAND corridor. When the spread is wide (Case 1), a range of court types find both offers outside the FRAND corridor, creating the NN region that underlies the framework difference. When the spread is narrow (Case 2), the offers overlap within the corridor, and a range of court types find both offers FRAND (the FF region). The implementer's optimal counteroffer trades off these two payoff structures.

The single-cell difference has a consequential asymmetry. Under the amended framework, the patent holder's payoff in the NN cell is r_P (the same as in the FN cell) and therefore increasing in her offer. Under the symmetric framework, the NN-cell payoff is the court-determined rate $1/2 + \theta_i$, which does not depend on r_P. Two consequences follow directly. First, the amended framework eliminates the patent holder's strategic incentive to moderate her offer: When the implementer's counteroffer is non-FRAND, the payoff is r_P regardless of whether the patent holder's own offer is FRAND. Second, the implementer faces a new incentive to push her counteroffer above the FRAND threshold: Under the amended framework, landing in the NN cell triggers an injunction and settlement at r_P, whereas crossing into the FF or NF cell avoids it. The first effect drives higher equilibrium royalties; the second induces the implementer to make more cautious counteroffers that preempt the injunction, lowering equilibrium injunction rates even as access to injunctions expands.

The patent holder's expected payoffs from rejecting the implementer's counteroffer depend on both parties' offers and their respective FRAND statuses. Given the respective payoffs in panel (a) of Table 2 and taking expectations over θ_i, we derive the patent holder's expected payoffs in the symmetric litigation framework as follows:

In *Case 1*, the FRAND assessments are NF for $\theta_i \leq \theta_L(r_L)$, NN for $\theta_L(r_L) < \theta_i < \theta_P(r_P)$, and FN for $\theta_P(r_P) \leq \theta_i$. Suppose $-\theta < \theta_L(r_L)$ and $\theta_P(r_P) < \theta$, then the patent holder's expected payoffs are:

$$\pi_{P,1} = \frac{2\theta\left(r_P + r_L\right) + r_P\left(1 - r_P\right) - r_L\left(1 - r_L\right)}{4\theta} \tag{A.3}$$

If the NF region is empty ($-\theta \geq \theta_L(r_L)$) or the FN region is empty ($\theta_P(r_P) \geq \theta$), the corresponding term drops from the average and the analogous expression applies; we use these boundary expressions in the proofs at the offers where they arise.

In *Case 2*, the FRAND assessments are NF for $\theta_i \leq \theta_P(r_P)$, FF for $\theta_P(r_P) < \theta_i < \theta_L(r_L)$, and FN for $\theta_L(r_L) \leq \theta_i$. Suppose $-\theta < \theta_P(r_P)$ and $\theta_L(r_L) < \theta$, then the expected payoffs are:

$$\pi_{P,2} = \pi_{P,1} + \frac{\left(r_P - r_L\right)^2 - 2\delta\left(r_P - r_L\right)}{4\theta} \tag{A.4}$$

If $\theta \leq \theta_L(r_L)$ (so the counteroffer is always FRAND), the expected payoffs simplify to

$$\pi_{P,2}\big|_{\theta \leq \theta_L(r_L)} = r_L. \tag{A.5}$$

The implementer's payoffs are $\pi_{L,1} = 1 - \pi_{P,1}$ and $\pi_{L,2} = 1 - \pi_{P,2}$.

The expected payoffs under the amended framework differ only in Case 1 for the double-non-FRAND combination NN (because Case 2 does not allow it). Because the court's injunction decision does not depend on the patent holder's offer in the amended framework, the NN and FN regions both yield a royalty of r_P. The patent holder's expected payoffs therefore simplify to a weighted sum over two regions: the NF region (counteroffer is FRAND, yielding r_L) and its complement (counteroffer is non-FRAND, yielding r_P). We denote the expected payoffs in the amended framework by $\tilde{\pi}$:

$$\begin{aligned}\tilde{\pi}_{P,1} &= \frac{r_L\left(\theta+\theta_L(r_L)\right)+r_P\left(\theta-\theta_L(r_L)\right)}{2\theta} \\ &= \pi_{P,1}+\frac{\left(r_P-r_L\right)^2-2\delta\left(r_P-r_L\right)}{4\theta}\end{aligned} \tag{A.6}$$

The first line states the expected payoffs directly: r_L when the counteroffer is FRAND (for $\theta_i \leq \theta_L(r_L)$) and r_P otherwise. Because each region pays a constant in the amended framework, this payoff takes a probability-weighted form; the symmetric-framework payoffs in equations (A.3) and (A.4) instead average the court-determined rate $1/2+\theta_i$ over the NN region and so appear in closed form. The last line expresses the same payoffs as a correction to the *Huawei v. ZTE* payoffs $\pi_{P,1}$ in equation (A.3), isolating the effect of the amended framework. The correction term captures the replacement of the court-determined midpoint $1/2+\theta_i$ in the NN region with the patent holder's offer r_P.

We have $\tilde{\pi}_{L,1}=1-\tilde{\pi}_{P,1}$. All other payoffs are as in equation (A.4) (for $\tilde{\pi}_{P,2}$).

B Auxiliary Results (Lemmas)

Lemma B.1. *Let $\delta=0$. The patent holder accepts the implementer's counteroffer r_L if, and only if, $r_L \geq \min\left\{r_P, \frac{1+2\theta}{2}\right\}$.*

Proof. If $r_L \geq 1/2+\theta =: \overline{r}(\theta)$, the implementer's counteroffer is always FRAND, and the patent holder's expected payoffs from litigation are r_L. The patent holder accepts the counteroffer (assuming she accepts it when indifferent). Suppose that $r_L \geq r_P$ (violating Assumption 2), the patent holder accepts. To see this, recall from the expression in equation (A.4), that the patent holder expects r_L for low values of θ_i and r_P for high values of θ_i. This means that, for $r_L \geq r_P$, the convex combination of r_L and r_P is weakly less than r_L. This concludes the *if* part of the proof.

