Fairness and Bargaining Efficiency under Deadlines: Experimental Evidence*

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Abstract

Monopolists often exploit a deadline to boost their bargaining power, but historically, experiments document significant compromises in ultimatums. Motivated by this gap between theory and the real world, I explore whether the market designer can leverage the fairness of the monopolist to restore the extracted bargaining efficiency. Employing a durable goods monopolist model under a deadline, I show that a threat of an earlier breakdown facilitates a trade by triggering a compromise even from the rational monopolist. I test these insights in approximately 1,200 pieces of randomly matched trade data from a laboratory experiment to find that the threat device is even more robustly effective; a non-zero threat augments the overall efficiency from shrinking delays until agreement and deterring breakdowns by inciting the fairness of monopolists.

JEL Classification: C78, C91

Keywords: bargaining, durable goods monopoly, fairness, deadline effect, laboratory experiment

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1 Introduction

The power of the monopoly in the modern economy is rising (see, for example, Autor et al. (2020) for the rise of superstar firms in the U.S.). In the cut-throat business world, dominant industry players force a favorable business contracts on sub-contractors, monopolistic pricing on clients and challenging labor conditions on unions. Analogous to a conventional dead weight loss under the monopolistic market, the heightened monopoly power extracts the surplus, leading to an uneven distribution in bilateral trades. Moreover, the monopolist may generate an efficiency loss; business negotiations are often lengthy and sometimes, breaks down.

Theoretically, the popular source of the monopolistic power stems from a deadline, where no future negotiation is possible. By credibly committing to an end point, the monopolist can kill the possibility of future compromises, framing the offer as an ultimatum. Employed in a conventional durable goods monopolist model under asymmetric information (Stokey (1981), Bulow (1982) and Sobel and Takahashi (1983)), the deadline significantly empowers the monopolist $--$ but more importantly, it harms the efficiency from frictional delay and potential breakdowns, leading to non-Pareto optimal outcomes.[1]

However, the experimental evidence of bargaining draws a drastically different picture of the monopolists. Especially in hundreds of ultimatum game laboratory experiments[2], albeit under a different context from durable goods monopoly, an average proposer offers between 30% and 50% of the money, and more than half of the opponents reject the proposal with his share under 20%. (See Camerer (2003) for a survey). The canonically reported compromise is viewed as displaying a preference for *fairness*[3], conflicting with an exploitative view of monopolists.[4]

Motivated to explore this gap between theory and experimental evidence, I examine whether

[1]In the context of strikes in labor disputes, the "Hicks Paradox" states that rational parties cannot reach a non-Pareto optimal outcome in a bargaining model under complete information. (Hicks (1963)) Embedding asymmetric information is a standard solution to this paradox (See, e.g., Hart (1989); Cramton and Tracy (1992)) as in my workhorse model.

[2]In an ultimatum offer game, a proposer offers a division of the pie to the opponent, and the division binds if the opponent accepts. If the opponent rejects, both get 0 as normalized outside options. The sub-game perfect equilibrium is that the proposer demands the whole pie, and the responder accepts even the extremely unfair offer. My model with $N = 1$ can be framed as a variant of an ultimatum offer game under incomplete information.

[3]Alternatively, experimental literature calls fairness a form of inequality aversion, equity, or reciprocity. In this paper, I consistently use this term of fairness.

[4]Negotiating with a single seller is typical in one-on-one transaction platforms. (e.g., e-bay) Analyzing the millions of negotiations on eBay, Backus et al. (2020) report that cooperative behaviors are ubiquitous across both parties.

a market designer can effectively leverage the fairness of the monopolist to achieve a fairer distribution and restores the trimmed bargaining efficiency. I start with a baseline bargaining model under a deadline (*a la* Sobel and Takahashi (1983)). Consider a *rational* monopolist ("he") selling his goods of infinite supply with a marginal cost which is normalized to 0 within N periods. A demand-side group comprises a continuum of buyers ("she") with a private value from 0 to 1. The marginal cost and the distribution of the values are common knowledge. The monopolist can update a price every period, and a buyer reacts by agreement or rejection. The trade continues until the buyer accepts the price; when the deadline arrives, both fall back to outside options, which is also 0.

Suppose that a market designer imposes a threat of breakdown at an earlier period $n^* < N$. (Below, I call this the *threat period* for convenience; see Figure 1).

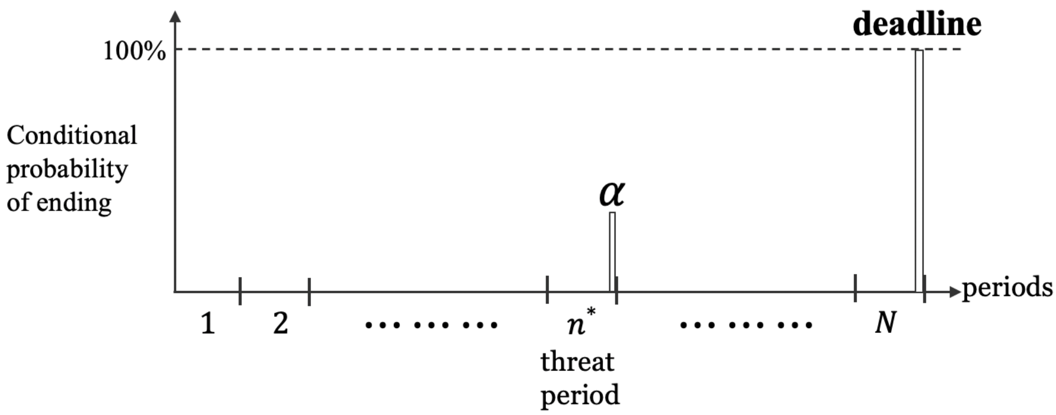

Figure 1: Threat to earlier ending

Note: An intermediate deadline with a conditional breakdown probability $\alpha \in (0,1)$ is imposed at the end of period n^* in contrast to the final deadline at period N. The negotiation might end at the end of n^* with probability α but continue with probability $1-\alpha$. In the main text below, I allow for multiple threat periods for generality. For a laboratory experiment, by contrast, I use $n^* = 3$ and $N = 6$.

Intuitively, the threat is a stochastic *time bomb*, characterized by a conditional probability α: if the buyer at period n^* rejects the offer, they are forced to leave the table by a probability of α, and seek outside options of 0. If $\alpha = 0$, this is nothing beyond an original setting. If $\alpha = 1$, this becomes shorter-horizon bargaining with a deadline on $N = n^*$. The model analytically shows that with an interior magnitude of threat ($\alpha \in (0,1)$), even a rational monopolist is induced to offer a compromised price schedule accompanied by a compromise from a buyer. (See Figure 2 for predicted behaviors of both parties.)

This compromise is founded on the forward-looking reasoning of the monopolist. For example, suppose that the buyer rejects at the threat period n^* despite a positive breakdown risk.

Then, her value is credibly shown as substantially low. If the breakdown does not occur, the monopolist is tempted to discount the price at $n \geq n^* + 1$ if the negotiation continues. Because a monopolist foresees the possibility of his own price discrimination, he offers a compromised prices at periods $n \leq n^*$ with a lower opening price. However, if α is close to 1, the model appears closer to an ultimatum game. The monopolist jacks up the price path, just backfiring to the buyers.

I demonstrate that when both parties are sufficiently patient, the bargaining ex-ante can achieve the highest efficiency with an optimal threat $\alpha^* \in (0,1)$, characterized by bargaining primitives. This finding mirrors a dynamic trade-off between the deterrence effect and breakdown effect of the threat α: if α is small, the risk facilitates the compromise of both parties in contrast to an expected cost of a breakdown. However, if α is large, the game resembles an ultimatum game, and an expected breakdown cost dominates the efficiency benefit of risk-induced compromise. To uncover the mechanism behind it, the simulation of a parameterized model shows that the optimal threat (α^*) shortens the expected trade period and suppresses an ex-ante breakdown probability, retrieving the overall efficiency. As a distributional implication, I also show that α^* ex-ante achieves the most favorable surplus share for the buyer.

Employing the rational monopolist model as a benchmark, I ask a behavioral question of whether this design of earlier threat of breakdown serves as a stochastic analog of ultimatum, prompting fairness in a flesh-and-blood monopolist. As a vast body of ultimatum experiments demonstrated, if a monopolist is destined to display fairness before the deadline, the stochastic *time bomb* should induce some compromise from the monopolist, even in the seller-buyer framework under asymmetric information.

To empirically test the device's validity, I designed and implemented a laboratory experiment for four days at the Missouri Social Science Experimental Laboratory (MISSEL) at Washington University in St. Louis. I obtained approximately 1,200 pieces of trade data from sixty-two subjects. The subjects were randomly chosen to engage in a bilateral bargaining game ($N = 6$) under various threat levels predetermined at the middle threat period ($n^* = 3$). The experiment broadly supports the key features of the model. Expectedly, I find the monopolists' *irrational* cooperative behaviors very robust during the threat and terminal periods, which diverges from the *rational* monopolist model. Moreover, the magnitude of *irrational* compromise expands as earlier breakdown becomes credible. Therefore, I interpret these compromises as a display of fairness from the monopolist side. Augmented by the compromise out of fairness, the buyer is more likely to agree on the threat period.

