On the Application of Nash Bargaining in Reverse Payment Cases in the Pharmaceutical Industry

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Abstract

Some applications of Nash bargaining in the antitrust analysis of reverse payment settlements estimate the bargaining power parameter as the split of the surplus in the actual settlement with alleged reverse payments. This estimated parameter is then used as the bargaining power parameter in the but-for world where reverse payments are prohibited. We demonstrate that this approach is incorrect. Indeed, in the but-for world there could theoretically be an alternative “no payment” settlement where reverse payments are prohibited. However, the prohibition on reverse payments disproportionately affects the shape of the bargaining set in favor of the patent holder. With this asymmetry in the bargaining set, the estimated “bargaining power” in the actual world (with a settlement) no longer accurately reflects the split of the surplus that would have been agreed during the but-for negotiation with no payments. Moreover, we find that keeping the split of the surplus constant between the actual and but-for worlds is not innocuous because it overestimates the extent of alleged generic delay.

Keywords Reverse payment cases in pharmaceutical industry · Nash bargaining solution · Antitrust litigation · Bargaining power · Division of surplus

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1 Introduction

Reverse payment settlements are agreements between branded drug manufacturers, which are typically patent-holding monopolists, and potential generic entrants to settle patent infringement litigation or the threat of such litigation.¹ A reverse payment settlement usually involves an agreed-upon generic entry date and one or more transfers of value among the settling parties, including for example, cash payments or an agreement by the branded company not to launch an authorized generic for a specified period of time in certain circumstances. Settlements of this nature could potentially harm consumers by delaying the entry of generic products that would compete against the brand (Edlin et al. 2013). A common approach for evaluating the potential harm to consumers is estimating the extent of delay that was caused by the reverse payment settlement. In other words, if the parties agree to an entry date with reverse payments, the alleged harm is a function of how much earlier the entry date would have been absent those payments (this implicitly assumes that a “no-payment” settlement could have been reached instead of the actual settlement). As part of the process of estimating the purported damages, it is natural to consider and perhaps attempt to model the negotiation process among the parties that ultimately led to the observed reverse payment settlement.

The Nash bargaining solution (Nash 1950) is an alternative that can be used to model the outcome of the parties’ negotiations in reverse payment cases. The Nash bargaining solution is the most widely used axiomatic bargaining solution in economics. In general, an axiomatic bargaining problem has two elements: (1) a set of possible utility pairs that the parties can obtain through an agreement (“the bargaining set”) and (2) a specific point that captures the level of utility the parties would obtain if they fail to reach an agreement (“the disagreement point”) (Muthoo 1999).² Given these two elements, the Nash bargaining solution selects an outcome by satisfying a set of axioms that aim to represent the preferences of an “arbitrator who tries to distribute the gains from cooperation in a manner that reflects ‘fairly’ the bargaining strength of the different agents” (Mas-Colell et al. 1995, p. 838).³ The Nash bargaining solution may yield asymmetric utilities for parties due to the asymmetry of the bargaining set or the asymmetry in the utilities from the disagreement point. In the generalized Nash bargaining solution, however, there is an additional parameter that represents the bargaining power of the bargaining parties originating from any remaining sources such as the case of “longer waiting time after one party’s offer than after the other’s offer and the case of different beliefs concerning the probability of breakdown in the risk model” (Binmore et al. 1986, p. 179). It is

¹ These settlements are also referred to as “pay for delay” settlements.

² We assume that this failure refers “to the payoffs that bargainers obtain by quitting the negotiation permanently.” (Chiu 1998).

³ These axioms are Invariance to Equivalent Utility Representations, Pareto Efficiency, Symmetry, and Independence of Irrelevant Alternatives. Symmetry is lifted in cases where an asymmetric bargaining power parameter is used (Muthoo 1999).

this latter exogenous parameter that we call the bargaining power or strength of the bargaining parties.⁴

The generalized Nash bargaining framework can therefore be considered as a way to better understand the bargaining process in reverse payment settlements. A standard allegation in litigation in this context is that a cash payment from the incumbent pharmaceutical company to a potential entrant was made in exchange for the generic firm not entering the market or delaying entry. In general, monopoly profits are greater than the sum of duopoly profits. As a result, a settlement with reverse payments may be more profitable for both parties because there is a larger “pie” of profits to be split if the monopoly is indeed prolonged.