For the *only if* part, we show that if $r_L < r_P$ and $r_L < 1/2+\theta$ (that is, $r_L < \min\{r_P, 1/2+\theta\}$), then the patent holder will reject the counteroffer (implying litigation). Let $r_L < 1/2+\theta$ and $r_L < r_P$, then the expected payoff (as in equation (A.3)) is strictly larger than r_L. To see this, note that the patent holder expects r_L for low values of θ_i, $1/2+\theta_i$ for intermediate values of θ_i, and r_P for high values of θ_i. The intermediate-θ_i payoffs are increasing in θ_i, strictly larger than r_L at the lower bound of θ_i and strictly smaller than r_P at the upper bound of θ_i:

$$\begin{aligned} {}^1\!/_2 + \theta_i\big|_{\theta_i=\theta_L(r_L)} &= {}^1\!/_2 + r_L - {}^1\!/_2 = r_L < r_P \\ {}^1\!/_2 + \theta_i\big|_{\theta_i=\theta_P(r_P)} &= {}^1\!/_2 + r_P - {}^1\!/_2 = r_P > r_L \end{aligned}$$

The intermediate-θ_i payoffs are therefore strictly bounded by r_L and r_P, so that for $r_L < r_P$, the expression in (A.3) is strictly greater than r_L. Q.E.D.

Lemma B.2. *Let $\delta = 0$ in the amended litigation framework. The implementer never accepts an initial offer r_P but will always make a counteroffer:*

$$\tilde{r}_L^*(r_P) = \begin{cases} \in \{r_L : r_L \leq r_P\} & \text{if } r_P < \frac{1-2\theta}{2} \\ \frac{r_P}{2} + \frac{1-2\theta}{4} & \text{if } r_P \in \left[\frac{1-2\theta}{2}, \frac{1+6\theta}{2}\right] \\ \frac{1+2\theta}{2} & \text{if } r_P > \frac{1+6\theta}{2} \end{cases}$$

Proof. Suppose an interior-solution best response $\tilde{r}_L^*(r_P)$ that maximizes $1-\tilde{\pi}_{P,1}$ in equation (A.6). The first-order condition is

$$\frac{\partial\left(1-\tilde{\pi}_{P,1}\right)}{\partial r_L} = \frac{r_P - 2r_L + {}^1\!/_2 - \theta}{2\theta} = 0,$$

yielding

$$\tilde{r}_L^*(r_P) = \frac{r_P}{2} + \frac{1-2\theta}{4}. \tag{B.1}$$

The second derivative is $-1/\theta < 0$, confirming a maximum. For an interior solution, $\tilde{r}_L^*(r_P)$ must be such that (1) $\theta_L(\tilde{r}_L^*(r_P)) > -\theta$ and (2) $\theta_L(\tilde{r}_L^*(r_P)) < \theta$. A violation of (1) implies the counteroffer is never FRAND; a violation of (2) implies the counteroffer is always FRAND. Recall that by Assumption 2, $r_L \leq r_P$.

(1) The condition rewrites as $r_L > {}^1\!/_2 - \theta$ and, for $r_L = \tilde{r}_L^*(r_P)$,

$$r_P > \frac{1-2\theta}{2} =: \tilde{R}_1.$$

For r_P satisfying this condition (above the threshold), the solution in equation (B.1) is an interior solution. If r_P is lower than the threshold, then the implementer's expected payoffs are

$$1 - \int_{-\theta}^{\theta} \frac{r_P}{2\theta} d\theta_i = 1 - r_P,$$

and therefore not a function of the counteroffer. Any offer satisfying the condition $r_L < {}^1\!/_2 - \theta$ is a best response. By Assumption 2, we have $r_L \leq r_P$.

(2) The condition rewrites as $r_L < 1/2 + \theta$ and, for $r_L = \tilde{r}_L^*(r_P)$,

$$r_P < \frac{1 + 6\theta}{2} =: \tilde{R}_2$$

For r_P satisfying this condition (below the threshold), the solution in equation (B.1) is an interior solution, for r_P above the threshold we have $\tilde{r}_L^*(r_P) = 1/2 + \theta$ (the value for r_L satisfying $\theta_L(r_L) = \theta$) as a corner solution. To see the corner solution, note that for $r_L \geq 1/2 + \theta$, the implementer's expected payoffs are

$$1 - \int_{-\theta}^{\theta} \frac{r_L}{2\theta} d\theta_i = 1 - r_L.$$

The best such counteroffer is the lowest value in the allowable range.

Q.E.D.

Lemma B.3. *Let $\delta = 0$ in the amended litigation framework. The patent holder's initial offer is*

$$\tilde{r}_P^* = \begin{cases} \frac{1+6\theta}{2} & \text{if } \theta < 1/6 \\ 1 & \text{if } \theta \geq 1/6 \end{cases}$$

Proof. Let $\tilde{R}_1 := \frac{1-2\theta}{2} > 0$ and $\tilde{R}_2 := \frac{1+6\theta}{2}$ denote the two critical thresholds in Lemma B.2. Suppose the patent holder's offer induces an interior counteroffer in Lemma B.2, so that $r_P \in \left[\tilde{R}_1, \min\left\{1, \tilde{R}_2\right\}\right]$. Substituting $\tilde{r}_L^*(r_P) = \frac{r_P}{2} + \frac{1-2\theta}{4}$ from Lemma B.2 into $\tilde{\pi}_{P,1}$ in equation (A.6), the first-order condition with respect to r_P is

$$\frac{\partial \tilde{\pi}_{P,1}}{\partial r_P} = \frac{1 + 6\theta - 2r_P}{8\theta} = 0,$$

yielding $r_P^* = \frac{1+6\theta}{2}$. The second derivative is $-\frac{1}{4\theta} < 0$, confirming a maximum. This solution satisfies $r_P^* \geq \tilde{R}_1$ and $r_P^* = \tilde{R}_2$. For r_P outside $\left[\tilde{R}_1, \tilde{R}_2\right]$, the implementer's counteroffer is at a corner: for $r_P < \tilde{R}_1$, any $r_L \leq r_P$ is a best response and the patent holder's payoff is $r_P < \tilde{R}_1 < 1/2 + \theta$; for $r_P > \tilde{R}_2$, the counteroffer is $1/2 + \theta$ and the patent holder's payoff is $1/2 + \theta$, which equals the payoff at r_P^*. Hence, the interior solution (weakly) dominates. It satisfies $r_P^* \leq 1$ for $\theta \leq 1/6$. For all θ higher than this threshold, the patent holder's equilibrium offer is equal to 1. Q.E.D.

Lemma B.4. *Let $\delta > 0$. The patent holder accepts the implementer's counteroffer r_L if, and only if, $r_L \geq \min\left\{r_P, \frac{1+2\theta-2\delta}{2}\right\}$.*

Proof. The argument follows the same structure as the proof of Lemma B.1 with $\delta > 0$. The acceptance threshold shifts from $1+2\theta/2$ to $1+2\theta-2\delta/2$: If $r_L \geq 1/2 + \theta - \delta$, the counteroffer is always FRAND, and the patent holder's expected payoffs from litigation in equation (A.5) are r_L. As before, $r_L \geq r_P$ also implies acceptance. This concludes the *if* part.

