ARE JOINT NEGOTIATIONS IN STANDARD SETTING “REASONABLY NECESSARY”?

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Abstract

The quote in the title refers to a recurring principle in the Antitrust Guidelines for the Licensing of Intellectual Property, issued jointly by the US Department of Justice and the Federal Trade Commission in 1995. That report states that “The Agencies” general approach in analyzing a licensing restraint under the rule of reason is to inquire whether the restraint is likely to have anticompetitive effects and, if so, whether the restraint is reasonably necessary to achieve procompetitive benefits that outweigh those anticompetitive effects.” We apply this standard of evaluation to recent proposals for joint licensing negotiations in standard setting contexts, which have been offered as a solution to the problem of opportunistic licensing and patent hold up. We find that, to the contrary, joint negotiations are not “reasonably necessary” to prevent hold up. Instead, other more moderate policy solutions that take advantage of existing institutional features within standard setting bodies have a greater likelihood of preventing hold up without running the risk of anticompetitive licensee collusion that is present with joint negotiations. In particular, we posit that standard setting bodies should set voting rules to obtain majority support in the selection of technologies for a standard and should consider means of encouraging ex ante bilateral negotiations. In addition, competition authorities could focus on the enforcement of non-discriminatory licensing as a means of preventing anticompetitive opportunistic hold up.

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1. Introduction

In antitrust circles, a great deal of attention has been focused of late on the problem of opportunistic patent licensing within standard setting. So, for instance, the US Federal Trade Commission’s concern in Unocal was that Unocal Corporation had illegally obtained monopoly power by failing to inform relevant parties that it held patents over the reformulated gasoline that the California Air Resources Board (CARB) was adopting in regulation. Absent that deception, the FTC argued, CARB would never have enacted the reformulated gasoline regulatory standard that required Unocal’s patents. Similar concerns are behind the more recent cases involving Rambus, which also entail allegations of anticompetitive deception through a failure to disclose patents, this time to JEDEC, the cooperative standard setting organization (SSO) developing computer DRAM standards.

Non-disclosure, while the most prevalent charge in the handful of standard setting antitrust cases filed thus far, is not the only source of concern over opportunistic licensing. A second tranche of cases has involved allegations of “unreasonable” licensing terms. So, for example, Broadcom has alleged that Qualcomm obtained monopoly power by promising to ETSI (the European Telecommunications Standards Institute) that it would license its patents relevant for the 3G mobile telecom standard on Fair, Reasonable, and Non-Discriminatory (FRAND) terms—a commitment that Broadcom claims Qualcomm made in bad faith and has since reneged on. Taking the FRAND promise even farther, the FTC recently settled a complaint against Negotiated Data Solutions for licensing its patents on terms that did not match the original terms disclosed to the IEEE (the Institute of Electrical and Electronics Engineers) for their Ethernet standard. The FTC grounded its complaint in the same sort of deception-as-an-antitrust-

2 Multiple cases are at issue here. See, Rambus, Inc., Docket No. 9302 (F.T.C. Aug. 2, 2006) (opinion of the commission), available at http://www.ftc.gov/os/adpro/d9302/index.shtm. The US Court of Appeals for the DC Circuit ruled in April 2008 that the Commission’s orders be “set aside”, remanding the case for further proceedings that are “consistent” with the DC Circuit opinion; see, Rambus Inc. v. Federal Trade Commission, No. 07-1124 (D.D.C. App. Ct. 2008). Private suits were also brought against Rambus by JEDEC members, but Rambus has won a significant victory here as well, with the District Court of San Jose ruling that the firm did not behave anticompetitively; see Consolidated Rambus Litigation, Hynix Semiconductor Inc., Nanya Tech. Inc. & Micron Tech. Inc. v. Rambus Inc., Case Nos. C-00-20905-RMW, C-05-00334-RMW & C-06-00244-RMW (N.D. Cal. March 26, 2008) (special verdict form).
4 In the Matter of Negotiated Data Solutions LLC, Docket No. 051-0094 (F.T.C. January 23, 2008)
violation logic as developed in *Unocal* and *Rambus*, despite the fact that in the Negotiated Data case the patents were fully disclosed before the standard was finalized, the original licensing terms were disclosed eight years before Negotiated Data attempted to alter the terms, and the original licensing terms were offered by a separate entity from whom Negotiated Data later obtained the patents.\(^5\)

At the bottom of the previous disputes is the idea of opportunistic licensing. That is, the idea that patent holders for the specific technologies that are included in the standard are in the position to exploit the cost of switching to a different technological solution after a standard is defined. Thus the costs involved in defining a new standard, around different technologies, or the costs of shifting investments for implementing one technology as opposed to another can be held hostage, enabling patent holders to charge more than the value of their patented technologies.

In light of these antitrust concerns, the policy oriented literature has proposed remedies for eliminating opportunistic licensing in standard setting contexts. One particular proposal put forth by Daniel Swanson and William Baumol has captured considerable attention.\(^6\) Their proposal consists of giving a patent holding innovator a reward for his patented technology equivalent to what he could have obtained through an ex ante auction of a license for the downstream implementation of his invention. In other words, the licensing terms would be defined by the most that the patent could have commanded while the standard was still under development, before the specific technologies have been settled upon. Moving licensing discussions ex ante, before the technology path for the standard is frozen, offers a means of capturing competition over technologies and thereby reducing the risk of patent hold up and “non-FRAND” licensing. The auction approach would compensate an innovator for his contribution to an SSO over what the next best alternative technology could generate. Thus, the patent holder would receive the value of the incremental improvement that his patent offered to the standard compared to the closest rival.

While ex ante negotiation appears to have gained broad support, an important question

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remains: how best to put such negotiations into practice. One option is an ex ante auction, the approach described by Swanson and Baumol. The auction concept has already been used as a reference point in an antitrust case, namely in the FTC Rambus matter. However, there is no guarantee that the terms set by an ex ante auction would ensure optimal investment in innovation and properly balance the needs of both licensors and licensees. Equally important, actually implementing an ex ante auction within an SSO presents a number of practical challenges that likely rule out this method for anything other than ex post thought experiments.