Consequently, I find that the threat-induced compromises from both parties may restore the efficiency and distributional share of the buyer's expected surplus, leading to fairer outcomes. Because this behavioral bias supposedly applies differentially across institutional contexts[5], I conclude that my rational monopolist model delivers a lower bound of the efficiency gain generated from the threat of breakdown. In the real world, I argue that this predicted irrationality of the proposer might potentially tilt up the equilibrium in favor of the responders.

This paper contributes to two strands of experimental literature on bilateral bargaining. First, as stated above, the study is well-aligned with a large body of experimental literature reporting cooperative behaviors in non-cooperative games, both within ultimatum games (the game was first experimented with by Güth, Schmittberger and Schwarze (1982); and its variants were then tested (e.g. Croson (1996); Gneezy, Haruvy and Roth (2003)). See Güth and Kocher (2014) for a review.) and outside the ultimatum games (e.g., Neelin, Sonnenschein and Spiegel (1988). See Camerer (2003) for a survey). Furthermore, I find that the proposer's compromise is substantially driven by *irrational* concessions of proposers on the threat period and the terminal deadline.

In the second strand, last-minute agreements before deadlines have been robustly demonstrated as the leading cases of the *deadline effect*, both in the real world (Cramton and Tracy (1992) for labor group disputes; Spier (1992) for pre-trial negotiations; Roth and Ockenfels (2002) for last-minute bidding observed in internet auctions), and in the controlled laboratory experiments (e.g., Roth, Murnighan and Schoumaker (1988)). Consistent with the literature, I document that last-minute agreements occur even under a stochastic deadline; when the threat of breakdown becomes more credible, more trades reach agreements on the threat period. To my knowledge, this study is the first attempt to empirically test the effect of deadline credibility on bargaining outcomes.

Layout: The paper is organized as follows: Section 2 presents a bargaining framework with the threat of breakdown and characterizes the unique equilibrium. Then, I explore the overall efficiency and distributional outcome's sensitivity concerning the intensity of the threat and the ex-ante probability of a breakdown and delay until agreement. Next, section 3 presents the design and findings of the laboratory experiments. Finally, section 4 concludes the paper. The

[5]See List (2007) for a caution regarding the external validity of laboratory experiments.

Appendix provides auxiliary proofs of theoretical results and administration of experiments.

2 Bargaining with Threat of Breakdown

I build a benchmark model of a rational monopolist based on a finite-horizon durable goods monopolist model under asymmetric information. (See e.g., Fudenberg, Levine and Tirole (1985); Fuchs and Skrzypacz (2013))

2.1 Setup

A monopolist ("he") sells a durable good on a market of buyers ("she") with unknown private values. The market has no supply shortage with a zero marginal cost for each good, which is common knowledge. Each infinitesimal buyer has her private value $v \in [0,1]$ for the good. I assume that v is distributed according to the shared cumulative distribution function $F(v) = v^{\sigma}\,(\sigma > 0)$.[6] Suppose that both are rational and risk-neutral.

Time is measured into discrete and finite periods with $n = 1,2,3\cdots$ and a length $\Delta > 0$ for each bargaining round. Suppose that the monopolist credibly imposes a deadline at period N. At the beginning of the period n, the monopolist proposes an offer P_n. Then, the buyer immediately accepts or rejects. If she accepts the price at the end of period n, the game ends up with an outcome: the monopolist gets $\delta^{n-1}P_n$, and the buyer gets $\delta^{n-1}(v - P_n)$, where $\delta \in [0,1]$ is a periodic discount factor. If she keeps rejecting the price until $n = N$, both get 0 as an outside option.[7]

Suppose that a market designer imposes a series of threats of breakdown at an earlier period $n^*_d \in [1,N)$ $(d \in [1,\cdots,D])$, what I call *threat periods.* (For simplicity, a subscript d is omitted throughout the paper, especially when only one threat period is imposed $(D = 1)$). The threat's credibility is captured by a conditional breakdown risk $\alpha_d \in (0,1)$ at the end of each threat period n^*_d. (See Figure 1) This capture implies that if a proposal is rejected at period n^*_d, bargaining ends with probability α, and both get outside options, but proceeds to period $n^*_d + 1$ with probability $1-\alpha$.

[6]This distributional assumption is taken due to analytical convenience (See Ausubel and Deneckere (1992), Fuchs and Skrzypacz (2013)).

[7]The model presumes no gap between a marginal cost and the lowest value of the buyer (so called a "non-gap" case in the bargaining literature), suggesting that some buyers cannot trade.

The problem of the monopolist is recursively defined as follows:

$$\max_{P_n} \Gamma(P_n)P_n + \{1-\Gamma(P_n)\}\eta_n \delta V_{n+1}$$

Where $\Gamma(P_n)$ is a probability of agreement at period n if he offers P_n. V_n is his value function at period n, and η_n is a risk adjustment factor attached to a discount factor δ such that $\eta_n = 1-\alpha_d$ $(n = n^*_d)$, and $\eta_n = 1$ $(n \neq n^*_d)$. The buyers' problem is to choose the acceptance period $\widehat{n}$ given the monopolist's price schedule of $\{P_n\}$ such that

$$\widehat{n} = \arg\max_n \Pi \eta_n \delta^{n-1}(v-P_n).$$

2.2 Equilibrium

Both players share the posterior of private value as a belief system. (See Sobel and Takahashi (1983) and Fudenberg, Levine and Tirole (1985) for the theoretical foundation.) Let $[0, K_n)$ be a posterior valuation at period n, and both players know K_n at period n as an upper bound of private value v. Given K_n and P_n, the buyer calculates the cutoff value C_n satisfying:

$$\underbrace{C_n - P_n}_{\text{payoff of agreement today}} = \underbrace{\eta_n \delta (C_n - P_{n+1})}_{\text{payoff of agreement tomorrow}} \tag{1}$$

Intuitively, (1) implies that a marginal buyer with a value $v = C_n$ is indifferent between buying today and tomorrow. Then, at period n, the buyer's cutoff strategy is to accept P_n if $v \geq C_n$ and rejects if $v < C_n$. Therefore, $\Gamma(P_n) = \dfrac{F(K_n) - F(C_n)}{F(K_n)}$ $(\forall n \in \{1, \cdots, N\})$ holds. Immediately from the buyer's cutoff strategy, the belief system of the posterior valuation is characterized by the buyer's cutoff such that

$$C_n = K_{n+1} \ \ (\forall n \in \{1, \cdots, N-1\}), \tag{2}$$

suggesting that cutoff at period n serves as a posterior at period $n+1$, constituting a belief system. Then, employing $\{K_n\}$ and $\{(P_n, C_n)\}$, I introduce a standard perfect Bayesian equilibrium.

Definition 1. *Given the a belief system $\{K_n\}$, both parties take mutual best responses from a pair of strategies $\{(P_n, C_n)\}$ after every history of the game as a perfect Bayesian equilibrium.*

2.3 Equilibrium Paths

The model is solved by backward induction. The schedules $\{(P_n, C_n)\}$ of both players are periodically pinned down by a pair of sequences $\{(A_n, B_n)\}$ as follows.

Proposition 1. [Equilibrium schedules and bargaining powers]

Given the state variable $\{K_n\}$ at period n, the equilibrium path of $\{(P_n, C_n)\}$ $(n \in \{1, \cdots, N\})$ is sequentially characterized as

$$P_n = A_n K_n \text{ and } C_n = B_n P_n \tag{3}$$

where the following difference equations recursively characterize $\{A_n\}$ and $\{B_n\}$:

$$\begin{cases} A_n = ((\sigma+1) - \sigma\eta_n\delta A_{n+1}B_n)^{\frac{-1}{\sigma}}/B_n & (n \in \{1, \cdots, N-1\}) \\ B_n = \{1 - \eta_n\delta(1 - A_{n+1})\}^{-1} & (n \in \{1, \cdots, N-1\}), \\ A_N = (1+\sigma)^{\frac{-1}{\sigma}};\ B_N = 1 & \end{cases} \tag{4}$$

The monopolist's and the buyer's value functions, V_n and W_n, respectively, are characterized as follows by $\{A_n\}$:

$$V_n = A_n K_n \mathbb{E}(v),\ \ W_n = (1 - \frac{\sigma+2}{\sigma+1} A_n) K_n \mathbb{E}(v)$$

where $\mathbb{E}(v) = \dfrac{\sigma}{\sigma+1}$ is an ex-ante expected private value.