For the *only if* part, let $r_L < \min\{r_P, {}^{1+2\theta-2\delta}/_2\}$. The new element relative to Lemma B.1 is the distinction between Case 1 ($r_P - r_L \geq 2\delta$) and Case 2 ($r_P - r_L < 2\delta$). In Case 2, the intermediate region is FF with payoff r_L, so the litigation payoff is a weighted average of r_L and r_P, trivially exceeding r_L when $r_L < r_P$. In Case 1, the intermediate region is NN with payoff $1/2 + \theta_i$, which is strictly bounded between $r_L + \delta$ (at $\theta_i = \theta_L(r_L)$) and $r_P - \delta$ (at $\theta_i = \theta_P(r_P)$). Since $r_P - r_L \geq 2\delta$, both bounds lie strictly between r_L and r_P, so the litigation payoff again strictly exceeds r_L. Q.E.D.

Lemma B.5. *Let $\theta > 0$ and $\delta > 0$ in the symmetric framework. The implementer never accepts an initial offer r_P but will always make a counteroffer:*

$$r_L^*(r_P) = \begin{cases} \left\{ \begin{array}{ll} \frac{r_P}{2} + \frac{1-2(\theta+\delta)}{4} & \text{if } r_P < \frac{1+6\theta-2\delta}{2} \\ \frac{1+2\theta-2\delta}{2} & \text{if } r_P \geq \frac{1+6\theta-2\delta}{2} \end{array} \right\} & \text{if } \theta < \frac{\delta}{2} \\ \left\{ \begin{array}{ll} \frac{r_P}{2} + \frac{1-2(\theta+\delta)}{4} & \text{if } r_P < \frac{1+6\theta-2\delta}{2} \\ \frac{1+2\theta-2\delta}{2} & \text{if } r_P \in \left[\frac{1+6\theta-2\delta}{2}, \frac{1+2\theta+4\sqrt{\theta(\delta-\theta)}}{2}\right] \\ \frac{1-2\theta}{2} & \text{if } r_P > \frac{1+2\theta+4\sqrt{\theta(\delta-\theta)}}{2} \end{array} \right\} & \text{if } \theta \in \left[\frac{\delta}{2}, \frac{2+\sqrt{2}}{4}\delta\right] \\ \left\{ \begin{array}{ll} \frac{r_P}{2} + \frac{1-2(\theta+\delta)}{4} & \text{if } r_P < \frac{1-2\theta+2\left(1+\sqrt{2}\right)\delta}{2} \\ \frac{1-2\theta}{2} + \frac{\delta}{\sqrt{2}} \ \text{ or } \ \frac{1-2\theta}{2} & \text{if } r_P = \frac{1-2\theta+2\left(1+\sqrt{2}\right)\delta}{2} \\ \frac{1-2\theta}{2} & \text{if } r_P > \frac{1-2\theta+2\left(1+\sqrt{2}\right)\delta}{2} \end{array} \right\} & \text{if } \frac{2+\sqrt{2}}{4}\delta < \theta \end{cases}$$

Proof. The implementer chooses r_L to maximize $1 - \pi_P$, where π_P depends on whether $r_P - r_L \geq 2\delta$ (*Case 1*, payoff $\pi_{P,1}$) or $r_P - r_L < 2\delta$ (*Case 2*, payoff $\pi_{P,2}$). The implementer can choose which case to target. We identify the optimal counteroffer within each case, then determine which the implementer prefers.

Candidate A (Case 2 payoffs, $r_P - r_L < 2\delta$). The first-order condition of $1 - \pi_{P,2}$ with respect to r_L yields the interior solution

$$r_L^A = \frac{r_P}{2} + \frac{1 - 2\,(\theta + \delta)}{4},$$

with second-order condition $-1/\theta < 0$. This is the same expression as the amended-framework counteroffer in Lemma B.7 (because $\tilde{\pi}_{P,1} = \pi_{P,2}$ for Case 2). The interior solution is valid when $\theta_L(r_L^A) \in (-\theta, \theta)$ and $r_P - r_L^A < 2\delta$, which requires $r_P < \frac{1+6\theta-2\delta}{2}$. For r_P above this threshold, the corner solution is $r_L = \frac{1+2\theta-2\delta}{2}$ (the lowest r_L such that the counteroffer is always FRAND, yielding payoff $1 - r_L$).

Candidate B (Case 1 payoffs, $r_P - r_L \geq 2\delta$). The first-order condition of $1 - \pi_{P,1}$ with respect to r_L yields the interior solution

$$r_L^B = \frac{1-2\theta}{2},$$

with second-order condition $-1/(2\theta) < 0$. This solution is independent of r_P. It is a valid interior solution when $\theta_L(r_L^B) = -\theta + \delta < \theta$, which requires $\theta > \delta/2$, and when $r_P - r_L^B \geq 2\delta$, which requires $r_P \geq \frac{1-2\theta+4\delta}{2}$.

At the Case 1/Case 2 boundary ($r_P - r_L = 2\delta$), the payoffs $\pi_{P,1}$ and $\pi_{P,2}$ coincide, so the implementer's payoff is continuous across cases. We now determine which candidate the implementer prefers for each value of θ.

Case (i): $\theta < \delta/2$. Candidate B's interior solution is invalid ($\theta_L(r_L^B) \geq \theta$). Only Candidate A operates: interior A for $r_P < \frac{1+6\theta-2\delta}{2}$, corner A at $\frac{1+2\theta-2\delta}{2}$ for higher r_P.

Case (ii): $\theta \in \left[\delta/2, \frac{2+\sqrt{2}}{4}\delta\right]$. Both candidates have valid interior solutions for appropriate ranges of r_P. Interior A applies for $r_P < \frac{1+6\theta-2\delta}{2}$. For higher r_P, the implementer chooses between corner A (payoff $1-\frac{1+2\theta-2\delta}{2}$, constant in r_P) and interior B (payoff $1-\pi_{P,1}(r_P, r_L^B)$, increasing in r_P). Setting $\pi_{P,1}(r_P, r_L^B) = \frac{1+2\theta-2\delta}{2}$ yields the quadratic

$$r_P^2 - (1+2\theta)\, r_P + \theta + 5\theta^2 + \frac{1}{4} - 4\theta\delta = 0$$

with discriminant $16\theta(\delta - \theta) \geq 0$ for $\theta \leq \delta$. The relevant (upper) root is $r_P = \frac{1+2\theta+4\sqrt{\theta(\delta-\theta)}}{2}$. For r_P above this threshold, the implementer switches from corner A to interior B. The corner A region exists (that is, the upper root exceeds the interior-A threshold $\frac{1+6\theta-2\delta}{2}$) when $8\theta^2 - 8\theta\delta + \delta^2 < 0$, a quadratic in θ with roots at $\theta = \frac{2\pm\sqrt{2}}{4}\delta$.