Another proposal for instituting ex ante licensing is to allow SSO members to jointly negotiate licensing terms with patent holders prior to settling a standard. While joint negotiations of prices are typically shunned for antitrust reasons, Robert Skitol argues that “buying collaborations [within standard setting] … warrant more permissive rule of reason treatment because they entail integration efficiencies, can protect against anticompetitive uses of seller market power, reduce costs for downstream consumers, and can thus be procompetitive in their net impact.” Ex ante joint negotiations garnered further support in early 2007 when a cooperative US Department of Justice–Federal Trade Commission report suggested that such “buyer collaborations” would indeed be viewed under a rule of reason by the agencies. The report concluded that in the context of standard setting organizations, joint negotiations should not be deemed as per se illegal because of the potential for procompetitive effects. In particular, the agencies wrote that

In most cases, it is likely that the Agencies would find that joint ex ante activity undertaken by an SSO or its members to establish licensing terms as part of the standard-setting process is likely to confer substantial procompetitive benefits by avoiding hold up that could occur after a standard is set, and this would be an important element of a rule of reason analysis. Ex ante licensing discussions may lead to price competition, in effect allowing for broader competition among alternative

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10 Id. at 728.
technologies vying for inclusion in the standard.\textsuperscript{12}

A third option for putting the ex ante concept into practice—one not yet discussed to any extent in the literature—is for SSOs to encourage bilateral licensing negotiations ex ante. This alternative would simply take the current process of confidential licensor-licensee negotiations and shift it forward in time, to a point before a standard’s technology path is frozen and technological alternatives might still exist and compete with one another.

In this article, we consider whether either ex ante joint negotiations or ex ante bilateral negotiations offers a viable route to achieving the competitive ideal. Taking the Swanson-Baumol proposal to define the benchmark for a reasonable royalty as the ex ante incremental contribution over the next best alternative (i.e., the amount obtainable in their hypothetical ex ante auction), we evaluate the two ex ante negotiation approaches by assessing the extent to which they could be expected to lead to outcomes that diverge from this benchmark. The Antitrust Guidelines for the Licensing of Intellectual Property, issued jointly by the DOJ and the FTC in 1995, observes that “The Agencies’ general approach in analyzing a licensing restraint under the rule of reason is to inquire whether the restraint is likely to have anticompetitive effects and, if so, whether the restraint is reasonably necessary to achieve procompetitive benefits that outweigh those anticompetitive effects.”\textsuperscript{13} The question of “reasonably necessary” forms the basis of our evaluation: are joint negotiations reasonably necessary to preclude the risks of patent hold up within standard setting?

We begin in Section 2 with some key definitions. First, we clarify patent hold up. Second, we provide a brief summary of the Swanson-Baumol proposal, describing their ex ante benchmark for reasonable royalties. Section 3 then explores joint negotiations, considering when such an approach could be expected to achieve the ex ante benchmark and when it could be expected instead to have anticompetitive effects. Next we consider ex ante bilateral negotiations in Section 4, making the same comparison to the reasonable benchmark and considering the potential for anticompetitive effects. We offer conclusions and policy implications in Section 5.

We find that while each ex ante approach has its shortcomings, bilateral negotiations are more likely to meet the pro-competitive objectives envisioned in the ex ante licensing proposals.

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\item \textsuperscript{12} Id. at 52.
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In particular, as recognized in the DOJ-FTC 2007 report, joint ex ante negotiation might entice collusion in final markets: “multilateral licensing negotiations certainly may offer an opportunity for SSO members to reach naked price-fixing agreements that lack plausible and cognizable justifications.”¹⁴ Moreover, joint ex ante negotiations might deny technology owners a fair return to innovation in cases where ex ante no viable alternatives exist, so that the adoption of the standard does not imply any increase in market power. As the DOJ-FTC 2007 report observed,

…such [joint] negotiations might be unreasonable if there were no viable alternatives to a particular patented technology that is incorporated into the standard, the IP holder’s market power was not enhanced by the standard, and all potential licensees refuse to license that particular patented technology except on agreed-upon licensing terms. In such circumstances, the ex ante negotiation among potential licensees does not preserve competition among technologies that existed during the development of the standard but may instead simply eliminate competition among the potential licensees for the patented technology.¹⁵

Bilateral ex ante negotiations can pose problems of their own, in either direction. Under certain circumstances (which we explain below) bilateral licensing can enable a patent holder to charge royalties in excess of the reasonable benchmark, even when determined ex ante. Under certain other circumstances, bilateral licensing can result in the same kind of under-compensation for patent holders as joint negotiations do. Nonetheless, we find that both these circumstances are less likely to be seen in practice than the circumstances in which joint negotiations pose the risk of falling below the reasonable benchmark.

While neither bilateral nor joint ex ante negotiations are perfect, ex ante bilateral negotiations emerge as the approach most likely to appropriately balance the needs of both patent holders and licensees. On the one hand, technology owners should be sufficiently rewarded to provide adequate incentives to undertake risky investments in research and development. On the other hand, excessive licensing rewards generate costs similar to those incurred under ex post hold up and can therefore give rise to higher consumer prices. The balance must be just right to satisfy both parties’ needs, maintaining investments in R&D but still resulting in moderate prices in the downstream market. The rate achieving that balance is the “first best” royalty rate, in the language of economics. Bilateral negotiations can fail to reach the first best rate by leading to excessive rewards to innovators under some circumstances or by under-rewarding innovators in other circumstances. Joint negotiations, however, would

¹⁴ DOJ-FTC 2007, supra note 11, at 51.
¹⁵ DOJ-FTC 2007, supra note 11, at 53.
systematically lead to inefficiently low rewards, below the first best. We show that the potential for excessive rewards in the case of ex ante bilateral negotiations is reduced or even eliminated altogether once we account for some factors that are common in the cooperative standardization.

We conclude that, rather than imposing price regulations through royalty caps or risking a buyer cartel through the implementation of joint negotiation procedures, more moderate policy options are preferable. First, SSOs can consider how technologies are selected for inclusion in their standards. Majority requirements for a technology to be included in a standard can provide greater leverage for licensees in ex ante bilateral negotiations and thus can lower the odds of patent hold up. Second, SSOs can consider policies that would encourage bilateral ex ante negotiations as a means of pushing licensing earlier in the standardization process, when competition among technologies can act to hold royalty rates down. Third, antitrust authorities can consider means of enforcing the non-discrimination element of the FRAND commitment made to SSOs. While defining what is and what is not discriminatory pricing in the context of differentiated licensees will not be easy, it seems far more tractable than defining what is and what is not fair or reasonable.\footnote{The many ambiguities of the FRAND promise are discussed in Anne Layne-Farrar, A. Jorge Padilla, & Richard Schmalensee, \textit{Pricing Patents For Licensing in Standard Setting Organizations: Making Sense of FRAND Commitments}, 74 \textit{Antitrust L. J.} 671 (2007).} The fair and reasonable assessment requires a but-for benchmark that will be difficult to estimate while the non-discriminatory assessment simply entails a comparison of existing licensing terms against one another.