See Appendix for proofs. Intuitively, A_n is monopolistic, and B_n is the buyer's bargaining power. By backward recursion, A_n and B_n are functions of primitives $\delta, \sigma, \alpha_d, n_d^*, N$. (See Appendix for explicit formula.) The analytical convenience of a functional form of $F(v) = v^{\sigma}$ yields that both P_n and C_n are linear in K_n, combined with A_n and B_n. In equilibrium, the model's recursive structure regulates that the monopolist chooses P_n only based on K_n, regardless of a history of prices $\{P_1, \cdots, P_{n-1}\}$. Likewise, using (1) and (2), the buyer chooses C_n only based on K_n. In the durable goods monopoly with a demand pool of buyers, W_n is interpreted as the collective buyer's option value at the beginning of period n. Analogous to prices and cutoffs, the value functions V_n, W_n of both the monopolist and the buyer are also linear in the state variable K_n. V_n and W_n split a share of $\mathbb{E}(v) = \dfrac{\sigma}{\sigma+1}$ or the ex-ante total pie of the bargaining. The sum of the value functions at the initial period characterizes the bargaining efficiency in the next section.

Then, how do both players behave in equilibrium? Figure 2 illustrates the simulated paths of prices and cutoffs under a set of parameters $\delta = 0.98, \sigma = 1$. First, the buyer's cutoff curve sharply drops at $n^* = 3$ and $N = 6$ (left in Figure 2). The drop at $N = 6$ is a canonical *deadline*

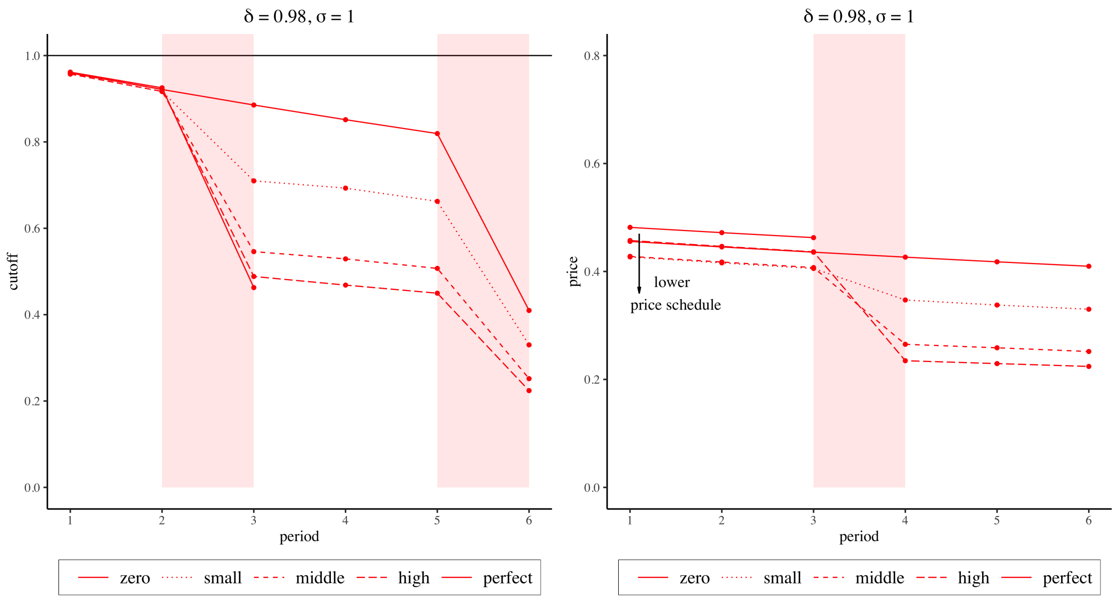

Figure 2: Cutoff and price dynamics across the levels of threat (left: cutoff; right: price)
Note: The model is simulated under an experimental setting. ($n^* = 3, N = 6, D = 1$. See Figure 1.) A threat is zero if $\alpha = 0$, small if $\alpha \in \{0.05, 0.1, 0.2, 0.3\}$, middle if $\alpha \in \{0.4, 0.5, 0.6\}$, large if $\alpha \in \{0.7, 0.8\}$ and complete if $\alpha = 1$. I simulate the theoretical average prices within the threat category, weighted by the number of experimental observations of each environment. (See section 3.1 for an experimental setting.) The red shades feature deadline effects for a buyer at $n = 3, 6$ (left) and a big sale of a monopolist at $n = 4$ (right).

effect, while the one at $n^* = 3$ corresponds with a stochastic version. Second, due to the cutoff drop at $n^* = 3$, the monopolist performs a conspicuous compromise just after the threat period $n = 4$ (right in Figure 2). This big sale is new to my model; as the monopolist knows the cutoff drop at $n^* = 3$ and infers that the remaining buyer's value at $n = 4$ is significantly bounded from above, he is rationally price discriminating. As the threat level increases, more buyers agree on the threat period. Therefore, the sales of the price expand. Moreover, before the threat period, an opening price is lower when the threat is minor ($\alpha \in [0.05, 0.1, 0.2, 0.3]$) or moderate ($\alpha \in [0.4, 0.5, 0.6]$) relative to when the threat is zero. The compromises of the both parties are tested in the laboratory.

2.4 Efficiency Gain

Theoretically, the central question is how the overall efficiency responds to the intensity of the threat of breakdown. To see this, I define the bargaining efficiency as the sum of the players' ex-ante expected payoffs at $n = 1$ before the private value v is realized such that

$$U \equiv V_1 + W_1 = (1 - \frac{A_1}{\sigma + 1})\mathbb{E}(v). \tag{5}$$

One can see that U is strictly decreasing in A_1, or an ex-ante monopoly power. Given the specification, below is the crucial theoretical result of the paper.

Proposition 2. [Efficiency gain from threat]

Suppose that the players are sufficiently patient. Then, $\alpha_d^* \in (0,1)$ exists that uniquely maximizes U s.t.

$$\alpha_d^* = \frac{\delta A^2_{n_d^*+1} - (1-\delta)\{(1+\sigma) - (2+\sigma)A_{n_d^*+1}\}}{\delta(1 - A_{n_d^*+1})(1 + \sigma - A_{n_d^*+1})}. \tag{6}$$

where $A_{n_d^*}$ is a function of primitives $A_n \delta, \sigma, \alpha_d, n_d^*$ and N.

[***Sketch of the Proof***] Evidence supporting $\alpha_d^* \in (0,1)$ to satisfy the first-order condition (F.O.C.) $\frac{dU}{d\alpha_d} = 0$ and the second-order condition (S.O.C.) $\frac{d^2U}{d\alpha_d^2} < 0$. First, one gets the F.O.C. as

$$\frac{dU}{d\alpha_d} = -\frac{\mathbb{E}(v)}{(\sigma+1)^2}\frac{dA_1}{d\alpha_d} = -\frac{\mathbb{E}(v)}{(\sigma+1)^2}\underbrace{\frac{dA_1}{dA_{n_d^*}}}_{(>0)\text{ Appendix}}\frac{dA_{n_d^*}}{d\alpha_d} = 0. \tag{7}$$

In Appendix, I show $\frac{dA_1}{dA_{n_d^*}} > 0$. The F.O.C. (7) is reduced to

$$\frac{dA_{n_d^*}}{d\alpha_d} = \delta(1 - A_{n_d^*+1})(1 + \sigma - A_{n_d^*+1})\alpha - \delta A^2_{n_d^*+1} + (1-\delta)\{(1+\sigma) - (2+\sigma)A_{n_d^*+1}\} = 0.$$

Solving for α, one gets the desired α_d^* in (6). (The detailed derivation and the S.O.C. are shown in Appendix.) Then, I show that $\alpha_d^* \in (0,1)$. Using (6), $\alpha_d^* > 0$ requires a sufficiently large $\delta > \delta^*$; the threshold discount factor is given by

$$\delta^* = \frac{(1+\sigma) - (2+\sigma)A_{n_d^*+1}}{(1+\sigma - A_{n_d^*+1})(1-A_{n_d^*+1})}.$$

Suppose $\alpha_d^* \geq 1$. Then by (6), $A_{n_d^*+1} \geq \dfrac{1+\sigma}{2+\sigma}$ must hold. Because $A_{n_d^*+1} < A_N = (1+\sigma)^{-\frac{1}{\sigma}} < \dfrac{1+\sigma}{2+\sigma}$ $(\forall \sigma > 0)$ holds, this is a contradiction. Therefore, $\alpha_d^* < 1$. $\square$

The theorem shows that given the specific threat period n_d^*, some intermediate threat of breakdown maximizes the overall bargaining efficiency. The intuition stems from dynamic trade-off between the deterrence effect and breakdown effect; when the efficiency benefit from avoided breakdown and saved discounting from compromises outweighs the expected termination cost (i.e., breakdown loss), the non-zero threat of breakdown could *enhance* the bargaining efficiency.

Note that the efficiency gain is conditional on sufficient patience of both players because the threat induces compromise only if both parties significantly evaluate the option value of future continuation. When players are highly short-sighted, otherwise, the bargaining loses dynamics and essentially resembles a one-shot ultimatum game.[8]

To illustrate the implication of Proposition 2, Figure 3 shows the inverted-U sensitivity of the efficiency. A simulation of a model parameterized with $N = 6, \sigma = 1, \delta = 0.98$ finds that the overall efficiency is maximized at an interior threat $\alpha^* = 0.28$. With every rise of 10 $p.p.$ of the threat, when $\alpha < \alpha^*$, the expected surplus improves by 0.88 $p.p.$ but otherwise deteriorates by 0.56 $p.p.$ However, when the discount factor is not large $(\delta = 0.7)$, the efficiency is monotonically decreasing in the threat.