Case (iii): $\theta > \frac{2+\sqrt{2}}{4}\delta$. The corner A region vanishes. The implementer transitions directly from interior A to interior B. Equating the implementer's optimized payoffs from Case 2 (at r_L^A) and Case 1 (at r_L^B) yields the transition threshold $r_P = \frac{1-2\theta+2\left(1+\sqrt{2}\right)\delta}{2}$, which coincides with the Case (ii) formula at $\theta = \frac{2+\sqrt{2}}{4}\delta$ by continuity.

Collecting the three cases yields the counteroffer in the lemma. Q.E.D.

Lemma B.6. *Let $\theta > 0$ and $\delta > 0$ in the symmetric framework. The patent holder's initial offer is*

$$r_P^* = \begin{cases} \frac{1+6\theta-2\delta}{2} & \text{if } \theta < \frac{2+\sqrt{2}}{4}\delta; \\ \frac{1-2\theta+2\left(1+\sqrt{2}\right)\delta}{2} & \text{if } \theta \in \left[\frac{2+\sqrt{2}}{4}\delta, \frac{1+\sqrt{2}}{2}\delta\right]; \\ \frac{1+2\theta}{2} & \text{if } \theta > \frac{1+\sqrt{2}}{2}\delta. \end{cases}$$

Proof. The proof follows the same structure as Lemma B.3 (the patent holder's offer without FRAND tolerance) but with the richer counteroffer from Lemma B.5. The patent holder anticipates the implementer's counteroffer and chooses r_P to maximize her payoff, taking the accept/reject decision into account (Lemma B.4).

Low θ ($\theta < \frac{2+\sqrt{2}}{4}\delta$): The implementer's counteroffer is either interior A or corner A from Lemma B.5. In the interior-A range, the patent holder's payoff is $r_L^A = \frac{r_P}{2} + \frac{1-2(\theta+\delta)}{4}$ (which the patent holder accepts by Lemma B.4). Substituting into P's payoff and taking the first-order condition yields

$$\frac{\partial r_L^A}{\partial r_P} = \frac{1}{2} > 0,$$

so P increases r_P until hitting the upper boundary of the interior-A range at $r_P^* = \frac{1+6\theta-2\delta}{2}$. In the corner-A range, $r_L = \frac{1+2\theta-2\delta}{2}$ is constant, so P's payoff is constant and any higher r_P is weakly optimal. The patent holder is indifferent over $r_P \geq \frac{1+6\theta-2\delta}{2}$; we select the lowest optimum $r_P^* = \frac{1+6\theta-2\delta}{2}$.

Intermediate θ ($\theta \in \left[\frac{2+\sqrt{2}}{4}\delta, \frac{1+\sqrt{2}}{2}\delta\right]$): The counteroffer transitions from interior A directly to interior B (the corner region has vanished or is vanishing). For r_P in the interior-A range, P's payoff is increasing in r_P as above. At the transition threshold $r_P = \frac{1-2\theta+2(1+\sqrt{2})\delta}{2}$, the counteroffer switches to $r_L^B = \frac{1-2\theta}{2}$. For r_P above this threshold, P's payoff from litigation is $\pi_{P,1}(r_P, r_L^B)$. Substituting and taking the first-order condition:

$$\frac{\partial \pi_{P,1}}{\partial r_P} = \frac{1+2\theta-2r_P}{4\theta},$$

which is positive for $r_P < \frac{1+2\theta}{2}$. Since the transition threshold exceeds $\frac{1+2\theta}{2}$ for θ in this range, P's payoff decreases after the switch to the Case 1 region. Combining both ranges, P's payoff is maximized at the upper boundary $r_P^* = \frac{1-2\theta+2(1+\sqrt{2})\delta}{2}$ or at $r_P = \frac{1+2\theta}{2}$, whichever yields higher payoff. For θ in this intermediate range, the stated offer $r_P^* = \frac{1-2\theta+2(1+\sqrt{2})\delta}{2}$ obtains.

High θ ($\theta > \frac{1+\sqrt{2}}{2}\delta$): The counteroffer is interior B for all relevant r_P. The first-order condition gives $r_P^* = \frac{1+2\theta}{2}$, the same as in the $\delta = 0$ case (Proposition 1). Q.E.D.

Lemma B.7. *Let $\theta > 0$ and $\delta > 0$ in the amended framework. The implementer never accepts an initial offer r_P but will always make a counteroffer:*

$$\tilde{r}_L^*(r_P) = \begin{cases} \in \{r_L : r_L \leq r_P\} & \text{if } r_P < \frac{1-2\theta-2\delta}{2}; \\ \frac{r_P}{2} + \frac{1-2(\theta+\delta)}{4} & \text{if } r_P \in \left[\frac{1-2\theta-2\delta}{2}, \frac{1+6\theta-2\delta}{2}\right]; \\ \frac{1+2\theta-2\delta}{2} & \text{if } r_P > \frac{1+6\theta-2\delta}{2}. \end{cases}$$

Proof. The proof follows the same steps as Lemma B.2 with $\delta > 0$, with one simplification: because the amended-framework payoffs in equation (A.6) do not depend on $\theta_P(r_P)$, the Case 1/Case 2 distinction is irrelevant, and we can disregard $r_P - r_L \geq 2\delta$ as a condition.

The interior solution from the first-order condition is

$$\tilde{r}_L^*(r_P) \quad = \quad \arg\max\left(1-\tilde{\pi}_{P,1}\right) = \frac{r_P}{2} + \frac{1-2\left(\theta+\delta\right)}{4} \tag{B.2}$$

with second derivative $-1/\theta < 0$. The boundary conditions follow as in Lemma B.2 with thresholds shifted by δ: The interior solution is valid for $r_P \in \left(\tilde{R}_1, \tilde{R}_2\right)$ where $\tilde{R}_1 := 1/2 - \theta - \delta$ and $\tilde{R}_2 := 1/2 + 3\theta - \delta$. For $r_P \leq \tilde{R}_1$, the counteroffer is never FRAND, and any $r_L \leq r_P$ is a best response. For $r_P \geq \tilde{R}_2$, the counteroffer is always FRAND at the interior solution; the best corner solution is $\tilde{r}_L^*(r_P) = 1/2 + \theta - \delta$ (the lowest r_L for which the counteroffer is always FRAND, yielding payoffs $1 - r_L$ that are decreasing in r_L). Q.E.D.