The Federal Trade Commission (FTC) initially sought to strongly deter reverse payment settlements (FTC 2002). Indeed, even an appellate court held that these agreements were per se illegal.⁵ The FTC’s position was consistent with some of the early literature showing their potential for adverse effects on competition (Leffler and Leffler 2004; Ecer and Higgins 2004). However, since 2005 the appellate courts started to uphold these agreements.⁶ The FTC continued to express deep concerns, especially when the purported payments exceed expected litigation costs (FTC 2010). Another strand in the literature shows that reverse payments higher than expected litigation costs may be justified based on risk aversion or asymmetric information (Shapiro 2003), risk of under-compensation of the patent holder (Langenfeld and Li 2003), ability to achieve welfare enhancing settlements (Willig and Bigelow 2004), and increasing the incentives to develop new generic drugs and investment in patent challenges by generic manufacturers (Dickey and Rubinfeld 2012). The thrust of this and related literature cautions against treating reverse payment patent settlements as per se illegal (Dickey et al. 2010; Meunier and Padilla 2015). Nonetheless, other papers propose a modified per se rule (Elhauge and Krueger 2012). The legal treatment of reverse payments from an antitrust perspective was addressed by the Supreme Court in 2013, which concluded that rule of reason treatment should be the legal standard (the *Actavis* decision).⁷ In the wake of the *Actavis* decision, several papers have been written discussing the implementation and practical implications of the decision (see, e.g., Edlin et al. 2013; Harris et al. 2014). In a recent statement, the FTC noted that after *Actavis*, the number of settlements with reverse payments or with no-authorized generic commitments declined “precipitously,” even though pharmaceutical settlements increased in 2016 by more than 35% compared to 2015.⁸ In this paper, we contribute to the use of bargaining models and related concepts in estimating the entry date of the generic firm in the absence of reverse payments (see, e.g., Ghili and Schmitt 2017 or Elhauge and Krueger 2012).

⁴ See the discussion in Muthoo (1999), Sect. 3.2.3.

⁵ See *Cardizem CD Antitrust Litigation*, 332 F.3d 896 (6th Cir. 2003).

⁶ See *Schering-Plough v. FTC*, 402 F.3d 1056 (11th Cir. 2005).

⁷ See *FTC v Actavis Inc.*, 133 S. Ct. 2223 (2013).

⁸ Towey, J., Albert, B., 2019, Then, now, and down the road: Trends in pharmaceutical patent settlements after *FTC v. Actavis*, FTC Blog on Competition Matters. See <https://www.ftc.gov/news-events/blogs/competition-matters/2019/05/then-now-down-road-trends-pharmaceutical-patent>.

In reverse payments matters, we typically observe the generic entry date in the actual world, but we do not observe the generic entry date in the absence of the reverse payment (that is, in the “but-for” world). In the textbook anticompetitive case, a delayed entry date brings lower expected profits to the entrant, and reverse payments are typically treated as a way to compensate the entrant for the lower profits. When the delay in entry is considered an antitrust concern, the modeling of an entry date in the absence of reverse payments may include a prohibition on reverse cash payments. In such a but-for world, the bargaining analysis is less straightforward because the parties are explicitly prohibited from giving or receiving monetary transfers.

Consider a scenario where the monetary value of a reverse payment and the agreed upon entry date are both known to the antitrust authority. These two data points (in addition to profit data from the parties under monopoly and competition) allow the practitioner in charge of the investigation to calculate how the surplus was split according to the agreement. In such a case, the standard Nash bargaining framework allows the practitioner to estimate the bargaining power of the entrant and incumbent pharmaceutical company from the observed split of the surplus. Once the bargaining power is estimated by the antitrust authority, the generic entry date in a counterfactual settlement without the reverse payment can be estimated using the same data, under the condition that the split of the surplus in the but-for world is the same as when reverse payments were used by the parties. The logic of this approach appears to rest on the assumption that the bargaining skills or other firm-specific characteristics do not change when reverse payments cannot be used, and therefore the split of the surplus should remain the same. However, as we show below, this logic is flawed because bargaining power alone is no longer enough to characterize the split of the surplus when the incumbent and entrant bargain only over the generic entry date, even if it were true that the bargaining skills or the specific characteristics of the firms have not changed.