From the perspective of bargaining protocol, the source of inefficiency in the durable goods monopoly bargaining stems from asymmetric information and deadline.[9] As Coase (1972) conjectured, without the backup of the deadline, the monopolist loses all the bargaining power, offering the marginal cost pricing.

In my model, this corresponds with the extreme case under the infinite horizon $(N \to \infty)$, U increases to the maximum pie of $\mathbb{E}(v)$. To restore the bargaining power, the monopolist exploits

[8] Güth and Ritzberger (1998) shows that sufficiently high patience is necessary for the Coase conjecture.

[9] Without asymmetric information and a terminal deadline, the monopolist perfectly price discriminates each buyer. In this case, the entire pie goes to the monopolist.

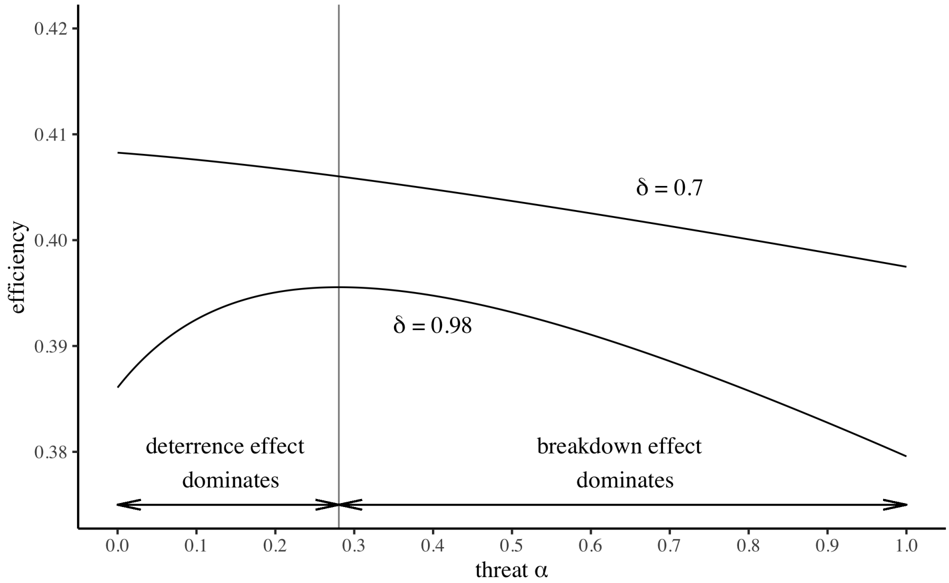

Figure 3: The efficiency curve with respect to the intensity of threat

Note: A model is simulated based on the analytical formula with $N = 6$, $\sigma = 1$, $\delta \in \{0.7, 0.98\}$, and a single threat period is set on $n^* = 3$. The vertical line is the optimal threat $\alpha^* = 0.28$. Deterrence effect is an indirect impact of the threat to enhance the efficiency by facilitating compromises. Breakdown effect is a direct impact of the threat to harm the efficiency.

a deadline. In the extreme case of a one-period ultimatum game ($N \to 1$), the monopolist gains the most potent bargaining power and minimizes the efficiency. My model establishes that even under the multi-stage game $(1 < N < \infty)$, a market designer can partially recover the efficiency by embedding a stochastic deadline with a breakdown probability $\alpha \in (0,1)$ to facilitate compromises from both parties.

To see how the optimal threat level behaves, I simulate its sensitivity concerning the other bargaining primitives δ and σ as depicted in Figure 4. As $\sigma > 0$ increases, a higher-type buyer is less likely to remain after the breakdown, and thus the monopolist finds the current demand pool more lucrative. Therefore, increasing threat strengthens his bargaining power, as suggested by the lower α^*. As $\delta \in (0,1)$ increases, the monopolist focuses more on evaluating the option value of continuation. Thus, increasing threat enlarges the deterrence effect, as indicated by the rise of α^*, dominating the breakdown effect for a broader range of threat $\alpha \in [0, \alpha^*]$. As a durable good monopolist model generates a positive link between the buyer's bargaining power and the overall efficiency, the statement of surplus division is immediately follows below.

Corollary 1. [Fairer distribution from the threat] *Suppose that the players are sufficiently patient. Let α_d^* vary. Then, $\alpha_d^* \in (0,1)$ uniquely maximizes a share of buyers' expected surplus.*

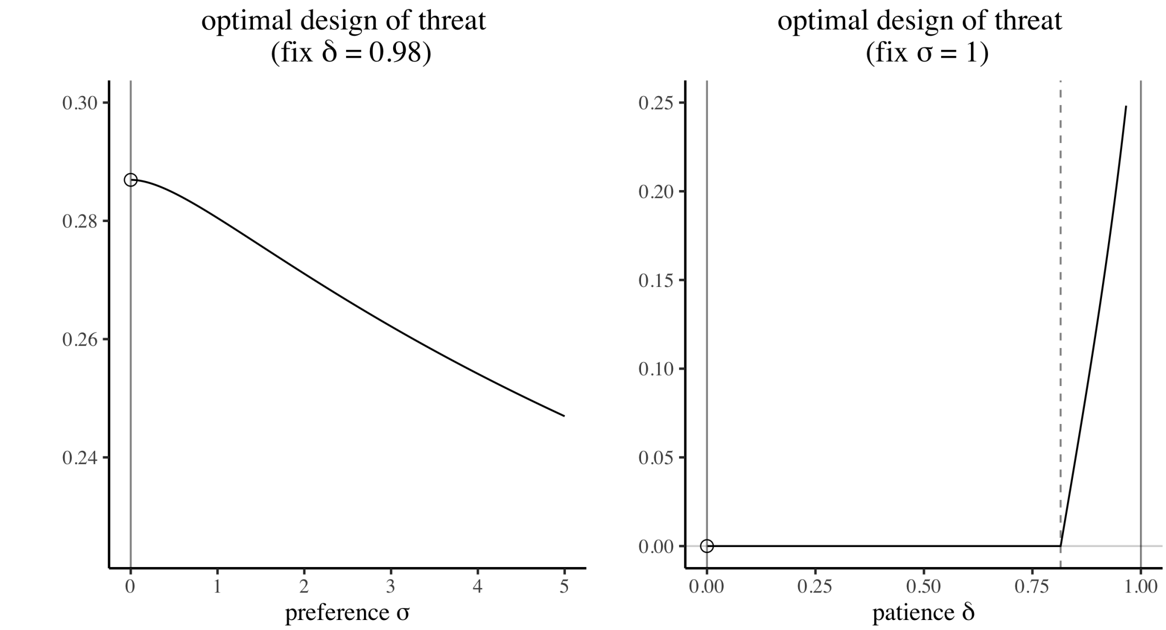

Figure 4: Optimal threat regarding primitives

Note: A formula for $\alpha^*(\delta,\sigma,n^*,N)$ (6) is simulated with $N=6,\sigma=1,\delta=0.98$, and a single threat period is set after $n^*=3$. A vertical dashed line is a threshold patience δ^*. When $\delta\leq\delta^*$and $\sigma=1$, $\alpha^*=0$.

[Proof] By **Proposition** 5, the level of buyers' expected surplus is given by $W_1=(1-\dfrac{\sigma+2}{\sigma+1}A_1)\mathbb{E}(v)$. Combined with (5), the share of buyers' expected surplus is computed by $W_1/U=\dfrac{(\sigma+1)-(\sigma+2)A_1}{(\sigma+1)-A_1}$. W_1/U is strictly decreasing A_1 because $\dfrac{d(W_1/U)}{dA_1}=-(\sigma+1)^2<0$ holds. To see how W_1/U responds with α_d, it is sufficient to analyze the response of A_1 with α_d such that

$$\frac{dA_1}{d\alpha_d}=\underbrace{\frac{dA_1}{dA_{n_d^*}}}_{(>0)\text{ Appendix}}\frac{dA_{n_d^*}}{d\alpha_d}.$$

Therefore, the sign of $\dfrac{d(W_1/U)}{d\alpha_d}$is flipped to $\dfrac{dA_{n_d^*}}{d\alpha_d}$. This implies that the share of the buyer's expected surplus inherits the sensitivity of $A_{n_d^*}$ with α_d. The result follows the proof of Proposition 2.□

As shown in the proof, an optimally designed threat α_d^* yields maximizations in the efficiency and the share of buyer's expected surplus. This implies that the buyers' group enjoys the largest possible premium at the cost of expected breakdown under the optimal threat α_d^*. Figure 5 shows the share (left) and level (right) simulation of the buyer's ex-ante surplus. Under the baseline parameters ($N = 6, n^* = 3$, $\sigma = 1$, $\delta = 0.98$), one can see that the proposer or the monopolist takes the majority of surplus. As in the Figure 3, the share and level of buyer's expected surplus are maximized with α^*.