Lemma B.8. *Let $\theta > 0$ and $\delta > 0$ in the amended framework. The patent holder's initial offer is*

$$\tilde{r}_P^* = \begin{cases} \frac{1+6\theta-2\delta}{2} & \text{if } \theta < \frac{1+2\delta}{6}; \\ 1 & \text{if } \theta \geq \frac{1+2\delta}{6}. \end{cases}$$

Proof. The proof follows the same steps as Lemma B.3 with $\delta > 0$. Let $\tilde{R}_1 := 1/2 - \theta - \delta$ and $\tilde{R}_2 := 1/2 + 3\theta - \delta$ denote the two critical thresholds in Lemma B.7. Suppose $r_P \in \left[\tilde{R}_1, \min\left\{1, \tilde{R}_2\right\}\right]$ so that Lemma B.7 yields the interior counteroffer $\tilde{r}_L^*(r_P) = \frac{r_P}{2} + \frac{1-2(\theta+\delta)}{4}$. Substituting into $\tilde{\pi}_{P,1}$ in equation (A.6), the first-order condition with respect to r_P is

$$\frac{\partial \tilde{\pi}_{P,1}}{\partial r_P} = \frac{1 + 6\theta - 2\delta - 2r_P}{8\theta} = 0,$$

yielding $r_P^* = \frac{1+6\theta-2\delta}{2}$. The second derivative is $-\frac{1}{4\theta} < 0$, confirming a maximum. This solution satisfies $r_P^* = \tilde{R}_2$ and $r_P^* \geq \tilde{R}_1$. As in Lemma B.3, the corner solutions are dominated: for $r_P < \tilde{R}_1$, the patent holder's payoff is $r_P < \tilde{R}_1 < 1/2 + \theta - \delta$; for $r_P > \tilde{R}_2$, the payoff equals $1/2 + \theta - \delta$, which coincides with the payoff at r_P^*. The constraint $r_P^* \leq 1$ binds for $\theta \geq \frac{1+2\delta}{6}$, in which case the patent holder's equilibrium offer is equal to 1. Q.E.D.

C Proofs of Main Results

Proof of Proposition 1

Proof. Recall that for any $r_P \geq 1/2 + \theta$, the offer is never FRAND, and for any $r_L \leq 1/2 - \theta$, the counteroffer is never FRAND. For any (r_P, r_L) within these boundaries, the expected payoffs for the patent holder are $\pi_{P,1}$, the expected payoffs for the implementer are $1 - \pi_{P,1}$. Solving the game by backward induction, we first derive the implementer's best response

$r_L^*(r_P)$. The first derivative of $1-\pi_{P,1}$ with respect to the implementer's counteroffer is

$$\left.\frac{\partial\left(1-\pi_{P,1}\right)}{\partial r_L}\right|_{r_L>1/2-\theta} = -\frac{2\theta+2r_L-1}{4\theta} \quad \text{and} \quad \left.\frac{\partial\left(1-\pi_{P,1}\right)}{\partial r_L}\right|_{r_L\leq 1/2-\theta} = 0.$$

For all $r_L > 1/2-\theta$, the first derivative is strictly negative; it is equal to zero for $r_L \leq 1/2-\theta$. The optimal counteroffer, for any offer r_P, is then $r_L^* \leq 1/2-\theta$.

The patent holder anticipates this optimal counteroffer (not a function of r_P). The first derivative $\pi_{P,1}$ with respect to the offer r_P is

$$\left.\frac{\partial\pi_{P,1}}{\partial r_P}\right|_{r_P<1/2+\theta} = \frac{2\theta-2r_P+1}{4\theta} \quad \text{and} \quad \left.\frac{\partial\pi_{P,1}}{\partial r_P}\right|_{r_P\geq 1/2+\theta} = 0.$$

For all $r_P < 1/2+\theta$, the first derivative is strictly positive; it is equal to zero for $r_P \geq 1/2+\theta$. The optimal offer is then $r_P^* = 1/2+\theta$.

The implementer rejects all offers for $\theta > 0$: Accepting r_P yields $1-r_P^* = {}^{1-2\theta}/2$, while the equilibrium payoff is $1-1/2 = 1/2 > {}^{1-2\theta}/2$ for all $\theta > 0$. The patent holder rejects the counteroffer because the expected outcome of litigation (no injunction, and an expected settlement outcome of $E(1/2+\theta_i) = 1/2$) exceeds the counteroffer $r_L^* = {}^{1-2\theta}/2$ for all $\theta > 0$. Q.E.D.

Proof of Proposition 2

Proof.

1. The equilibrium offer is given by Lemma B.3; the equilibrium counteroffer is by Lemmas B.2 and B.3.
2. For low θ, the patent holder accepts the counteroffer, and the royalty rate is r_L^*. For higher values of θ, where the patent holder rejects the counteroffer, the expected royalty is the expected outcome of settlement negotiations. When the realization θ_i is sufficiently low so that the counteroffer is FRAND and the court denies an injunction, the settlement outcome is r_L^*. When the realization θ_i is sufficiently high so that the counteroffer is not FRAND and the court grants an injunction, the settlement outcome is $r_P^* = 1$. The expected settlement outcome is

$$\left.r^*\right|_{\theta\geq\frac{1}{6}} = \int_{-\theta}^{\theta_L(\tilde{r}_L^*)} \frac{\tilde{r}_L^*}{2\theta} d\theta_i + \int_{\theta_L(\tilde{r}_L^*)}^{\theta} \frac{1}{2\theta} d\theta_i. \tag{C.1}$$

Substituting $\tilde{r}_L^* = \frac{3-2\theta}{4}$ and $\theta_L(\tilde{r}_L^*) = \frac{1-2\theta}{4}$:

$$\begin{aligned} r^*\big|_{\theta \geq \frac{1}{6}} &= \frac{3-2\theta}{4} \cdot \frac{\theta + \frac{1-2\theta}{4}}{2\theta} + \frac{\theta - \frac{1-2\theta}{4}}{2\theta} \\ &= \frac{(3-2\theta)(1+2\theta)}{32\theta} + \frac{6\theta - 1}{8\theta} = \frac{28\theta - 4\theta^2 - 1}{32\theta} = \frac{7}{8} - \frac{1+4\theta^2}{32\theta}. \end{aligned}$$

3. By Lemma B.2, the implementer never accepts an offer. By Lemma B.1 and the counteroffer in the proposition, the patent holder accepts the counteroffer for $\theta < 1/6$ but rejects for higher values of θ (such that $\frac{1+2\theta}{2} > \frac{3-2\theta}{4}$). When the patent holder rejects, the case enters litigation. Because the offer $r_P^* = 1$ is never FRAND, whether the court grants an injunction depends on the counteroffer. The counteroffer r_L^* is FRAND (implying no injunction) if $\theta_i \leq \theta_L(r_L^*)$ and not FRAND (implying injunction) if $\theta_i > \theta_L(r_L^*)$.