2. Key Definitions: Hold up and Reasonable Royalties

Before we turn to a reasonable ex ante benchmark or an assessment of joint negotiations against that benchmark, let us define the hold up problem more precisely. Hold up typically occurs when two parties contract on the provision of a good and one of the parties (usually the buyer) needs to make a specific investment ex ante before the price is negotiated. If the other party has most of the bargaining power ex post it may choose a price that does not reward the sunk investment and thus would have destroyed the incentives to invest in the first place, had the price been known ex ante.

 Consider a simple scenario in which just one firm comprises an SSO. Within this SSO, two technologies are vying for inclusion in the standard. Suppose that no licensing occurs during the
development phase, but rather occurs only after the SSO members have voted on which technology to include in the standard. Whereas one technology is publicly available, the superior one is controlled by a patent holder. The patent holder does not compete in the downstream market with the prospective licensee. The patented technology offers better cost-savings and implies production costs of \( c_1 \) for the firm implementing the standard. The other technology is freely available in the public domain but implies higher production costs, \( c_0 > c_1 \). The incremental contribution of the patented technology to the standard is therefore the production cost savings over the public technology, \( c_0 - c_1 \). The licensee, therefore, will value the patented technology at \( v_1 = c_0 - c_1 > 0 \) per unit of production. Since the alternative public technology is freely available, it forms the baseline and it is valued at \( v_0 = 0 \). The licensee charges an exogenous price \( p \) in the marketplace, so that if technology 1 is chosen, we have \( p = c_1 + m_1 \) with \( m_1 \) representing the implementers’ markup, as opposed to a markup \( m_0 = p - c_0 \) if the publicly available technology is chosen.

If licensing negotiations take place ex post, the patent holder can exploit the switching costs of moving to a different standard after the technology is selected.\(^\text{17}\) We can illustrate patent hold up in a number of ways. For example, if the patent holder holds all of the bargaining power, it might set the royalty rate so as to appropriate the licensee’s markup above production costs, in addition to the value the patent contributes to the standard. In this case the hold up royalty rate \( r' \) would be set as \( r' = v_1 + (m_1 - c) \), so that the licensee’s profits would be zero. Another way to think of hold up is in terms of a switching cost \( s \) that the licensee might face to move from the standard based on technology \( v_1 \) back to one of the rival technologies that competed with \( v_1 \) prior to the vote. In this case, the hold up royalty rate would be set as \( r' = v_1 + s \). However we arrive at the hold up rate, the key point is that it would exceed the value that the patented technology contributed to the standard, \( r' > r \leq v_1 \). It is important to emphasize, though, that if the licensee expects a rate \( r' > v_1 \), it will choose not to accept the technology into the standard; there must be some element of deception or surprise for hold up to work.

Had the two firms established licensing terms ex ante, when the holder of patent \( v_1 \) faced competition, the negotiated royalty rate would have been at most \( r = v_1 \). That is, the patent

\(^{17}\) Note that hold up is not automatic even when negotiations occur ex post. There are other reasons the patent holder would choose not to charge the hold up royalty, including repeat-play reputation effects or the desire to maximize the downstream market to maximize royalty earnings as opposed to maximizing the royalty rate.
holder could have charged no more than the value it brought to the standard or the licensee would have chosen to license a competing technology. In fact, since the royalty rate emerges from a negotiation process, it will depend on the relative bargaining strength of the patent holder as compared to the licensee. Set the patent holder’s bargaining power at $\beta$ (and the licensee’s power to $1 - \beta$), where $0 \leq \beta \leq 1$. With ex ante negotiations, when the patent holder faces competition, the royalty rate would be $r = \beta v_1$, with the special case of $r = v_1$ when the patent holder has all of the bargaining power (i.e., $\beta = 1$). Under this framework, licensee profits would be $\pi = p - (c_1 + \beta v_1)$, which would equal $\pi = m_1 - \beta v_1$ after substituting for $p = c_1 + m_1$. That is, the licensee’s profits are equal to its markup less the licensing fee.

With this more precise understanding of patent hold up in mind, turn next to the benchmark rate that Swanson and Baumol propose. In order to define a reasonable royalty, Swanson and Baumol present a very simple model of patent licensing within an SSO similar to that developed above. They envision an auction where a single potential licensee bids a royalty that it is willing to pay to be the only user of the technology. The incremental contribution of the patented technology to the standard is again the production cost savings over the public technology, $c_0 - c_1$. The licensee therefore values the patented technology at $v_1 = c_0 - c_1 > 0$ per unit of production. For the reasons discussed earlier, this hypothetical ex ante auction will never yield a royalty rate higher than $v_1$, since the licensee would otherwise face a licensing cost in excess of the production cost savings from using the technology. Paying such a royalty would not make business sense, and so the licensee would instead opt for the free public technology. In this latter case, the patented technology would not be chosen for the standard and the patent holder would receive no royalty earnings at all.

The royalty rate $r = v_1$ is the ex ante reasonable benchmark proposed by Swanson and Baumol, and it has a number of desirable properties. It is equal to the incremental value of the best technology option as compared to the next best alternative. The closer the available alternatives, the smaller is $v_1$; the greater the incremental contribution of the best option (i.e., the more pioneering the technology is), the higher is $v_1$. This royalty therefore captures the competition between the available technologies vying for inclusion in the standard. It rewards better innovations with higher earnings and penalizes me-too technologies with lower (or even zero) earnings. As such, $r = v_1$ presents a yardstick against which to gauge the reasonableness of other royalty rates.
It is important to point out, though, that the Swanson-Baumol ex auction benchmark makes implicit assumption about bargaining power, namely that $\beta = 1$. In other words, the outcome of an ex-ante negotiation would coincide with this benchmark only if the patent holder has all of the bargaining power within the negotiation and can thus extract the full value of its incremental contribution to the standard.