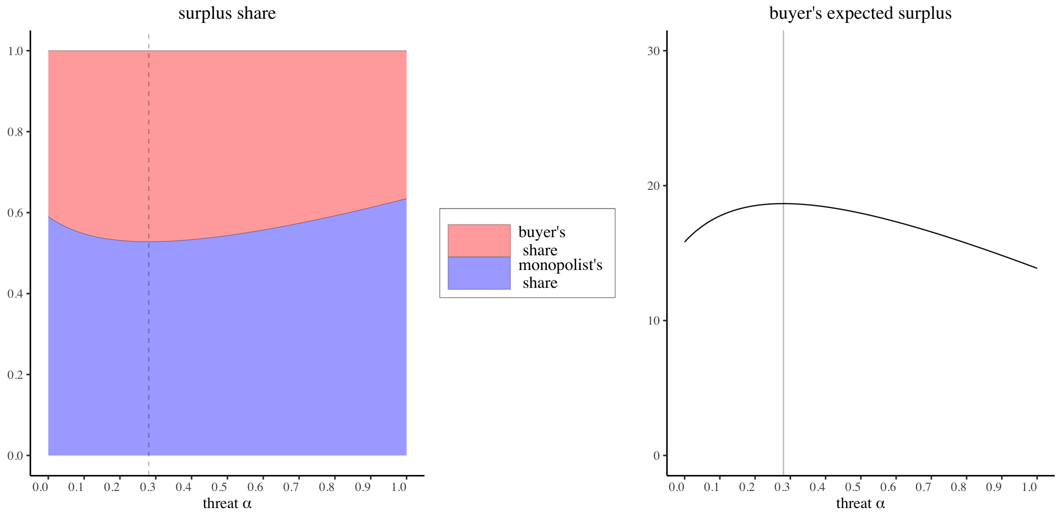

Figure 5: The share (left) and level (right) of buyer's expected surplus regarding the intensity of the threat

Note: A model is simulated based on the analytical formula with $N = 6$, $\sigma = 1$, $\delta = 0.98$, and a single threat period is set on $n^* = 3$. Dashed lines show $\alpha^* = 0.28$.

2.5 Mechanism

In the last section, I showed that the well-designed threat of breakdown augments the efficiency. However, the outcome remains below the Pareto optimality from asymmetric information. Therefore, I complement the efficiency analysis by examining the sources of efficiency loss and threat intensity. In this bargaining protocol, one's loss of the pie stems from potential breakdown and frictional delay. To explore their sensitivity to the threat intensity, I define an ex-ante breakdown probability and a delay until agreement as follows.

Definition 2. [Ex-ante breakdown probability and delay until agreement]

The ex-ante breakdown probability for an infinitesimal single buyer is defined by

$$\underbrace{\alpha_d C_{n_1^*}}_{\text{first threat period } (d=1)} + \underbrace{\sum_{d=2}^{D}\left(\left(\prod_{d'=2}^{D}(1-\alpha_{d'-1})\right)\alpha_d C_{n_d^*}\right)}_{\text{following threat periods } (d\geq 2)} + \underbrace{\prod_{d=1}^{D}(1-\alpha_d)C_N}_{\text{terminal period}}. \tag{8}$$

The ex-ante delay until agreement is defined by

$$\mathbb{E}(\widehat{n}) = \sum_{n=1}^{N} n \left(\prod_{l=1}^{n} \eta_l \right) \underbrace{(K_n - C_n)}_{\text{ratio of buyers of agreement at } n} . \tag{9}$$

Based on Definition 2, I simulate the sensitivity of these two sources of inefficiency with the threat level as depicted by Figure 6.

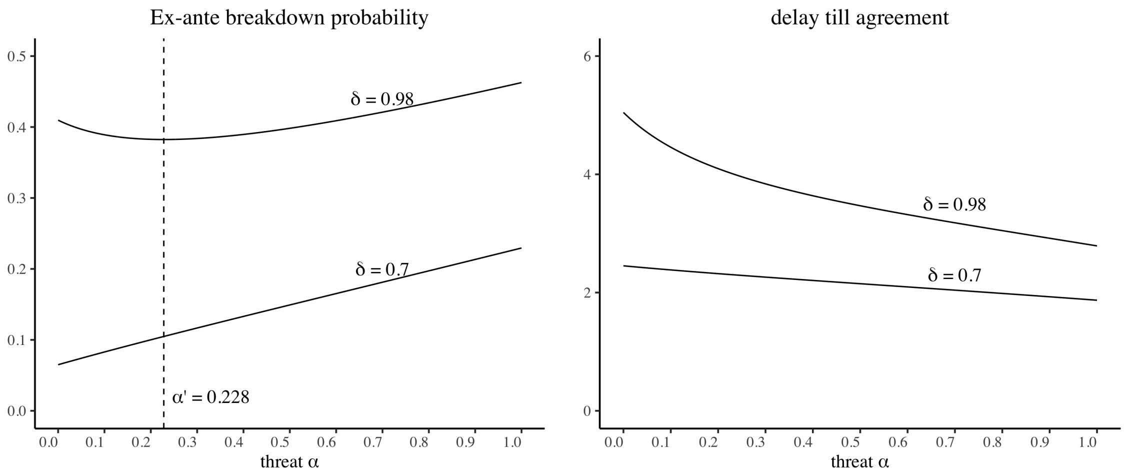

Figure 6: Ex-ante breakdown probability and delay until agreement (simulation)

Note: (8) and (9) are simulated with $N = 6$, $\sigma = 1$, $\delta \in \{0.7, 0.98\}$, and a single threat period is set on $n^* = 3$. When $D = 1$, (8) is reduced to $C_{n^*}\alpha_{n^*} + (1 - \alpha_{n^*})C_N$.

The simulation shows that when the players are relatively patient ($\delta = 0.98$), the ex-ante breakdown probability exhibits a U shape with an interior minimizer $\acute{\alpha} \in (0,1)$. This suggests that for a small range of threats $\alpha \in [0, \acute{\alpha})$, increasing threat *deters* the realization of a breakdown. Under the model with baseline parameters ($\sigma = 1$, $\delta = 0.98$), when $\alpha < \acute{\alpha} = 0.228$, the average effect is $-1.2\ p.p.$ Otherwise, $1.0\, p.p.$ for every rise in $10\ p.p.$ of the threat. This mirrors an inverted-U-shaped efficiency concerning α shown in Proposition 2. When a sufficiently patient player (high δ) cares for the option value after the threat period, the deterrence effect is larger than the breakdown effect for a small threat, generating the initial decline of the U-curve. Moreover, I examine the expected duration of the bargaining conditional on agreement (right in Figure 6). The ex-ante bargaining duration conditional on agreement strictly decreases in α regardless of the discount factor, contributing to another efficiency gain from the threat. The laboratory experiments below also test the predicted breakdown outcomes and delay until an agreement with the threat.

3 Laboratory Experiments

I draw on a laboratory experiment to assess the threat design's efficacy and test the model's key predictions. The operational details of the experiments are in Appendix.

3.1 Setup

Experiments were conducted over four days at the Missouri Social Science Experimental Laboratory (MISSEL) in Washington University in St. Louis. Sixty-two participants joined the experiments under monetary incentives where the payoffs earned during the day were exchanged for their monetary compensation under a linear conversion rate. To operationalize the experiment, I divided the subjects into two groups, and subjects in each group took turns playing as monopolists or buyers. In addition, subjects were informed that they were randomly matched with a different subject across groups in every trade to exclude potential coordination with the same opponent.

I simplified my model into a laboratory version of $N = 6$; $n^* = 3$; $D = 1$. Each environment e was characterized by its unique set of three primitives of the game $\{\alpha^e, \sigma^e, \delta^e\}$. To focus on identifying the effect of threat, I set up environments with a variety of threat levels α^e, along with a common discount factor δ^e (capturing patience) and a shape parameter σ^e for the private value (representing the buyers' preference). Multiple sessions under three sets of parameters $(\sigma, \delta) \in \{(1, 0.98), (2, 0.98), (1, 0.7)\}$ were operated during the day. Within each session, I allowed the threat intensity α^e to vary such that $\alpha^e \in \{0.1m, 0.05\}$, $(m \in \{0, 1, \cdots, 10\})$, allowing for extracting fixed effects of risk sensitivity of each subject (See Table 1 for samples for each environment e). [10] A common discount factor took $\delta^e \in \{0.98, 0.7\}$. Before each trade started, both parties knew their role (monopolist or buyer) and the environment e. A private value for a buyer was drawn from the shape parameter σ^e takes $\sigma^e \in \{1, 2\}$, generating a uniformly distributed or an upward-biased draw of the private value. To help their decision be as dynamically consistent as possible, we asked participants to record all their actions and results on paper (See Appendix for detail).

[10] $\alpha = 0.05$ is intended to examine the effect of a small positive threat, guided by a simulation in Figure 3.