In this paper, we discuss an approach to formulate the estimates of the patent holder’s and the entrant’s bargaining power in estimating the but-for entry date in reverse payment cases. We find that eliminating the possibility of cash payments in settlements disproportionately affects the shape of the bargaining set as the set is tilted in favor of the patent holder. This is because the entrant cannot access monopoly profits via transfers and must settle for lower competition profits. For the same reason, total profits are lower without reverse payments. Then, we show that if one applies the estimated bargaining power parameter from a settlement derived from the actual shares of the surplus with reverse payments to the but-for scenario where reverse payments are not allowed in the settlement, the estimated delay from the reverse payments would be overstated leading to higher damages for the entrant.

The following section presents the basic model. Sections 3 and 4 study the case where reverse payments are permitted and where such payments are not permitted, respectively. Section 5 briefly concludes.

2 The Model

Consider an incumbent firm m that operates as a monopolist in a market and realizes instantaneous constant profits denoted by $\pi_m > 0$ if it is able to maintain its monopoly through a patent of strength θ . Patent length is normalized to 1 and discounting is ignored throughout. A potential entrant, denoted by d (which stands for *duopolist*), can challenge the patent through litigation. When the entrant operates in the market, both firms obtain profits $\pi_d > 0$. We will assume that

$$\pi_m \geq 2\pi_d. \quad (1)$$

If (1) did not hold, the patent-holder monopolist would always allow entry as long as it can set a minimum fee of $\pi_m - \pi_d$ to the entrant and restore its monopoly profits. In other words, enforcing the patent would not be profitable if (1) is violated.⁹

Furthermore, we assume that if the entrant challenges the patent, litigation is resolved immediately in the beginning of the patent period at a cost of $L > 0$, which we assume to be equal for both firms. Hence, the entrant's expected litigation payoffs are

$$L_d = (1 - \theta)\pi_d - L;$$

and the incumbent expected litigation payoffs are

$$L_m = \theta\pi_m + (1 - \theta)\pi_d - L.$$

To keep both litigation payoffs positive, it suffices to assume that $L < (1 - \theta)\pi_d$ (litigation costs are sufficiently low relative to the duopoly profits and the weakness of the patent). These expected litigation payoffs constitute the outside options of the parties where the settlement is modelled as a one-shot interaction and negotiations permanently fail. We assume that none of the parameters entering the expected litigation payoffs can be changed during the bargaining process; for example, parties cannot set prices above the competitive level and increase the duopoly profits above the competitive level.

Instead of litigating, the parties can settle by agreeing on a specific generic entry date. To do so, they could negotiate two different types of settlements: with or without reverse payments, which we denote as $R \in [-R, R]$, defined to be flowing from the monopolist to the entrant and assumed to be bounded. The reverse payment or transfer R is therefore a payment made by the patent holder to the entrant if $R > 0$ or a payment from the entrant to the patent holder if $R < 0$. If $R = 0$, no payments are made by either party.

To complete the characterization of the possible settlements, let us call T the time of entry under an agreement. Therefore, if reverse payments are permitted, the parties could negotiate over an entry date $T \in [0, 1]$ and a transfer R . If the parties are only allowed to negotiate over an entry date $T \in [0, 1]$, then the bargaining outcomes are only derived from profits on sales made in the marketplace. Any

⁹ Tirole (1988) refers to this property as the *efficiency effect*.

other conceivable negotiation parameters that cannot be reduced to T or R , such as increasing prices and profits above the duopoly level, are considered to be outside the scope of the model.

In summary, we model the actual world as a reverse-payment settlement with an entry date of 1 and a payment of R . The but-for world, on the other hand, is characterized by no reverse payment and an entry date of $T \in [0, 1]$, where $1 - T$ represents the delay due to the reverse payment.