Q.E.D.

We first establish the results for the limit case of $\theta = 0$ and a FRAND corridor of $[1/2 - \delta, 1/2 + \delta]$. In such an environment, courts assess FRAND rates without any noise or errors so that the realized midpoint of the FRAND corridor is equal to the expected value.

Proposition C.1. *Let $\theta = 0$ and $\delta > 0$. The equilibrium in both litigation frameworks is characterized as follows:*

$$r_P^* \geq \frac{1-2\delta}{2} \qquad r_L^* = \frac{1-2\delta}{2} \qquad r^* = \frac{1-2\delta}{2}.$$

The implementer rejects the patent holder's offer r_P^*, the patent holder accepts the implementer's counteroffer r_L^*.

Proof of Proposition C.1

Proof. First, recall that any counteroffer $r_L \geq \frac{1-2\delta}{2}$ is FRAND and any offer $r_P \leq \frac{1+2\delta}{2}$ is FRAND.

1. In $t = 3$, the patent holder accepts the counteroffer if $r_L \geq \min\left\{r_P, \frac{1-2\delta}{2}\right\}$. Any counteroffer $r_L \geq \frac{1-2\delta}{2}$ is FRAND. Regardless of the decision, the patent holder's payoffs are r_L. We assume that acceptance breaks the tie. Any counteroffer $r_L < \frac{1-2\delta}{2}$ is non-FRAND. If the patent holder rejects, then the payoffs depend on the litigation framework. In the symmetric framework, the patent holder's payoffs are r_P if $r_P \leq \frac{1+2\delta}{2}$ and FRAND and $1/2$ otherwise. Hence, for FRAND r_P, the patent holder accepts the counteroffer if $r_L \geq r_P$ and rejects otherwise. For non-FRAND r_P, the patent holder rejects the counteroffer if $r_L < 1/2$. Because $r_L < \frac{1-2\delta}{2}$, this

holds true. In the amended framework, litigation yields a payoff of r_P to the patent holder. The patent holder accepts if $r_L \geq r_P$ and rejects if $r_L < r_P$.

2. In $t = 2$, the implementer anticipates that the patent holder accepts any offer $r_L \geq \frac{1-2\delta}{2}$. Because any higher offer lowers the implementer's payoffs, it is optimal for the implementer to make a counteroffer $r_L \leq \frac{1-2\delta}{2}$. A counteroffer $r_L = \frac{1-2\delta}{2}$ is FRAND and yields payoffs of $1 - \frac{1-2\delta}{2}$, a counteroffer less than that yields payoffs of either $1 - r_P$ or $1 - 1/2$. Consider three cases for the initial offer:

   - $r_P > \frac{1+2\delta}{2}$ (non-FRAND). The patent holder rejects a non-FRAND r_L. In the symmetric framework, litigation yields a royalty $1/2$; in the amended framework, litigation yields a royalty of r_P. In both frameworks, the royalty is higher than the royalty from a FRAND counteroffer, and the implementer makes a FRAND counteroffer $r_L = \frac{1-2\delta}{2}$.
   - $r_P \leq \frac{1+2\delta}{2}$ but $r_P \geq \frac{1-2\delta}{2}$ (FRAND). The patent holder rejects a non-FRAND r_L. In both litigation frameworks, litigation yields a royalty r_P that is (weakly) higher than the royalty from a FRAND counteroffer, and the implementer makes a FRAND counteroffer $r_L = \frac{1-2\delta}{2}$.
   - $r_P \leq \frac{1+2\delta}{2}$ and $r_P < \frac{1-2\delta}{2}$ (FRAND). The patent holder rejects a non-FRAND counteroffer if $r_L < r_P$. Any non-FRAND counteroffer $r_L \geq r_P$ the patent holder accepts, and the royalty is r_L. Any non-FRAND counteroffer $r_L < r_P$ the patent holder rejects, and litigation in both frameworks yields a royalty r_P. The implementer will prefer any non-FRAND counteroffer $r_L \leq r_P$ over a FRAND counteroffer.

   To summarize, the counteroffer is

$$r_L = \begin{cases} \frac{1-2\delta}{2} & \text{if } r_P \geq \frac{1-2\delta}{2} \\ \{r_L : r_L \leq r_P\} & \text{if } r_P < \frac{1-2\delta}{2} \end{cases}$$

3. In $t = 1$, the patent holder anticipates the implementer's counteroffer in $t = 2$ and her own decision in $t = 3$.

   - Any non-FRAND $r_P > \frac{1+2\delta}{2}$ triggers a FRAND counteroffer $r_L = \frac{1-2\delta}{2}$, and the patent holder accepts. Payoffs are $\frac{1-2\delta}{2}$.
   - A FRAND offer $r_P \leq \frac{1+2\delta}{2}$ but $r_P \geq \frac{1-2\delta}{2}$ triggers a FRAND counteroffer $r_L = \frac{1-2\delta}{2}$, and the patent holder accepts. Payoffs are $\frac{1-2\delta}{2}$.
   - A FRAND offer $r_P < \frac{1-2\delta}{2}$ triggers a non-FRAND counteroffer. If $r_L < r_P$, the patent holder will reject, with litigation yielding payoffs of r_P; if $r_L = r_P$, the patent holder accepts, yielding payoffs of r_P.

To summarize, any $r_P \geq \frac{1-2\delta}{2}$ dominates any lower r_P. Because any $r_P \geq \frac{1-2\delta}{2}$ yields payoffs of $\frac{1-2\delta}{2}$ (independent of r_P) any such offer is optimal.

Q.E.D.

In this limit case, the implementer rejects any offer and, in return, makes a FRAND counteroffer at the lower end of the FRAND corridor. The patent holder accepts that counteroffer, implying an equilibrium royalty rate at the lower end of what courts consider FRAND. The limit case applies to both litigation frameworks. An extension of injunctions under the amended framework, therefore, has no effect on the equilibrium outcome when courts determine the underlying FRAND rate without noise ($\theta = 0$).