3.2 Descriptive Statistics

3.2.1 Summary

Table 1 summarizes the statistics of the experiment. Excluding trades with research assistants

Environment			Observations		Breakdown			Agreement		
patience δ	preference σ	threat α	player	pair	intermediate cases (n=3)	terminal cases (n=6)		ratio	payoff (monopolist)	payoff (buyer)
0.98	1	**0**	88	35	0	10		0.71	26	16
		0.05	91	41	2	5		0.83	35	14
		0.1	88	38	3	7		0.74	28	15
		0.2	89	39	5	12		0.56	22	11
		0.3	90	41	8	5		0.68	27	14
		0.4	91	40	6	2		0.80	34	17
		0.5	88	37	7	3		0.73	31	14
		0.6	88	38	7	4		0.71	28	14
		0.7	91	41	18	1		0.54	20	10
		0.8	86	36	10	3		0.64	24	18
		0.9	91	38	9	2		0.71	30	14
		1	88	39	9	0		0.77	29	27
	sum		**1,069**	**463**	**84**	**54**	**mean**		**28**	**15**
0.98	2	**0**	60	27	0	2		0.93	42	23
		0.05	59	27	2	1		0.89	45	24
		0.1	60	28	0	1		0.96	36	26
		0.2	59	27	2	0		0.93	41	23
		0.3	59	28	3	1		0.86	39	21
		0.4	59	26	4	1		0.81	38	22
		0.5	60	27	6	0		0.78	41	16
		0.6	60	27	3	0		0.89	41	20
		0.7	59	27	5	1		0.78	36	18
		0.8	60	27	4	0		0.85	43	23
		0.9	59	27	5	0		0.81	38	21
		1	60	27	2	0		0.93	45	23
	sum		**714**	**325**	**36**	**7**	**mean**		**40**	**22**
0.7	1	**0**	57	27	0	7		0.74	17	7
		0.05	80	37	1	8		0.76	18	10
		0.1	57	24	2	5		0.71	20	12
		0.2	80	37	3	8		0.70	13	10
		0.3	80	38	8	4		0.68	18	10
		0.4	80	35	7	1		0.77	20	11
		0.5	55	24	2	0		0.92	33	16
		0.6	57	26	8	2		0.62	17	9
		0.7	78	37	5	1		0.84	25	16
		0.8	57	25	5	2		0.72	22	19
		0.9	80	38	17	0		0.55	19	10
		1	56	25	6	0		0.76	25	20
	sum		**817**	**373**	**64**	**38**	**mean**		**20**	**12**
	aggregate		**2,600**	**1,161**	**184**	**99**	**mean**	**0.76**	**29**	**16**

Table 1: Summary of experiments

and/or timeouts[11] from the outcomes analysis, I obtained 1,161 trades. In total, 788 trades are under the high-patience $\delta = 0.98$, and 373 trades are under the low-patience $\delta = 0.7$. The breakdown is twofold: an intermediate stochastic one occurs at $n^* = 3$, and a terminal deterministic one happens at $N = 6$. The agreement ratio is computed as the pairs reaching agreement over the total pairs within each environment.

Consistent with the model, one can see that the monopolist's mean payoff is persistently larger than the buyer's mean payoff for all environments, suggesting a first-mover advantage

[11]To conduct the experiments efficiently, I imposed a mild time limit on decision-making within each period (30 seconds for the earlier sessions and 15 seconds for the latter sessions). In practice, the time limit did not bind for most trades. See the Appendix for details.

for the monopolist in the game.[12]

3.2.2 Fairness under the threat

Before testing the efficiency and distributional implications, I ask whether the threat design induces a compromise from the monopolists. I then compare the proposed price to the simulated price schedules in Figure 7. Formerly, Table 2 reports the levels and inter-period ratios of offered prices for each threat level (Table 2A, 2C) and the estimated sensitivity of each proxy with threat level (Table 2B, 2D). I will first discuss pre-threat periods and then move on to post-threat periods.

On the threat period and before: In Figure 7, one can notice that the price substantially drops *before* the threat in the experiment ($n = 2$ to 3), not *after* the threat realizes ($n = 3$ to 4), as the rational monopolist model predicts. (See red shaded areas.) This substantial drop just before the threat significantly contributes to price discounting for both the pre- and post-threat periods. In Table 2B, I find that the price drop for pre-threat periods $n = 1,2,3$ is strictly expanding concerning the threat. $(-0.074, -0.074, -0.171$ with $p < 1\%)$. Observe that this drop is most notable at $n = 3$.

In Table 2C, compared to the non-threat trades, under the substantial level of threat ("middle," "high"), $\frac{P_3}{P_2} < \min\{\frac{P_2}{P_1}, \frac{P_4}{P_3}, \frac{P_5}{P_4}\}$ holds. In Table 2D, I examine how the threat affects each inter-period price ratio, $\frac{P_{i,n+1}}{P_{i,n}}$ $(n = 1,\ldots,5)$. I find that only coefficient of $\frac{P_3}{P_2}$ is statistically and economically significant $(-0.210$, with $p < 1\%)$, as visually captured in Figure 7. This indicates that in response to a 10% rise in threat, the price drops more by 2.1% *before* the threat. Other ratios $\frac{P_2}{P_1}, \frac{P_4}{P_3}, \frac{P_5}{P_4}, \frac{P_6}{P_5}$ are not large in magnitude or statistically significant.

Regarding the earlier occurrence of the drop, observe that the game before the higher threat of breakdown is reminiscent of the canonical ultimatum offer game. Rationality dictates an incredibly selfish proposal to be accepted by an opponent; however, hundreds of experiments show this as a well-known puzzle. The literature adopts the proposer's *fairness* as the critical explanation (See Fehr and Schmidt (1999); Bolton and Ockenfels (2000) for a general theo-

[12]For reasonable parameter settings of $\{\alpha^e, \sigma^e, \delta^e\}$, including those of my experiment, one can see that a surplus share of a buyer is below 0.5; $W_1/U = \frac{(\sigma+1)-(\sigma+2)A_1}{(\sigma+1)-A_1} < 0.5$ requires that an ex-ante monopoly power is bounded from below such that $A_1 > \frac{1-\sigma}{3}$. For $N = 6$ periods, the simulation finds that this is satisfied for all parametric trios in the experiment.

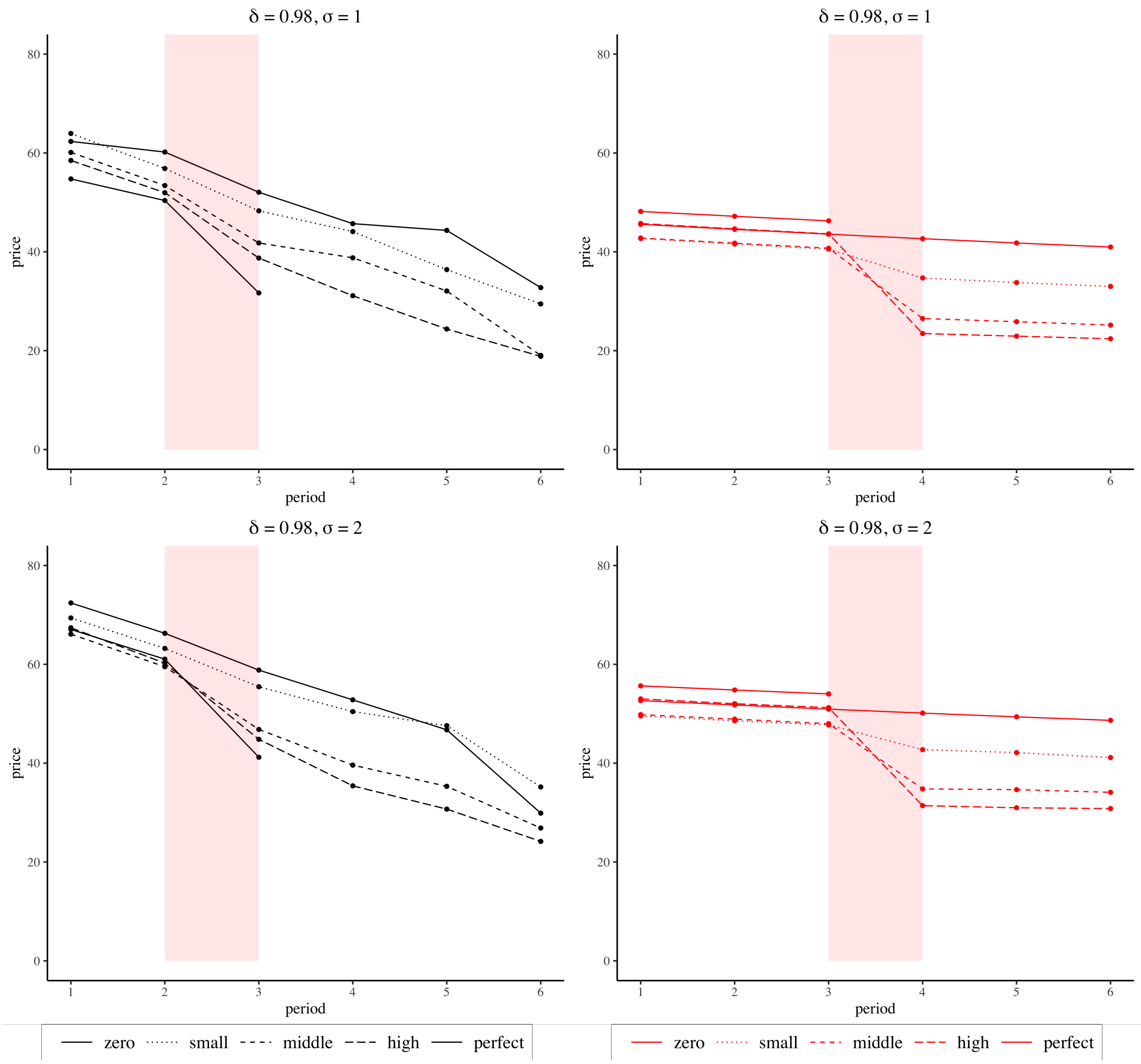

Figure 7: Threat effect on price dynamics under sufficient patience across intensities of threats (black: experiment vs. red: model)