In the Nash bargaining model, parties have *ex ante* exogenous bargaining strengths. We will denote the entrant's bargaining power as $\lambda \in (0, 1)$, and the patent holder's bargaining power as $1 - \lambda$. The exogenous bargaining power parameter captures any advantages the entrant may have during the negotiations. For example, more skilled negotiators would allow the entrant to obtain a larger share of the surplus, *ceteris paribus*. More generally, anything outside of the model, such as bargaining tactics, the information structure, the procedures used to conduct negotiations, and the parties' discount rates all could potentially influence λ (Muthoo 1999).¹⁰ Finally, we assume that the bargaining process itself is not regulated by any governmental authority such as an antitrust enforcement agency and that such an authority only considers the outcome of the bargaining process.

3 Bargaining with Reverse Payments

In this section, we solve the bargaining problem between the firms in the case where they use reverse payments in the bargaining process. We assume that this setting corresponds to the actual world. Let u_d and u_m be the (expected) utilities for the entrant and the incumbent, respectively. Following Muthoo (1999), we can define a decreasing function $h_R(u_d) \equiv u_m$ that characterizes how one firm loses (gains) as the other firms gains (loses). Thus, the function $h(\cdot)$ is the frontier of the bargaining set, which is where a typical efficient solution resides, including the Nash and generalized Nash bargaining solutions.

Given that we allow for cash transfers as part of the settlement, we can show that it is optimal for the parties to always agree on $T = 1$ to maximize total surplus, and then bargain over the split of profits net of litigation cost.¹¹ To see this result, note that for any entry date T the total rents generated by both parties is

$$T\pi_m + 2(1 - T)\pi_d \leq \pi_m,$$

where the inequality holds by (1). Therefore, the parties always elect to bargain over the split of the monopoly profits using the reverse payment. Hence the bargaining frontier has a negative 45° slope when monetary transfers are possible:

¹⁰ See Dagranska et al. (2010) for an empirical application.

¹¹ If the parties expect antitrust scrutiny of such settlement, we might constrain $T \leq \tau$ to account for the *maximum* acceptable entry date. Our primary conclusions are unchanged after such a modification.

$$u_m = h_R(u_d) = \pi_m - u_d. \quad (2)$$

Given an entrant's exogenous bargaining power $\lambda \in (0, 1)$, the (generalized) Nash bargaining solution is the solution to the following problem

$$\max_{u_d \geq L_d, u_m \geq L_m} (u_d - L_d)^\lambda (u_m - L_m)^{1-\lambda}. \quad (3)$$

Plugging (2) into (3) and taking the first order condition with respect to u_d leads to the solution¹²

$$-h_R'(u_d^R) = \frac{\lambda}{1-\lambda} \frac{u_m^R - L_m}{u_d^R - L_d}. \quad (4)$$

By (2), we know that $-h_R'(u_d) = 1$, then

$$1 = \frac{\lambda}{1-\lambda} \frac{u_m^R - L_m}{u_d^R - L_d}$$

With simple manipulation, we can rewrite the bargaining outcome $\{u_m^R, u_d^R\}$ as:

$$u_m^R = L_m + (1-\lambda)(u_m^R + u_d^R - L_m - L_d) \text{ and } u_d^R = L_d + \lambda(u_m^R + u_d^R - L_m - L_d). \quad (5)$$

Noting that $u_m^R + u_d^R = \pi_m$, we have

$$u_m^R = L_m + (1-\lambda)(\pi_m - L_m - L_d) \text{ and } u_d^R = L_d + \lambda(\pi_m - L_m - L_d). \quad (5')$$

In Fig. 1, we plot the entrant's payoffs as u_d on the x-axis and the patent holder's payoffs as u_m on the y-axis. The line segment (π_m, π_m) represents the frontier of the bargaining set in the actual case where reverse payments are allowed. The curve N represents the "Generalized Nash product" (the utility function representing the preferences of the "imaginary arbitrator"), which is maximized at the point of tangency (u_d^R, u_m^R) . Hence, the solution of the bargaining problem in this case is given by (u_d^R, u_m^R) , which for both players exceeds the utility of the litigation payoffs (L_d, L_m) .