Note that the benchmark rate $r = v_1$, may not match the first best royalty rate described in the introduction—the rate which perfectly balances the need for incentives to innovate against the need to offer products implementing the innovation to consumers at reasonable prices. For example, if spillovers in innovation exist, the social optimum would call for more firms investing in R&D than would naturally occur. As a result larger rewards (i.e. larger royalties) would be necessary to lure entry into innovation efforts. Moreover, if ex ante competition between technologies is particularly fierce, $v_1$ could equal zero, which surely would not represent the value of the chosen technology, even if it did capture the incremental value of the chosen technology over the next best alternative. As a result, the $r = v_1$ ex ante benchmark can fall below the first best royalty. The two rates may be equal in many cases, but in some circumstances the ex ante benchmark may be too low to offer adequate incentives to innovate.\(^{18}\) Nevertheless, the incremental value benchmark $r = v_1$ offers a reasonable rate for analysis—especially considering that no one really knows what the first best rate is or how to even approximate it.\(^{19}\)

In the remainder of the paper, we discuss circumstances in which hold up can occur within an SSO and how different kinds of ex ante negotiations stack up in relation to the Swanson-Baumol benchmark. When we move away from the overly simplistic hypothetical auction setting, with its one licensee and single patent holder, we must recognize that any technology owner that wants his invention included in a standard must gather support from a sufficient number of SSO members in order to win the SSO vote. The rules governing these votes matter, as we show below. Competition among licensees helps to reward the patent holder properly—similar to competition among technologies keeping royalty rates reasonable—while too little competition among licensees systematically yields an under-reward for the patent holder.

\(^{18}\) Of course when bargaining power is split so that $\beta < 1$, then the royalty rate resulting from an ex ante negotiation will be even lower.

3. Joint Ex Ante Negotiations

We begin our evaluation by discussing how royalty rates would be determined when all buyers negotiate together ex ante with the patent holder. We consider, therefore, a case of full coordination among buyers in the pursuit of their best licensing deal. We continue our discussion in the context of the stylized model presented in Section 2 and we illustrate it using a very simple example. Assume that there are three potential licensees—firms A, B and C—that do not compete downstream and that each one sells only one unit of the good. Because the patent holder has a technology superior to what is publicly available, the parties have incentives to negotiate a licensing deal. If negotiations fail, the public technology is chosen for the standard, the patent holder earns zero profits, licensees A, B and C use the public technology at royalty $v_0 = 0$, and obtain a production cost of $c_0$. If the three firms reach agreement with the patent holder, however, then the incremental aggregate benefits (in relation to the next best alternative) equal $3v_1 = 3(c_0 - c_1)$. The royalty rate is used to split this surplus between the patent holder and the three licensees, so with royalty rate $r$ the patent holder obtains profits of $3r$ while each licensee enjoys a net return of $v_1 - r$.

How, then, is the surplus actually split? What is the royalty rate $r$ under joint negotiations? We assume that the patent holder’s bargaining power is $0 \leq \beta \leq 1$. The licensees, then, have bargaining power $1 - \beta$ as a group. For simplicity, assume the three licensees split their portion of the aggregate surplus equally amongst themselves. The royalty rate is therefore set at $r = \beta v_1$. Profits from the licensing deal are $3\beta v_1$ for the patent holder and $(1- \beta)v_1$ for each of the licensees.

Bargaining power can hinge on any number of factors, including firm size (market share), outside options, risk preferences (which influence threat points), and even individual negotiation skills. If $\beta = 0$, the patent holder has no bargaining power at all and obtains profits of 0. If $\beta = 1$ the patent holder can appropriate the entire license surplus (the incremental value), which is

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20 We make this simplifying assumption for expositional reasons as it results in straightforward and easy to follow equations. Our conclusions do not hinge on it.

21 Although economists often distinguish bargaining power per-se and the effects of other elements such as outside options, for the purpose of this paper it is enough to observe that they operate by shifting the surplus from the negotiation in the same direction. Abhinay Muthoo, Bargaining Theory with Applications (1999), for a general treatment of the Nash Bargaining solution and a discussion of applications that endogenize bargaining power. For a more general discussion of bargaining power in the context of banking, see Hirofumi Uchida, Empirical Determinants of Bargaining Power (2006) (Working Paper), available at http://ssrn.com/abstract=954534.
equivalent to the reasonable royalty benchmark defined in the previous section. It is therefore apparent that the reasonable ex ante benchmark \( r = v_1 \) forms the upper bound of the possible royalty rates under joint negotiations, and is in fact only achievable in the unlikely event the patent holder has all of the bargaining power and the group of licensees has none, even though they are negotiating jointly.

The general conclusion we draw from this analysis is that with joint ex ante negotiations the patent holder will in general be under-rewarded. This follows because joint ex ante negotiations are the de facto equivalent to the example discussed in the previous section where there was a unique licensee and all bargaining power resided with the patent holder. But the case where \( \beta = 1 \) is likely to be rare under joint ex ante negotiations. When there are no uses for the patented technology outside of the standard, the patent holder’s options are limited to earning zero or taking whatever the group of licensees will offer. When the group of licensees can credibly threaten to boycott the patented technology in favor of the public technology, we can expect \( \beta \) to be close or equal to zero.\(^\text{22}\) Thus, only in the rare case where the patent holder has a strong bargaining position, such as when it can threaten to leave the SSO altogether, will \( \beta \) equal 1. Typically, then, \( \beta \) will lie below one with joint negotiations. We conclude, therefore, that only under very narrow circumstances will the ex ante reasonable benchmark \( r = v_1 \) be reached under joint negotiations. More commonly, joint negotiations will under-compensate patent holders.

### 4. Bilateral Ex Ante Negotiations

Joint negotiations are, of course, not the only means by which to capture ex ante competition. Another alternative that has been largely ignored in the academic debate over patent hold up is bilateral ex ante negotiations. This approach would be closer to the current practice of two-way confidential negotiations, except the negotiations would take place ex ante, prior to the standard’s technology choices. We discuss next the possible outcomes of ex ante bilateral negotiations under different scenarios: (a) when unanimity within the SSO is required before a technology is selected, (b) when unanimity is not required but some members are pivotal, (c) when negotiations take place under non-discriminatory commitments and, finally, (d) when no SSO member is pivotal and discriminatory licensing is possible.

\(^{22}\) As we show below, the credibility of threats made within an SSO depend crucially on the SSO’s policies, including the voting rules and any FRAND requirement.
4.1 Full Consensus

In general, defining a cooperative standard is a consensus building process. As our first scenario, then, consider an SSO that has a unanimity rule: all SSO members must agree before any technology is included in the standard. In this case, each member has one vote and all votes are equal. Any technology owner that wants an invention to be included in the standard must gather support from all of the other SSO members in order to win the vote. In the context of our simple model, the three implementers A, B, and C constitute the other SSO members, each with an equal vote, and all three must support the patented technology for it to be included in the standard.