Note: A threat is zero if $\alpha = 0$, small if $\alpha \in \{0.05, 0.1, 0.2, 0.3\}$, middle if $\alpha \in \{0.4, 0.5, 0.6\}$, large if $\alpha \in \{0.7, 0.8\}$ and complete if $\alpha = 1$. The mean values are computed among pairs remaining in each period. Under the environments with less than 20 observations, the average is computed, including linearly extrapolated values. I simulate the theoretical average prices within the threat category, weighted by the number of experimental observations of each environment. The red-shaded area captures a concession for threat. The result under the lower patience $\delta = 0.7$ is in the Appendix.

retical overview). Observing the protocol's similarity, I interpret the monopolists' systematic cooperation before the threat as their display of *fairness*. The subjects in the laboratory presumably do not fully exploit their own advantage over their opponents to avoid appearing *unfair*. Instead of strategically leveraging the buyer's compromise as a first mover, the psychic bias seemingly encourages the laboratory monopolists to concede in the face of threat. This subsection documents the expected monopolist's behavioral bias in contrast to the price schedule

		level (normalized to a unit)					
		P1	P2	P3	P4	P5	P6
		Table 2A: descriptive statistics (mean)					
threat level	zero	0.67	0.62	0.54	0.48	0.44	0.33
	small	0.65	0.57	0.48	0.42	0.37	0.28
	middle	0.62	0.54	0.42	0.39	0.36	0.29
	high	0.61	0.53	0.39	0.32	0.30	0.24
	perfect	0.59	0.54	0.36	-	-	-
		Table 2B: OLS					
risk α		**-0.074**	**-0.074**	**-0.171**	**-0.146**	**-0.089**	-0.050
		(0.011)	(0.014)	(0.013)	(0.039)	(0.050)	(0.040)
value σ		**0.081**	**0.094**	**0.104**	**0.112**	**0.149**	**0.152**
		(0.011)	(0.013)	(0.013)	(0.027)	(0.035)	(0.031)
patience δ		**0.119**	**0.136**	**0.104**	0.174	0.094	0.102
		(0.033)	(0.040)	(0.039)	(0.074)	(0.099)	(0.103)
fixed effects of players		Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared		0.479	0.427	0.490	0.492	0.416	0.549
Observations		1,178	895	758	317	258	192

		inter-period ratio				
		P2/P1	P3/P2	P4/P3	P5/P4	P6/P5
		Table 2C: descriptive statistics (mean)				
threat level	zero	0.88	0.85	0.85	0.86	0.72
	small	0.85	0.85	0.83	0.80	0.76
	middle	0.88	0.75	0.86	0.79	0.73
	high	0.85	0.71	0.79	0.84	0.66
	perfect	0.82	0.64	-	-	-
		Table 2D: OLS				
risk α		-0.023	**-0.210**	0.001	0.047	-0.085
		(0.030)	(0.042)	(0.054)	(0.069)	(0.171)
value σ		**0.051**	**0.073**	0.016	**0.163**	-0.014
		(0.028)	(0.040)	(0.037)	(0.048)	(0.129)
patience δ		0.099	-0.109	**0.225**	0.015	-0.309
		(0.085)	(0.123)	(0.102)	(0.138)	(0.435)
fixed effects of players		Yes	Yes	Yes	Yes	Yes
Adjusted R-squared		0.155	0.103	0.197	0.211	0.013
Observations		895	758	317	258	192

Table 2: Threat effect on price schedules

Note: A threat is zero if $\alpha = 0$, small if $\alpha \in \{0.05, 0.1, 0.2, 0.3\}$, middle if $\alpha \in \{0.4, 0.5, 0.6\}$, large if $\alpha \in \{0.7, 0.8\}$ and complete if $\alpha = 1$. Parentheses contain standard errors. **Red bold**, red, and **black bold** figures show $p < 1\%$, $p < 5\%$ and $p < 10\%$, respectively. OLS regressions include constants. – shows a value unavailable by design ($\alpha = 1$).

shown in Figure 2.

After the threat period: The model predicts that the price schedule monotonically decreases with a threat for post-threat periods. (See Figure 7) Table B shows the price decreases at $n = 4$ and 5 ($-0.146, -0.089$ with $p < 1\%, 5\%$, respectively). At $n = 6$, the response is negative but not statistically significant, possibly due to the limited surviving sample. The threat induces the discounted offer for at least the first two post-threat periods.[13]

However, independently of the threat, an inter-price ratio before the final deadline is found to be the smallest compared to all other periods: $\frac{P_6}{P_5} < \min\{\frac{P_2}{P_1}, \frac{P_4}{P_3}, \frac{P_5}{P_4}\}$ holds for "zero," "small," "middle," and "high" threats.[14] Observing that the final period is also reduced to an analog of the ultimatum game indicates that monopolists' fairness has been working at the threat period and the terminal deadline.

3.3 Testing the Hypotheses on Outcomes

In the following sections 3.3.1–3.3.3, I test a list of five hypotheses on bargaining outcomes with laboratory experiments. The parentheses contain the results established in the previous chapter.

Hypothesis 1 [Deadline effect] *Increasing threat monotonically increases the agreements on the threat period* (left in Figure 2).

Hypothesis 2 [Shorter delay until agreement] *Increasing threat monotonically shortens the delay until agreements* (right in Figure 6).

Hypothesis 3 [Suppressed breakdown probability] *Increasing threat may decrease the breakdown probability* (left in Figure 6).

Hypothesis 4 [Improved efficiency] *Increasing threat may improve the efficiency* (Proposition 1).

Hypothesis 5 [Fairer distribution] *Increasing threat may yield the fairer distribution of surplus and expected premium to the buyer*s (Corollary 1).

3.3.1 Deadline effect

A model predicts that increasing threat induces more last-minute agreements on the threat and terminal periods (o.e.. Hypothesis 1. See the left in the Figure 2). As a proxy of the deadline

[13] A caveat is that it is hard to identify whether this drop comes from the inference of the buyer's posterior K_n, which is the model's prediction, or the bargaining power A_n.

[14] Note that for perfect threat, $\frac{P_2}{P_1} \gg \frac{P_3}{P_2}$ holds, indicating a compromise before the deadline as well.

effect, I examine how the occurrence of last-minute agreements just before the intermediate and terminal deadlines is sensitive to the threat. Figure 8 shows a sensitivity of the agreement ratio with threat intensity, measured by the number of pairs reaching an agreement out of all the pairs. As the threat rises, the agreement ratio at $n^* = 3$ is increasing while the one at $n = 6$ is decreasing.

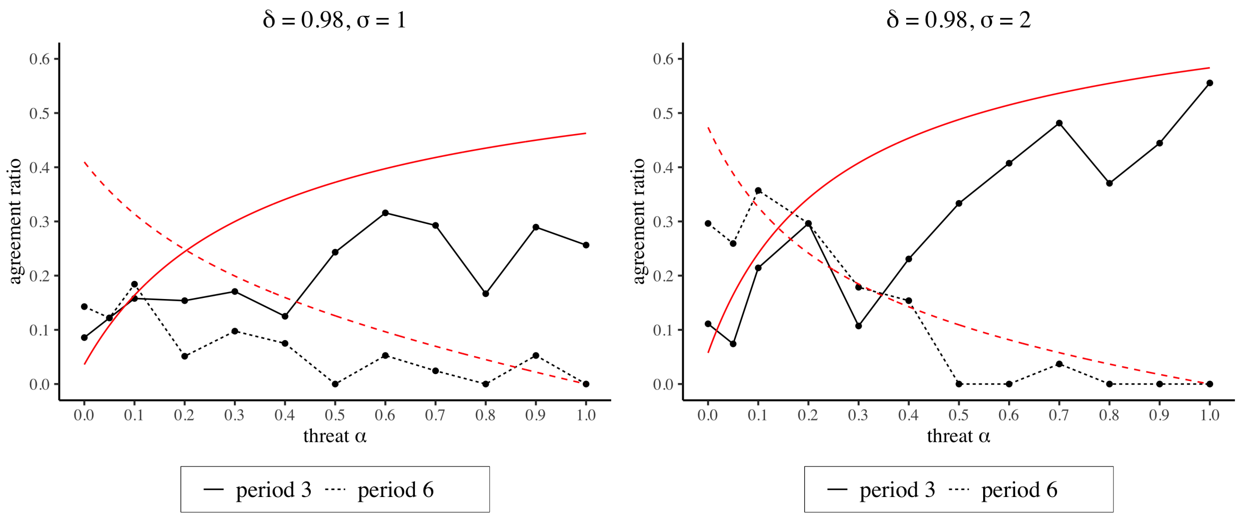

Figure 8: Threat effect on the agreement ratio at $n^* = 3$ and $n = 6$. (black: experiment vs. red: analytical prediction)

Note: The agreement ratio is the number of pairs reaching agreement divided by the total number of pairs reaching the $n^* = 3$ or $n = 6$, respectively. The result under the lower patience $\delta = 0.7$ is in the Appendix.