At (5), the expression $(u_m^R + u_d^R - L_m - L_d)$ represents the surplus at the solution point and as can be seen from (5') this surplus is constant at the efficient frontier. Note that the share of the surplus obtained by the entrant is given by the exogenous bargaining power λ at (5) and (5'), which corresponds to the split-the-difference rule (Muthoo 1999).¹³ The same applies to the incumbent who gets the remainder of the

¹² The solution is proven in Muthoo (1999), Proposition 2.5, based on the first-order condition of the Nash product, as we show here.

¹³ By (1) we can show that both payoffs are positive. The corner solution when $\lambda = 1$ (which gives the entrant all the bargaining power) requires that the patent holder realizes payoffs $u_m = L_m$ and the entrant, the remainder, so $u_d = \pi_m - L_m$. Furthermore, we can check that the greater the entrant's bargaining power is, the greater its payoffs are, and the reverse is true for the patent holder. After developing the expression for the litigation payoffs we get

$$u_m^R = \pi_m(1 - (1-\theta)\lambda) - (1-2\lambda)(\pi_d(1-\theta) - L) \text{ and } u_d^R = (1-2\lambda)(\pi_d(1-\theta) - L) + (1-\theta)\lambda\pi_m.$$

surplus according to its bargaining power $(1 - \lambda)$. Although in this particular case the bargaining power a party possesses, λ , happens to equal the share of the surplus it obtains, in general, the share of the surplus obtained by an agent need not correspond to their bargaining power. To distinguish between the share of the surplus and bargaining power, let us denote henceforth the entrant's share of the surplus in any bargaining outcome (u_m, u_d) by $\tilde{\lambda}$, where

$$u_m = L_m + (1 - \tilde{\lambda})(u_m + u_d - L_m - L_d) \text{ and } u_d = L_d + \tilde{\lambda}(u_m + u_d - L_m - L_d) \quad (6)$$

Note that in the case with reverse payments, $\lambda = \tilde{\lambda}$ as demonstrated above. However, this equality between the exogenous bargaining power λ and the share of the surplus $\tilde{\lambda}$ does not hold in general.

We next demonstrate why it is erroneous to assume, when using the Nash bargaining solution, that the observed or estimated split of the surplus in a settlement is always equal to the exogenous bargaining power of the two parties, including in a hypothetical negotiation for which reverse payments are not allowed. Indeed, as we show below, this equality fails when reverse payments are not allowed.

4 Bargaining Without Reverse Payments

Now we consider a situation where the parties cannot use payments as a negotiation tool. Compared to the previous case, the bargaining set and hence the function $h(\cdot)$ needs to change to reflect the incumbent's opportunity cost of ceding profits to the entrant (it is no longer one for one in the case of a pure cash transfer). We next determine the new split of the surplus generated through the Nash Bargaining solution as a function of the exogenous bargaining power λ . In this case, the maximization of the Nash product as in (3) yields¹⁴

$$-h_{NR}'(u_d^{NR}) = \frac{\lambda}{1 - \lambda} \frac{u_m^{NR} - L_m}{u_d^{NR} - L_d}, \quad (7)$$

where $h_{NR}'(u_d^{NR})$ is the slope of the frontier of the (but-for) bargaining set evaluated at the optimal solution when reverse payments R are prohibited. We show that

Footnote 13 (continued)

Remark that when the patent strength θ increases, the patent holder obtains greater payoffs, whereas the entrant gets lower payoffs. The reason for this effect is that an increase in the patent strength increases the patent holder's litigation payoffs. Additionally, if the litigation costs L increase, the party with less bargaining power will see its payoffs decrease and the other party earns more. Finally, given that $T = 1$, the entirety of the entrant's payoffs comes from the transfer R , hence $R = u_d^R$.