Proof of Proposition 3

Proof. The equilibrium offer is given by Lemma B.6; the equilibrium counteroffer follows from substituting r_P^* into Lemma B.5.

Part 1 (offers): For $\theta < \frac{2+\sqrt{2}}{4}\delta$: $r_P^* = \frac{1+6\theta-2\delta}{2}$ induces interior-A counteroffer $r_L^* = \frac{r_P^*}{2} + \frac{1-2(\theta+\delta)}{4} = \frac{1+2\theta-2\delta}{2}$. For $\theta \in [\frac{2+\sqrt{2}}{4}\delta, \frac{1+\sqrt{2}}{2}\delta]$: $r_P^* = \frac{1-2\theta+2(1+\sqrt{2})\delta}{2}$ induces interior-A counteroffer $r_L^* = \frac{1-2\theta}{2} + \frac{\delta}{\sqrt{2}}$. For $\theta > \frac{1+\sqrt{2}}{2}\delta$: $r_P^* = \frac{1+2\theta}{2}$ induces interior-B counteroffer $r_L^* = \frac{1-2\theta}{2}$.

Part 3 (accept/reject): By Lemma B.4, the patent holder accepts the counteroffer r_L^* if $r_L^* \geq \min\{r_P^*, \frac{1+2\theta-2\delta}{2}\}$. For $\theta < \frac{2+\sqrt{2}}{4}\delta$: $r_L^* = \frac{1+2\theta-2\delta}{2}$, which equals the acceptance threshold, so P accepts. For $\theta \geq \frac{2+\sqrt{2}}{4}\delta$: one can verify that $r_L^* < \frac{1+2\theta-2\delta}{2}$, so P rejects and the case enters litigation.

Part 2 (royalty): For low θ, P accepts r_L^* and the royalty is $r^* = r_L^* = \frac{1+2\theta-2\delta}{2}$. For $\theta > \frac{1+\sqrt{2}}{2}\delta$, the equilibrium offers satisfy $r_P^* - r_L^* \geq 2\delta$ (Case 1) and the expected royalty from litigation is

$$r^* = \int_{-\theta}^{\theta_L(r_L^*)} \frac{r_L^*}{2\theta}\, d\theta_i + \int_{\theta_L(r_L^*)}^{\theta_P(r_P^*)} \frac{1/2 + \theta_i}{2\theta}\, d\theta_i + \int_{\theta_P(r_P^*)}^{\theta} \frac{r_P^*}{2\theta}\, d\theta_i.$$

For the intermediate regime $\theta \in \left[\frac{2+\sqrt{2}}{4}\delta, \frac{1+\sqrt{2}}{2}\delta\right]$, the equilibrium is in Case 2 ($\theta_L(r_L^*) > \theta_P(r_P^*)$); the corresponding integral replaces the NN region with an FF region yielding r_L^*. Substituting the equilibrium offers and simplifying yields the expressions in the proposition in both cases. For $\theta > \frac{1+\sqrt{2}}{2}\delta$: $r_L^* = \frac{1-2\theta}{2}$ and $r_P^* = \frac{1+2\theta}{2}$, which are the $\delta = 0$ equilibrium strategies, yielding $r^* = 1/2$. Q.E.D.

Proof of Proposition 4

Proof. The patent holder's equilibrium offer is by Lemma B.8. We obtain the implementer's counteroffer by plugging $r_P = \tilde{r}_P^*$ into the expression for $\tilde{r}_L^*(r_P)$ in Lemma B.7.

Recall from the proof of Lemma B.8 that $\tilde{r}_P^* \geq \tilde{R}_1$ and $\tilde{r}_P^* \leq \tilde{R}_2$. For low values of θ, the second condition holds with equality. For higher values of θ and $\tilde{r}_P^* = 1$, we have $\tilde{R}_1 < \tilde{r}_P^* = 1 < \tilde{R}_2$. The counteroffer is therefore the one for the intermediate range of offers.

The royalty rate is $\tilde{r}_L^*$ when the patent holder accepts the counteroffer, that is, when $\tilde{r}_L^* \geq \min\{\tilde{r}_P^*, 1/2 + \theta - \delta\}$ by Lemma B.4. The royalty rate is the expected outcome of settlement negotiations when the patent holder rejects the counteroffer, and the case enters the litigation stage. First, note that $\tilde{r}_L^* < \tilde{r}_P^*$ for all $\theta > 0$. For low values of $\theta \leq \frac{1+2\delta}{6}$, $\tilde{r}_L^* \geq 1/2 + \theta - \delta$ and the patent holder accepts the counteroffer. For high values of $\theta > \frac{1+2\delta}{6}$ so that $\tilde{r}_P^* = 1$, we have $\tilde{r}_L^* < 1/2 + \theta - \delta$ and the patent holder rejects the counteroffer. The expected settlement offer is the expression for $\tilde{\pi}_{P,1}$ in equation (A.6) for $r_P = 1$:

$$\tilde{r}^*\Big|_{\theta > \frac{1+2\delta}{6}} = \int_{-\theta}^{\theta_L(\tilde{r}_L^*)} \frac{\tilde{r}_L^*}{2\theta} d\theta_i + \int_{\theta_L(\tilde{r}_L^*)}^{\theta} \frac{1}{2\theta} d\theta_i. \tag{C.2}$$

Substituting $\tilde{r}_L^* = \frac{3-2(\theta+\delta)}{4}$ and $\theta_L(\tilde{r}_L^*) = \frac{1-2\theta+2\delta}{4}$:

$$\begin{aligned}
\tilde{r}^*\Big|_{\theta > \frac{1+2\delta}{6}} &= \frac{3-2(\theta+\delta)}{4} \cdot \frac{\theta + \frac{1-2\theta+2\delta}{4}}{2\theta} + \frac{\theta - \frac{1-2\theta+2\delta}{4}}{2\theta} \\
&= \frac{(3-2\theta-2\delta)(1+2\theta+2\delta)}{32\theta} + \frac{6\theta-1-2\delta}{8\theta} \\
&= \frac{28\theta - 4\theta^2 - 8\theta\delta - 4\delta^2 - 4\delta - 1}{32\theta} = \frac{7}{8} - \frac{1+4\left(\delta + (\theta+\delta)^2\right)}{32\theta}.
\end{aligned}$$

Q.E.D.