Once the patent holder’s technology has the support of the members, the actual license can be negotiated either ex ante or ex post. In this scenario, ex ante licensing negotiations—and possibly the favorable terms that they might entail for those who sign early—are a useful lure to convince firms to support the technology during the standard vote. The downstream implementers anticipate that if they do not reach an agreement with the patent holder ex ante for a technology that is eventually included in the standard, they will need to reach an agreement ex post, when the bargaining position of the technology owner could be greatly improved. The potential licensees therefore have strong incentives to seek out early licenses for technologies they intend to support (or not oppose) for inclusion in the final standard.

What does the final license look like? For discussion purposes assume that the patent holder meets with the three firms in sequence. Prospective licensees decide to support a technology depending on their expectations of whether other potential licensees will reach an agreement or not and, if so, the ensuing royalty rate outcome. Because firms A and B will anticipate the outcome of the negotiation with firm C, we start with this last negotiation. Two outcomes are possible before the patent holder engages in negotiations with firm C:

1. The patent holder has not obtained support from firm A, firm B, or both. In that case, the negotiation with C is irrelevant as the technology will not be accepted by the SSO

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24 If negotiation costs are low, potential licensees have incentives to license all potentially included technologies and structure those licenses such that no payments are due unless the technology is in fact included in the standard.
25 Note that we are not assuming strict sequentiality here. Licensing negotiations can start, stop, and resume. We simply look at the negotiations in order for expository reasons. Below we explain how strictly sequential negotiations can be used to enhance a patent holder’s bargaining position.
because a full consensus is required.

2. The patent holder has obtained support from both firms A and B. In that case, firm C is pivotal in the decision because the alternative technology will be implemented if C rejects the offer, whereas if C accepts the offer then the patented technology will be chosen by the SSO. Given that the private benefit to firm C of accepting is $v_1$, firm C will accept the patent holder’s offer only if the royalty rate is less than or equal to the benefit: $r_C \leq v_1$. In this case it is licensee C that can practice a form of hold up: unless the patent holder shares a portion of the incremental value of the patent’s contribution to the standard, firm C will not support the patent for inclusion. Thus, $r_C =\beta v_1 \leq v_1$.

With firm C’s acceptance point determined, we can now turn to the negotiation between the patent holder and firm B. Both parties anticipate the outcome of the future negotiation with firm C. They both know that the patent holder will always offer a license that is acceptable for firm C in order to get the patented technology accepted in the standard. As a result, two possibilities are relevant, depending on whether firm A has already accepted or not.

1. If firm A has not accepted the offer from the patent holder, negotiations with firm B are irrelevant as the patented technology cannot gain the necessary consensus.

2. If firm A has accepted the offer of the patent holder, firm B knows that it is now pivotal in the negotiation. Analogous to firm C’s decision, firm B will only accept the license if the royalty is set as $r_B = \beta v_1 \leq v_1$.

With the other two licensees determined, we now turn to the negotiation between firm A and the patent holder. Similar to the above reasoning, firm A will accept any licensing agreement such that $r_A = \beta v_1 \leq v_1$.

With full consensus voting, ex ante licensing terms fall below the reasonable benchmark due to licensee’s bargaining power. Any higher rate and the licensees within the SSO will not support the technology and it will not be included in the standard. In other words, all SSO members are “pivotal” in that the patent holder must have the support of each and every member in order to earn any licensing fees at all. Just as with joint negotiations, consensus rules make all players pivotal so that the patent holder must accept a royalty rate less than the ex ante benchmark. However, in as much as joint ex ante negotiations entail a risk of downstream collusion among licensees individual negotiations in consensus SSOs will be
deemed a superior mechanism from a social welfare standpoint.

4.2 Pivotal Licensees

The discussion thus far highlights a crucial element in the hold up equation: the presence of pivotal players. Under the ex post hold up scenario it is the patent holder who is pivotal: the patent holder has a superior technology and can credibly threaten to withhold the patent if the licensee does not share its revenues above and beyond the value of the patent. Under ex ante joint negotiations, it is the licensees as a group that are pivotal: the group can credibly threaten to support an inferior alternative technology for the standard so that the patent holder’s only choice is to accept less than the incremental value of its patent. Likewise, under full consensus rules each licensee can make itself pivotal, so that again the patent holder must choose between no revenues at all or royalty earnings that may compensate it less than the full value of its patented technology.

We do not, however, need joint negotiations or a full consensus in order to have pivotal licensees. While consensus building is always important within SSOs, they do not all require 100% support for a technology to be included in a standard. Just how much support is required depends on the SSO’s voting rules and on the voting power of the particular patent holder. For instance, some SSOs apportion votes based on revenue categories.26 Without unanimity, a technology owner needs the support of either the necessary threshold proportion of SSO members or at a minimum the most powerful SSO members for its patented invention to be included in the standard. This is a particularly important point to understand, as the vast majority of SSOs are comprised of far more technology users than technology suppliers. That is, patent holders are commonly in the minority and must gain support from at least some potential licensees for their patented technology to be considered in standard development.

When an SSO apportions votes according to sales, certain firms will be pivotal simply by virtue of their relatively large voting rights. Similarly, when an SSO has majority vote rules, some firms will become pivotal as the patent holder needs their support to be included in the standard. These pivotal firms will have enhanced bargaining power because they can block the patented technology’s acceptance into the standard. As a result, the pivotal licensees will never accept licensing terms above the ex ante benchmark \( r = v_1 \). Instead, as explained earlier, the ex ante

royalty rate for any pivotal player will be \( r_b = \beta v_1 \).

### 4.3 Non-Discrimination Commitments

If pivotal players always pay, at most, the benchmark ex ante rate and in fact tend to pay rates less than that due to their relative bargaining power, what happens to the non-pivotal licensees? Without joint negotiations or full consensus to make all licensees pivotal, would the non-pivotal firms be subject to patent hold up? In most cases no. This follows because most SSOs request FRAND promises from their members. It is the “ND” portion of the FRAND commitment that comes into play here by requiring license terms to be identical for all similarly situated firms. Thus, the three identical licensees in our simplified model would all be entitled to the same terms under a FRAND promise. If a pivotal firm, say firm A, obtains a royalty \( r_A = \beta v_1 \), the patent holder would have to offer \( r_B = r_C = \beta v_1 \) as well in order to comply with its FRAND promise to the SSO. Even if firm A were the only firm to take a license ex ante, the patent holder could be bound to \( r = \beta v_1 \) ex post in order not to discriminate against firms B and C. With non-discrimination clauses, all firms would pay at most the ex ante reasonable royalty benchmark and no hold up would arise as long as at least one licensee entered into a reasonable agreement ex ante. A lower royalty rate obtained by one of the licensees spills over to the remaining firms.