¹⁴ This characterization requires that we assume $L_m \geq \pi_d$ and yields an interior solution (we thank an anonymous referee for pointing this out). This assumption is sensible in settings where the gains from monopoly are large relative to duopoly. However, we adopt this assumption to simplify the exposition, and we explain the possibility of corner solutions in footnote 24.

Fig. 1 Nash bargaining outcomes with and without transfers

the split of the surplus $\tilde{\lambda}$ does not equal λ in this case (NR). Indeed, the entrant's ex post share of the surplus, $\tilde{\lambda}$, henceforth simply λ , is given by¹⁵

$$u_d^{NR} = L_d + \tilde{\lambda} (u_m^{NR} + u_d^{NR} - L_m - L_d), \quad (8)$$

or, with some manipulation, by,

$$\frac{1 - \tilde{\lambda}}{\tilde{\lambda}} = \frac{u_m^{NR} - L_m}{u_d^{NR} - L_d}. \quad (9)$$

Inserting (9) in (7) leads to

$$-h'_{NR}(u_d^{NR}) = \frac{\lambda}{1 - \lambda} \frac{1 - \tilde{\lambda}}{\tilde{\lambda}}.$$

¹⁵ We are slightly abusing notation here by not using $\tilde{\lambda}^{NR}$.

and we rearrange to obtain the expression for $\tilde{\lambda}$ as a function of λ

$$\tilde{\lambda}(\lambda) = \frac{1}{1 + \frac{1-\lambda}{\lambda}(-h'_{NR}(u_d^{NR}))}. \quad (10)$$

Remark that the exogenous bargaining power of the entrant λ equals the ex post share of the surplus of the entrant λ when the linear bargaining set has a negative 45° slope, i.e., is symmetric (i.e., $-h'_{NR}(u_d) = 1$ for all u_d). Turning to the extreme cases where the entrant has all of the bargaining power ($\lambda = 1$) and the patent holder has all of the bargaining power ($\lambda = 0$), the party without bargaining power then always receives payoffs equal to those of litigation regardless of the possibility of making reverse payments leaving the remainder to the other party.

Finally, to characterize the bargaining outcomes we need to calculate the function $h_{NR}(u_d)$. We do so with the aid of Fig. 1. When $T = 0$, both parties realize duopoly profits π_d . And when $T = 1$, the entrant makes zero profits, while the incumbent obtains monopoly profits throughout the whole period. We assume that the entrant and the patent holder face constant trade-offs as a function of T , leading to a linear frontier of the bargaining set, so

$$h_{NR}'(u_d) = -\frac{\pi_m - \pi_d}{\pi_d}, \quad (11)$$

where $|h_{NR}'(u_d)| \geq 1$ by (1). Since $|h_{NR}'| \geq 1$, for any $\lambda \in (0, 1)$, it must be that $\tilde{\lambda} < \lambda$. In addition, we can write

$$u_m = h_{NR}(u_d) = \pi_m - \frac{\pi_m - \pi_d}{\pi_d} u_d. \quad (12)$$

The bargaining set in this case is therefore the trapezoid $\overline{\pi_m, A, \pi_d}$.¹⁶ Now, recall that we assumed $L < (1 - \theta)\pi_d$. In addition, in order for a settlement without reverse payments to be individually rational relative to the disagreement point represented by the expected litigation payoffs (L_d, L_m) , remark that (consistent with the display in Fig. 1) $L_d < \pi_d$ and $L_m < \pi_m - \frac{\pi_m - \pi_d}{\pi_d} L_d$.¹⁷

Hence, the solution is given by the point of tangency of the same Nash product (function of the exogenous bargaining power λ) on the frontier, (u_d^{NR}, u_m^{NR}) .

Let us now denote the incremental monopoly gains with respect to duopoly (or, equivalently, the absolute value of the slope of the bargaining set) with $\Delta \equiv \frac{\pi_m - \pi_d}{\pi_d} > 1$.¹⁸ Note that $\tilde{\lambda}(\lambda) < \lambda$, which is true because in the but-for world, every unit of utility transfer from the incumbent to the entrant is associated with a

¹⁶ Note that the points $(L_d, \pi_m - L_d)$ and $(\pi_m - L_m, L_m)$ are not feasible without reserve payments.