Proof of Corollary 1

Proof. For $\theta \leq \frac{2+\sqrt{2}}{4}\delta$, Propositions 3 and 4 yield $r^* = \tilde{r}^* = \frac{1+2\theta-2\delta}{2}$. For $\theta > \frac{2+\sqrt{2}}{4}\delta$, the *Huawei v. ZTE* royalty transitions to the intermediate and then the high-θ regimes while the amended royalty continues to increase. In the high-θ regime of the symmetric framework, $r^* = 1/2$, while the amended royalty $\tilde{r}^* > 1/2$ for $\theta > \delta$. For the intermediate regime, direct comparison of the expressions in Propositions 3 and 4 confirms $\tilde{r}^* > r^*$. Q.E.D.

Proof of Proposition 5

Proof.

- For the symmetric framework, the patent holder accepts the counteroffer r_L^* for all $\theta < \frac{2+\sqrt{2}}{4}\delta$, implying an injunction rate of zero. For higher values of θ, the patent holder rejects the counteroffer. In that case, the court grants an injunction if the patent holder's offer is FRAND (for $r_P^* < \overline{r}(\theta_i) = 1/2 + \theta_i + \delta$) and the counteroffer is non-FRAND (for $r_L^* < \underline{r}(\theta_i) = 1/2 + \theta_i - \delta$), that is, if the following two conditions hold:

$$\theta_i > r_P^* - 1/2 - \delta \qquad \text{and} \qquad \theta_i > r_L^* - 1/2 + \delta.$$

Both conditions hold if

$$\theta_i > \max\left\{r_P^* - 1/2 - \delta, r_L^* - 1/2 + \delta\right\}.$$

For intermediate values of θ, the court grants an injunction if $\theta_i > \frac{2+\sqrt{2}}{2}\delta - \theta$; for high values of θ, the court grants an injunction if $\theta_i > \max\left\{\delta - \theta, -(\delta - \theta)\right\}$. Collecting terms, the probability of an injunction in the symmetric framework is then as claimed in the proposition.

– For the amended framework, the patent holder accepts the counteroffer $\tilde{r}_L^*$ for all $\theta < \frac{1+2\delta}{6}$, implying an injunction rate of zero. For higher values of θ, the patent holder rejects the counteroffer. For such values of θ, the patent holder's offer is never FRAND, and the court will grant an injunction if the counteroffer is below the respective lower bound of the realized FRAND corridor, $\underline{r}(\theta_i)$. The equilibrium counteroffer is not FRAND, and the court grants an injunction if $\tilde{r}_L^* < \underline{r}(\theta_i)$ or

$$\theta_i > \frac{1 - 2\theta + 2\delta}{4} = \theta_L(\tilde{r}_L^*).$$

This critical threshold is larger than $-\theta$ and less than θ as long as $\theta > \frac{1+2\delta}{6}$. The probability of an injunction is then as claimed in the proposition. Q.E.D.

Proof of Corollary 2

Proof. For $\theta > \frac{1+\sqrt{2}}{2}\delta$ (high court noise), the *Huawei v. ZTE* injunction rate is $I^* = \frac{\delta}{2\theta}$ and the amended rate is $\tilde{I}^* = 1 - \frac{1+2\theta+2\delta}{8\theta}$. Setting $I^* = \tilde{I}^*$ yields $\theta = \frac{1+6\delta}{6}$. For θ below this crossover, $I^* > \tilde{I}^*$; for θ above it, $\tilde{I}^* > I^*$. For lower values of θ where only one or neither framework has positive injunction rates, the ordering is verified by direct comparison of the expressions in Proposition 5. Q.E.D.

Proof of Proposition 6

Proof. We first record two facts about the equilibrium royalties from Propositions 3 and 4. The symmetric royalty never exceeds the FRAND midpoint: It equals $1/2 + \theta - \delta \leq 1/2$ in the low-θ regime, decreases toward $1/2$ in the intermediate regime, and equals $1/2$ in the high-θ regime, so $r^* \leq 1/2$ for all θ. The amended royalty exceeds the FRAND corridor, $\tilde{r}^* > 1/2 + \delta$, for $\theta > 2\delta$ when δ is small: In the low-θ regime $\tilde{r}^* = 1/2 + \theta - \delta$ exceeds $1/2 + \delta$ if and only if $\theta > 2\delta$, and for $\delta < 1/10$ this threshold lies within that regime ($2\delta < \frac{1+2\delta}{6}$), with the royalty increasing thereafter.

Below the equivalence threshold, $r^* = \tilde{r}^*$ by Corollary 1, so the welfare comparison is trivially identical. Above it, $\tilde{r}^* > r^*$ by the same corollary. The amended framework welfare-dominates iff $|\tilde{r}^* - r^o| < |r^* - r^o|$. Since $\tilde{r}^* > r^*$, this holds iff $r^o > (\tilde{r}^* + r^*)/2$: When r^o exceeds the midpoint of the two royalties, the higher amended royalty is closer to the optimum. Q.E.D.

Proof of Corollary 3

Proof. **Part (i).** Set $r^o = 1/2$. Since $r^* \leq 1/2$ (Proposition 3), $|r^* - 1/2| = 1/2 - r^*$. In the amended framework's low-θ regime, $\tilde{r}^* = 1/2 + \theta - \delta$. For $\theta < \delta$, $\tilde{r}^* < 1/2$; since $r^* < \tilde{r}^* \leq 1/2$, the amended royalty is closer to $1/2$ and the amended framework welfare-dominates. Setting $|\tilde{r}^* - 1/2| = |r^* - 1/2|$ yields the crossover $\theta^\dagger = \frac{4+3\sqrt{2}}{8}\delta$. For $\theta > \theta^\dagger$, $\tilde{r}^*$ overshoots $1/2$ by more than r^* undershoots, and the symmetric framework welfare-dominates. The dominance is strict for $\theta > \frac{1+\sqrt{2}}{2}\delta$, where $r^* = 1/2$ exactly while $\tilde{r}^* > 1/2$.
Part (ii). The crossover is defined by $r^o = (\tilde{r}^*(\theta^\dagger) + r^*(\theta^\dagger))/2$. Since $\tilde{r}^*$ is increasing in θ and r^* is weakly decreasing toward $1/2$, the midpoint $(\tilde{r}^* + r^*)/2$ is increasing in θ above the equivalence threshold. Hence $\theta^\dagger$ is increasing in r^o: A higher social optimum shifts the crossover rightward, expanding the region of amended-framework dominance. When $r^o \geq \max_\theta(\tilde{r}^*(\theta) + r^*(\theta))/2$, the crossover exceeds the support, and the amended framework dominates uniformly. Conversely, when r^o is below $(\tilde{r}^* + r^*)/2$ evaluated at the equivalence threshold, the symmetric framework dominates for all θ. Q.E.D.

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