In fact, specific pivotal licensees are not necessary as long as non-discrimination promises can be enforced. To see this point, consider that under most SSO structures a technology must receive a minimum threshold of votes to be included in a standard. So, even if no one SSO member has a disproportionate percentage of votes, the patent holder must gain the support of the threshold proportion of members in order to be included in the standard. To gain that support, as explained above, the patent holder must offer a reasonable royalty rate ex ante. Non-discrimination clauses help align the incentives of the different licensees. They benefit from

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27 Non-discrimination commitments do not require identical terms for all parties, but rather identical terms for all similarly situated parties. Here, all licensees are assumed to be identical and so would have to receive identical licenses. Non-discrimination commitments could nonetheless be equally effective in the real world because the only differences tolerated under such rules are those justified by the differing circumstances. Ex post opportunism would not qualify as a justification.

28 If the risks involved in licensing ex ante were greater than ex post, say because the technology had been proven sound over the intervening time, then the ex post royalty rates could be justifiably higher. This would not constitute discrimination or patent hold up though since the differences in risk would define different circumstances.

29 As in the benchmark case, this result generalizes to an arbitrary number of firms or asymmetries in the voting power of possible buyers. See the appendix for details.
the best royalty offered to all the others and, as a result, some of them can withhold their support ex ante in order to make the remaining one pivotal in the negotiation. Then, just as in the case with specific pivotal players holding large voting blocks, once the threshold proportion of members have obtained reasonable royalty rates, the remaining licensees will obtain those rates as well under the non-discrimination promise.

4.3 Discriminatory Bargaining

As we have discussed before, ex-ante negotiations might lead to higher or lower royalties than the reasonable benchmark to the extent that these negotiations promote competition or cooperation among potential licensees. To conclude this section we consider an ex ante bilateral negotiation process where this competition is exploited by the patent holder. In particular, we consider an ex bilateral negotiation process that places the patent holder in the best possible position: strictly sequential negotiations with no FRAND commitment. This is a rather artificial process whereby the patent holder approaches each potential licensee in sequential order for a one-shot, no return negotiation. The sequentiality of the negotiation process prevents any firm from becoming pivotal in equilibrium, which allows for opportunistic licensing even ex ante. The outcome of these successive negotiations coupled with the absence of any non-discrimination commitment therefore allows the patent holder to reproduce ex ante what it could have obtained ex post—that is, patent hold up.

Sequential bargaining has been used in other contexts to illustrate "naked exclusion". 30 In its original context of vertical relations, it is used to study the exclusive agreements that a market incumbent, the producer of some intermediate good, can reach with its downstream buyers in order to prevent the entry of more efficient upstream competitors. In that context, as in ours, the decisions of different buyers are related. If buyers are able to coordinate to reject the terms the upstream incumbent offers, the boycott could trigger the entry of a more efficient producer and thus more competition facing the upstream incumbent with a lower price for the input as a result. However, if the upstream incumbent can negotiate with each buyer sequentially it can improve its negotiating position when facing the first firms in the sequence by using the threat of reaching entry-preventing agreements with buyers in later negotiation rounds.

30 This concept has become popular in the economics of antitrust, starting with papers such as Eric B. Rasmusen, Mark J. Ramseyer & John S. Wiley Jr., Naked Exclusion, 81 AM. ECON. REV. 1137 (1991), and Liya R. Segal & Michael D. Whinston, Naked Exclusion: Comment, 90 AM. ECON. REV. 296 (2000).
Similarly, in the standard setting context, purely sequential negotiation could prevent tacit coordination among licensees and, as a result, could maximize profits for the patent holder. This outcome is due to the fact that ex ante the patent holder only needs to reach an agreement with the threshold proportion of licensees necessary for the patented technology to be included in the standard. Once this proportion has been reached through offers of \( r = \beta v_1 \), in further ex ante negotiations the patent holder could charge the same royalty as in an ex post agreement \( (r') \), when it benefited from the created market power due to inclusion in the standard. Because we assume here that the patent holder is not bound by a FRAND commitment, it can earn hold up royalties from at least a portion of the licensees.

To see why this conclusion holds, return to the simple model with the three potential licensees. The patent holder negotiates with each of the three firms in a strict, no-return sequence, from A to B to C. Assume that support from two of the three firms is needed for the patented technology to be included in the standard. The patent holder first approaches firm A and offers an agreement for the patent to be licensed at royalty \( r_A \). If firm A accepts, it will obtain a return \( v_1 - r_A \). That is, the private benefit for firm A equals the value of the cost reduction net of the price paid for the license. If firm A rejects the offer two things can occur: either the technology does not obtain the necessary support and the public technology is chosen for the standard or both of the other two firms accept the patent holder’s offer and the patented technology is selected for the standard, implying that firm A must enter into ex post negotiations with the patent holder. If firm A is faced with ex post negotiation, the patent holder can charge \( r' > v_1 \).

We again start with the last negotiation, with firm C. There are three possible outcomes for the patent holder going into negotiation with C:

1. The patent holder has not obtained the necessary support from either firm A or B. In that case, the negotiation with C is irrelevant as the patent holder cannot reach the two-thirds majority needed for inclusion in the standard and thus the patented technology will not be accepted by the SSO.

2. The patent holder has obtained support from only one of the firms, A or B. In that case, firm C becomes pivotal in the decision because if C rejects the patent holder’s offer the alternative technology will be included in the standard. If C accepts the offer, the SSO will include the patented technology. Hence, in this case firm C will only accept the
patent holder’s offer if the royalty rate, $r_C$, is set equal to or below the incremental benefit to firm C of using the patented technology: $r_C = \beta v_1$.

3. The final possibility is that both firms A and B have accepted the patent holder’s offer. As a result, firm C is irrelevant for the standard to be implemented since the two-thirds majority has already been achieved. In this case, the patent holder has no incentive to reach an ex ante licensing agreement with firm C unless that agreement produces a return as high as an ex post agreement would grant. Since ex post there is no costless alternative to the patented technology, firm C would have to accept the hold up license $r'_C$. Hence, once the majority is reached the patent holder will offer ex ante $r_C = r'_C$.

Consider next the negotiation between the patent holder and firm B. Both parties anticipate the outcome of the future negotiation with firm C. They both know that the patent holder will always offer a license that is acceptable for firm C. As a result, two possibilities are relevant, depending on whether firm A has already accepted or not.

1. If firm A has not accepted the patent holder’s offer, firm B knows that it is now pivotal in the negotiation given the necessary two-thirds majority. Therefore, firm B will only accept the license if the royalty is at most equivalent to what it would obtain under the alternative technology, that is, $v_1$. Therefore, $r_B = \beta v_1$.