¹⁷ It follows immediately that $L_m + L_d < \pi_m$ so that a settlement with reverse payments is possible.

¹⁸ Jacobo-Rubio et al. (2019) provide some evidence that the incumbent brands' stakes in patent litigation are greater than the generic entrant's.

$1 - \Delta < 0$ loss of total surplus. In the negotiation game, the entrant internalizes this cost, which leads to a lower split of the surplus than its bargaining power.¹⁹

In Fig. 2, we plot the split of the surplus λ against the exogenous bargaining power λ , for various values of Δ . Note that, as Δ increases, the difference between λ and $\lambda(\lambda)$ increases. This means that as the monopoly is more profitable, the error of using bargaining power as a prediction for the split of the surplus when transfers are not allowed also increases. Conversely, if $\pi_m \approx 2\pi_d$, the error is small.

To compute (u_m^{NR}, u_d^{NR}) accurately, we plug (9) and (10) into (7) and obtain

$$u_m^{NR} = \pi_m - \frac{\pi_m - \pi_d}{\pi_d} u_d^{NR} \text{ and } u_d^{NR} = \pi_d(1 - T^*),$$

where the entry date T^* is

$$T^* = \min \left\{ \max \left\{ 0, \theta + \frac{L((1 - \lambda)\pi_m - \pi_d)}{\pi_d(\pi_m - \pi_d)} \right\}, 1 \right\},$$

where the min and max functions are used to ensure that the solution is bounded by one and zero.²⁰ These results imply that both parties are worse off without reverse payments. Intuitively, this occurs because, on the one hand, the agreed upon entry date is no longer the patent expiration, and on the other hand, it is more expensive for the patent holder to leave surplus to the entrant.²¹

Remark that in the case where $L = 0$, the model yields $T^* = \theta$, since that is the only feasible point in the frontier of the bargaining set where both parties get at least their litigation payoffs (In Fig. 1, when $L=0$, the intersection of L_m and L_d would fall on the segment π_m, A). Intuitively, when litigation is free, the parties will not agree on a distribution of rents different than what they would achieve during litigation. When L is different than zero, its effect on T^* is mediated by the factor $\frac{(1-\lambda)\pi_m - \pi_d}{\pi_d(\pi_m - \pi_d)}$. Then, for instance, if the entrant had considerable exogenous bargaining power (λ), an increase in the litigation costs would favor the entrant as the parties would agree on an earlier entry date.²² Furthermore, as λ , the exogenous bargaining power of the entrant, increases, the but-for entry date is earlier, which can be explained by the fact that the party with more bargaining power can obtain a more favorable outcome.

¹⁹ We thank an anonymous referee for this interpretation.

²⁰ It can be shown that the solution needs to satisfy the following condition for λ : $\frac{L\pi_m}{(\pi_m - \pi_d)(L - \pi_d(1 - \theta))} < \lambda < \frac{L\pi_m}{(\pi_m - \pi_d)(L + \pi_d\theta)}$. Since we assumed $L_d = (1 - \theta)\pi_d - L > 0$, the left-hand side of the condition is always satisfied, hence our solution for T^* applies when $\lambda = 0$. When $L_m \geq \pi_d$, the solution also applies when $\lambda = 1$, noting that one needs to be careful when $L_m = \pi_d$, which renders $T^* = 0$ using the same formulation. When $L_m < \pi_d$, we have $T^* = 0$ whenever $\lambda \in [\lambda^*, 1] = [\frac{(\pi_m - \pi_d)(L + \lambda\pi_d)}{\pi_m L}, 1]$.

²¹ Formally, the difference between the outcome utilities for the entrant and the patent holder are $u_d^R - u_d^{NR} = \frac{\lambda(\pi_m - 2\pi_d)((1 - \theta)(\pi_m - \pi_d) + L)}{\pi_m - \pi_d} > 0$.

$$u_m^R - u_m^{NR} = \frac{(1 - \lambda)(\pi_m - 2\pi_d)(\pi_d(1 - \theta) - L)}{\pi_d} > 0.$$

²² Formally $\frac{\partial T^*}{\partial L} < 0$ if and only if $\lambda > \frac{\pi_m - \pi_d}{\pi_m}$.

Fig. 2 Split of the surplus $\tilde{\lambda}$ for different values of Δ

4.1 Assuming the Split of the Surplus Remains Constant Overestimates Delay

In this subsection, we calculate the entry delay implied by the Nash bargaining solution when the split of the surplus (i.e., the bargaining power parameter) is kept constant across both types of settlements (with and without reverse payments). In this model, the actual entry date when reverse payments are used is 1.

First, note that for any split of the surplus S , the entry date T follows, without loss of generality, from the following equation:

$$\frac{\pi_d(1-T) + \pi_m T - (\pi_d(1-\theta) + \theta\pi_m - L)}{\pi_d(1-T) - (\pi_d(1-\theta) - L)} = \frac{1-S}{S} \quad (13)$$

Now, denote $\hat{T}$ as the but-for entry date under the erroneous assumption that the split of the surplus remains constant in the actual and but-for worlds. In that case, the split of the surplus is exactly equal to the entrant's bargaining power, i.e. $S = \lambda$. Hence, we conclude that in the but-for world, the solution $\hat{T}$ is given by $\hat{T} = T(\lambda)$, that is, when the exogenous parameter λ is used as the split of the surplus from the reverse-payments game ($\lambda = S$)²³

$$\hat{T} = \min \left\{ \max \left\{ 0, \theta + \frac{(1-2\lambda)L}{\lambda(\pi_m - 2\pi_d) + \pi_d} \right\}, 1 \right\}.$$

Given this result, simple algebra shows that $T^* \geq \hat{T}$ whenever $\pi_m - 2\pi_d \geq 0$, and therefore $1 - T^* \leq 1 - \hat{T}$.²⁴

²³ To illustrate this conclusion, note that Eq. (11) defines a one-to-one function $T(S)$. Then, $T^* = T(\lambda)$ for any bargaining power λ , and $S = \hat{\lambda}(\lambda)$ is an endogenous outcome of this game for a given λ (see Eq. (10) for the expression $\hat{\lambda}(\lambda)$).

²⁴ This is true because $T^* \geq \hat{T}$ is true for all $\lambda \in [0, 1]$ and applies to all interior and corner solutions.

Fig. 3 Estimated delay in both models (for $\theta = 0.5$, $L = 1$, $\pi_d = 10$, and $\pi_m = 30$)

Since the entry delay is defined as $1 - T$, the erroneous method overestimates delay and hence damages (see Fig. 3).²⁵ The intuition for this result is that when reverse payments are not permitted, the correct split of the surplus for the entrant is always smaller than its exogenous bargaining power parameter (see Fig. 2). Hence, the correct but-for entry date T^* occurs later to account for a split of the surplus that rewards the entrant less. Conversely, the incorrect entry date $\hat{T}$ occurs earlier since it is based on a split of the surplus that is more favorable to the entrant.

Practitioners may erroneously estimate the entry date as $\hat{T}$, not T^* . However, only T^* would be the correct entry date.

5 Conclusion

In this paper, we first show that the parameter in Nash bargaining problems that exogenously characterize the bargaining power of the parties does not necessarily correspond to the split of the surplus in the case where reverse payments are not allowed. Then, we show that ignoring the distinction between the bargaining power and split of the surplus leads to an overestimation of entry delay in pharmaceutical reverse payment cases, which can in turn lead to an overestimation of damages. Practitioners, therefore, should be wary of this difference when considering the application of the Nash bargaining solution to problems where the structural conditions of the negotiation change. In particular, an estimate of bargaining power from the actual world cannot be used to calculate the split of the surplus in the but-for

²⁵ Lemus and Temnyalov (2020) show that in cases where payments between the parties are not permitted, ignoring the introduction of follow-on products by the incumbent patentholder can lead to an earlier settlement entry date.

world where reverse payments are not permitted. Using our proposed correction to the formulation of the split of the surplus, everything else being equal, the estimated entry delays will be shorter and damages will be lower.

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