2. If firm A has accepted the patent holder’s offer, firm B anticipates that if it rejects the offer, the standard will be implemented anyway since the patent holder can set $r_C$ to ensure that firm C accepts. Hence, in this case firm B will be willing to pay ex ante the same amount it would have to pay ex post: $r_B = r'_B$.

We finally come to the first negotiation, between firm A and the patent holder. From the previous discussion we can deduce that if firm A declines the patent holder’s offer, the patent holder can set royalties such that both firms B and C will accept. As a result, the standard will be accepted regardless of firm A’s decision. In other words, firm A cannot be pivotal. As before, firm A will accept any licensing agreement that it would have obtained ex post, so $r_A = r'_A$. Because A accepts, firm B and C will also accept and they will all pay the ex post hold up royalty rate ($r'_A$, $r'_B$, $r'_C$).

Once again the negotiation power of each potential licensee hinges on the possibility of being pivotal in the decision. Each licensee will obtain better licensing terms the more
necessary is his acceptance for the standard to be implemented. If the patent holder expects to reach the necessary majority by negotiating with another party, it will only offer the current party ex ante terms equivalent to the higher ex post terms.

Note, however, that this result rests on several very special assumptions. First, the negotiation process is strictly sequential, with no firm revisited for a second round until after the standard is set. In reality, licensing negotiations are likely to be a combination of sequential and simultaneous. A patent holder may be engaged in negotiations with several potential licensees at any given time, but these negotiations tend to take time—months or even years. Nor are negotiations one-shot deals; firms can and do stop talks only to resume them later. While patent holders can attempt to play one licensee off of another in building a base of support, pure sequentiality cannot be used to prevent any licensee from becoming pivotal. Second, we have assumed no FRAND promise exists, counter to common practice at SSOs. With a FRAND promise, discrimination amongst the licensees is no longer possible, but discrimination is a key element of the patent holder’s negotiation method in the above process. If the other licensees know that they will be able to obtain equivalent deals at a later date, they can wait for the most pivotal of licensees to negotiate first. Finally, we have assumed that full consensus is not required for the patented technology to be included in the standard. The larger the quorum needed, the more likely it is that a significant proportion of licensees receive a reasonable rate (necessary to obtain their support) and the less successful sequential negotiations will be in achieving hold up results ex ante.

5. Policy Implications and Conclusions

We began this paper with a discussion of recent signals that the US antitrust agencies will take a more permissive view of joint licensing negotiations in the context of standard setting, evaluating such discussions under a rule of reason, rather than as per se illegal. Some scholars have extolled the virtues of ex ante licensing negotiations in SSOs as a means of preventing ex post opportunistic pricing from patent holders. We have focused on the practical question of how to achieve ex ante licensing, especially in light of typical institutional features found at most SSOs. In particular, we ask whether ex ante joint negotiations are “reasonably necessary” to prevent patent hold up and instead obtain competitive, reasonable, and fair royalty rates. Using a simple but informative model, we compare two forms of ex ante license negotiations, bilateral
We find that under a narrow set of assumptions, ex ante bilateral negotiations can be no better than ex post opportunistic ones: with strictly sequential negotiations and no FRAND commitments patent holders are able to extract in royalties more than their technology contributes to the standard. At the other extreme, if full consensus approval is required before a technology can be included in a standard, then bargaining power shifts in the direction of licensees and ex ante bilateral negotiations can under-compensate patent holders. Under more realistic scenarios, matching circumstances commonly found in standard setting, we find instead that ex ante bilateral negotiations are likely to come closer to a benchmark of reasonable and fair royalties whereby the patent holder charges no more than the incremental value its technology contributes to the standard. In fact, even when the patent holder has all of the bargaining power (i.e., $\beta = 1$ in our model), under most conditions the patent holder will still charge no more than the ex ante reasonable benchmark. In particular, ex ante bilateral negotiations that involve pivotal licensees, that require a reasonable quorum for the patented technology to be included in the standard, or that are bound by FRAND commitments tend to result in reasonable royalties.

In contrast, ex ante joint negotiations tend to under-compensate patent holders. The upper bound royalty rate under joint negotiations is the ex ante benchmark rate, but this upper bound is only reached in the unusual circumstance of the patent holder having all of the bargaining power while the aggregated licensees have none. This condition is unlikely to hold in most real world situations, especially given the common presence of pivotal SSO members that hold significant voting rights or have powerful positions in the downstream market.

Figure 1 summarizes these primary findings in graphical form, illustrating the relationship between the royalty rates that can be expected to emerge from various ex ante negotiation schemes:31

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31 The Swanson-Baumol reasonable benchmark (SB) represents the lower bound of a rate that perfectly balances incentives to innovation against moderate downstream prices, denoted as the “first best” royalty rate. It is possible that the SB rate equals the first best, or it could be lower.
Our findings suggest several more moderate policy prescriptions that would obviate the need for ex ante joint negotiations. First, a reasonably high degree of consensus (but short of full consensus) required for the acceptance of a technology within a standard creates a reasonably high number of pivotal licensees, and pivotal licensees curb patent holders' ability to charge royalties above the reasonable ex ante benchmark. SSOs could therefore examine the mechanisms by which they assess technologies for inclusion in standards. Moving toward majority rules will help to prevent patent hold up. While there could be a cost in terms of the speed at which standards are promulgated—consensus building tends to take more time to achieve—if patent hold up is seen as a serious potential problem within an SSO then the tradeoff could be worthwhile.

Second, SSOs could consider policies that encourage bilateral licensing negotiations to take place ex ante, before the technologies are chosen for a standard. Confidential, bilateral ex ante negotiations appear far more likely than joint negotiations to reach royalties closest to the first best solution, where the need for incentives to innovate are balanced against the need for moderate downstream product prices. Even if they fall short of the first best target, ex ante bilateral negotiations appear more likely to achieve the reasonable benchmark than joint negotiations.

Third, those few SSOs that do not have FRAND commitments in place should consider adding them. The non-discrimination component of these promises offers a route to maintaining
reasonable royalties for all licensees, one that has largely been ignored in the debate over patent hold up. In light of this point, we offer a fourth suggestion: antitrust authorities could consider ways in which to signal the enforcement of non-discrimination commitments. Determining what is and what is not discriminatory may not be easy, especially when firms are differentiated or when patent valuations differ by firm, but royalty discrimination is an issue that the courts are already well equipped to deal with as it is a regular issue in patent cases today. Moreover, determining what rates are or are not “fair” or “reasonable” strikes us as a far more complicated, controversial, and subjective task. Rather than defining a but-for world in which to estimate fair and reasonable rates to serve as a benchmark for an existing rate, assessing discrimination would involve comparing only those rates actually charged.

We conclude that ex ante joint negotiations are not “reasonably necessary” to prevent ex post opportunistic licensing. The danger with this solution is that it would likely introduce problems of its own. This is particularly worrisome in light of the fact that most SSOs have far more licensee members than licensor members. Even if joint negotiations did not result in overt collusion among licensees, it would tend to result in under-compensation for patent holders and an attendant reduction in the incentives to innovate. Encouraging ex ante bilateral negotiations appears a less risky solution to ex post licensing problems. This and other more moderate policies based on the institutional features of standard setting bodies offer greater odds of eliminating the risk of patent hold up without introducing the risk of licensee collusion that would keep royalty rates artificially low.
Appendix: A General Model for Individual Negotiations

Assume that N>1 firms comprise the SSO. We denote (potential) licensee i as Li. This licensee controls a percentage of voting shares αi. As in the main body of the paper, we restrict our environment to the competition between two technologies: technology 1 represents a value v1 for the licensees, arising for example from a cost reduction over the already available technology 0. The patent holder’s bargaining power is again denoted as β. Finally, in order to make the problem non-trivial we assume that a percentage A<1 of shares is necessary for the standard to be accepted, where A>αi for all i=1,...,N. That is, more than one firm is required for the technology to be accepted.

The timing of the game is as follows. The patent holder makes sequential offers to each innovator i. After all offers have been made and accepted or rejected all members of the SSO vote between technology 1 and 0. Once a technology has been accepted, firms that do not already have a license to the technology must negotiate ex post, where we assume that the patent holder can extract a royalty r'. We denote the ex ante royalty offered to firm i as ri.

We now introduce some definitions. We denote firm i’s decision as di, which takes one of two values. The value di=1 indicates the choice of technology 1 whereas di=0 indicates the choice of technology 0. Denote as γi the percentage of shares secured by the patent holder before an offer to firm i is made.

Definition A.1.: Given {di}Ni=1, firm i is pivotal if

γi + Σj=i+1 N αj < A < γi + αi + Σj=i+1 N αj.

The interpretation is straightforward. A firm is pivotal if, given what the previous firms have chosen, its acceptance is necessary for the standard to be accepted even in the case where all successive firms also accept.

The next proposition shows that the equilibrium royalty offered in the benchmark model where discriminatory royalties are possible coincides with the ex post one.

Proposition A.1: With discriminatory sequential offers, technology one is always chosen and firms pay a royalty ri= r'.

Proof: First notice that ex post, if technology 1 has been chosen any firm i that has not secured
an ex ante license will pay a license \( r' \).

Using an induction argument we now show that for all decision histories of previous firms, licensee \( i \) will always accept the equilibrium royalty offered by the patent holder. In order to do so, we establish this result first for the last licensee and show that it holds for a generic licensee \( i \).

Regarding the last potential licensee, firm \( N \), two possibilities might occur depending on whether this licensee is pivotal or not in the final decision.

If licensee \( N \) is pivotal, per unit profits for the licensee are increased by \( v_1 \) when \( d_N=1 \), as opposed to choosing technology 0 and paying a royalty 0. Hence, because acceptance of the standard increases profits for the patent holder and accounting for bargaining power, the royalty offered will be \( r_N=\beta v_1 \). If licensee \( N \) is not pivotal, the patent holder will offer ex ante the same royalty it could collect ex post, \( r' \).

Let's consider now the case of firm \( i \), where using the induction argument we assume that \( d_j=1 \) for all \( j>i \). Given a history \( d_k \) for \( k<i \), two situations can occur. If firm \( i \) is pivotal, as before, the patent holder will offer the highest royalty compatible with the firm optimally choosing technology 1, that is, \( r_i=\beta v_1 \). Otherwise, if firm \( i \) is not pivotal, \( r_i=r' \).

We can now turn to the first licensee, firm 1. Since by assumption \( \alpha_i<A \) for all \( i \), firm 1 is not in equilibrium pivotal. As a result, in the equilibrium path of play \( r_1=r' \). Similarly, given that in equilibrium \( d_i=1 \) for all \( i \), no firm is pivotal and \( r_i=r' \) for all \( i \).

Incidentally, the proof of the previous proposition also shows that if a firm, say firm \( i \), had enough voting power for the standard to be accepted only if it were present (that is, if it were pivotal), its royalty would be \( r_i=\beta v_1 \).

We now turn to the case in which the patent holder is restricted to making non-discriminatory offers. As in the rest of the paper, we understand non-discrimination as the possibility that any firm can obtain a royalty ex post that is no worse than what its (identical) competitors might have obtained ex ante.

**Proposition A.2:** Under non-discriminatory sequential offers, technology 1 is always chosen and firms pay a royalty \( s_i=r_i=\beta v_1 \).

Proof: First, notice that technology 1 will always be implemented, since the patent holder can
always offer a royalty sufficiently small to lure acceptance.

Second, we show that in the unique subgame perfect equilibrium, \(\max_i \{r_i\} \leq \beta v_1\) for all firms that have chosen \(d_i=1\). We do that by contradiction. Suppose that \(\{d_i^*\}\) is an equilibrium where technology 1 is accepted. If \(\max_i \{r_i\} > \beta v_1\) then at least one firm that has accepted technology 1 ex ante is not pivotal. Otherwise, this firm, denoted as \(i'\) would have rejected the offer since pivotal firms can always negotiate \(r_i=\beta v_1\) through the threat of non-acceptance. Moreover, firm \(i'\) is such that if it had not accepted technology 1, no future firm would be pivotal. The reason is that a future pivotal firm could have secured \(r_j \leq \beta v_1\) exploiting the patent holder’s higher earnings from \(i'\), leading to an ex post royalty \(\beta v_1\) by non-discrimination. Moreover, using this argument recursively, firm \(i'\) is such that if it had not accepted technology 1, no future firm \(i''\) would be in the position that by also not accepting another future firm would be pivotal, etc. This argument would eventually result in a contradiction since at some point some firms must be pivotal.

Third, we show that \(\min_i \{r_i\} \geq \beta v_1\) for all firms that have chosen \(d_i=1\). Otherwise, if there exists an \(i\) for which \(r_i < \beta v_1\), the patent holder can simply increase \(i\)’s royalty rate without changing firm \(i\)’s or any other firm's decision. ■
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