Table 3 formally shows the risk sensitivity of the agreement ratio at $n = 3$ and 6. Setting

	agreement at n = 3		agreement at n = 6	
	multinomial logit	binary logit	multinomial logit	binary logit
threat α	**1.05**	**1.33**	**-4.00**	**-3.98**
	(0.231)	(0.226)	(0.526)	(0.521)
value σ	**0.735**	**0.57**	**1.09**	0.819
	(0.173)	(0.171)	(0.279)	(0.260)
patience δ	-2.73	0.56	-2.65	1.14
	(0.651)	(0.650)	(0.466)	(1.10)
fixed effects of players	Yes	Yes	Yes	Yes
Observations	1,161	1,161	1,161	1,161
AMPE (p.p.) per 10 p.p.	1.98	2.17	-7.06	-2.64
Log-likelihood	-836	-584	-836	-272

Table 3: Deadline effects at the threat period vs. final period

Note: Parentheses contain standard errors. **Red bold** and red figures show $p < 1\%$ and $p < 5\%$, respectively. All the models include intercepts. AMPE (average marginal probability effect) is computed as an average of the MPE of each observation.

a binary outcome of agreement of $n = 3, 6$, I jointly estimate a multinomial logit model or a binary logit model separately. Both models show consistent results with the model; as the threat rises, the *last-minute* agreements at $n = 3$ occurs more frequently, while the one at $n = 6$ before the final deadline happens less often. The average marginal probability effect is 2.17 and -2.64, respectively, in the binary logit. Also, I confirm that larger σ facilitates agreements of $n = 3, 6$, respectively, as is intuitively interpreted; as the buyer is more eager to buy the good (larger σ), the expected cost of a breakdown is larger, prompting the agreement. This sub-chapter serves as an evidence for Hypothesis 1.

3.3.2 Shorter delay until agreement

Hypothesis 2 (shown at the right of Figure 6) states that rising threat monotonically shortens the bargaining delay conditional on agreements, contributing to efficiency improvement. Figure 9 draws a mean duration across environments in the experiment, compared with the simulation. The expected duration (red lines) is simulated by (9).

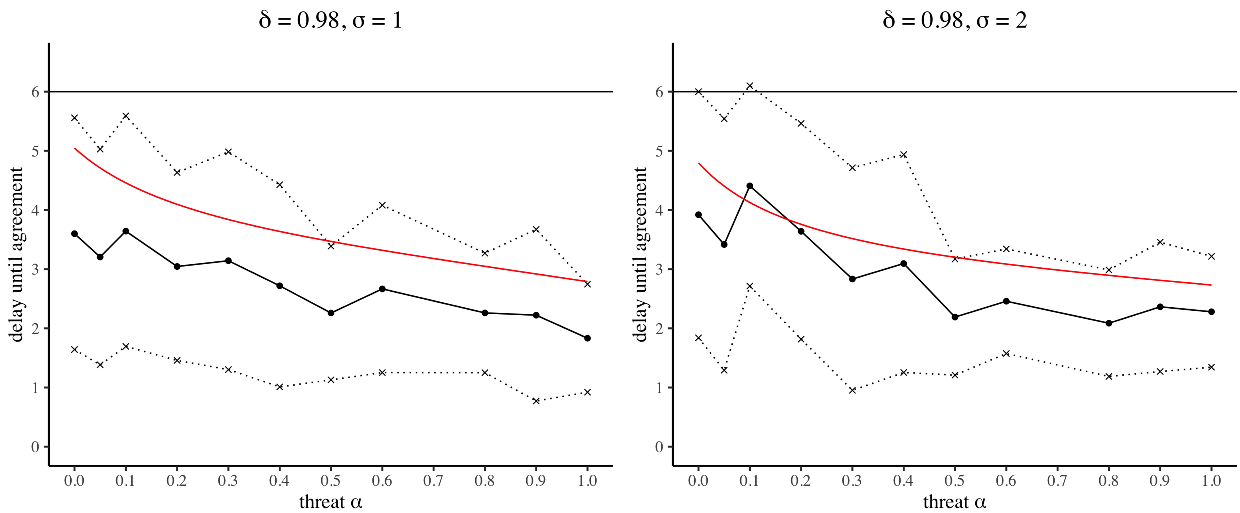

Figure 9: Mean duration until agreement (black: experiment, red: model)
Note: The duration is only defined when reaching agreements. The black dots are standard deviations.

The delay until agreements are monotonically decreasing, with threat across all environments. Table 4 analyzes the effect of threat on the delay until agreement. I regress bargaining duration until an agreement is reached, normalized to a unit interval concerning the threat as shown in Table 4.

The coefficient of threat is significantly negative $(-0.284, p < 1\%, (2))$. This indicates that a 10% rise in threat shortens the expected delay by 2.8%, conditional on agreement (i.e., 0.17 periods out of 6 periods). The coefficients on σ and δ are found to be significantly positive, as

	delay until agreement (normalized to a unit)	
	(1)	**(2)**
threat α	**-0.287**	**-0.284**
	(0.026)	(0.025)
preference σ	**0.034**	0.049
	(0.021)	(0.024)
patience δ	0.159	**0.141**
	(0.074)	(0.076)
Fixed effects of players	No	Yes
Adjusted R-squared	0.130	0.252
Observations	878	878

Table 4: Threat effect on the delay until agreement

Note: Delay until agreement is normalized to a unit interval. Samples are limited to 878 trades reaching agreements. Parentheses contain standard errors. **Red bold**, red, and **black bold** figures show $p < 1\%$, $p < 5\%$, and $p < 10\%$, respectively. OLS regressions include constants.

intuitively interpreted by the theory. A highly skewed value distribution (larger σ) delays the bargaining because the monopolist charges a higher price under the more lucrative market, and the buyer typically rejects more to elicit his discount. More patient players (larger δ) seek better agreements by permitting a longer delay. This sub-chapter serves as evidence for Hypothesis 2.

3.3.3 Breakdown and efficiency

In this section, I jointly examine Hypotheses 3 and 4. First, the results are shown in Table 5. Then, setting a binary outcome of a breakdown as a dependent variable, I run a logit model in (1) and (2) in Table 5A, guided by the simulation in Figure 6, (2), which includes an α^2 term interacted with a dummy of $\delta = 0.98$. Though the quadratic coefficient is positive, as expected, it does not show a sufficient significance (0.036, $p > 10\%$).

In (5) and (6) in Table 5B, I regress the efficiency U, or the sum of the payoffs of each pair of the raw data, with the same set of bargaining primitives. Intriguingly, threat α exhibits positive and mildly significant coefficients (0.052 and 0.083, respectively, with $p < 10\%$), indicating that breakdown risk actually *enhances* the efficiency. As Proposition 2 states the quadratic risk sensitivity under sufficient patience, parallel to Figure 6, (6) interacts α^2 with sufficient patience. The quadratic coefficient is negative, as expected, but is not strongly significant

Table 5A dependent variable: breakdown				
	Logit			
	raw data		MC data	
	(1)	(2)	(3)	(4)
threat α	0.275	0.256	**0.098**	**-0.068**
	(0.209)	(0.260)	(0.020)	(0.026)
α-squared × (δ = 0.98)		0.036		**0.304**
		(0.294)		(0.029)
patience δ	0.034	0.032	**-0.092**	**-0.099**
	(0.287)	(0.288)	(0.027)	(0.027)
preference σ	**-1.05**	**-1.04**	**-0.782**	**-0.773**
	(0.194)	(0.194)	(0.018)	(0.018)
log likelihood	-627	-627	-66,154	-66,099
mean deviation (p.p.)	12.5	12.4	11.6	10.8

Table 5B dependent variable: efficiency				
	OLS			
	(5)	(6)	(7)	(8)
threat α	**0.052**	**0.083**	**0.022**	**0.042**
	(0.030)	(0.049)	(0.003)	(0.005)
α-squared × (δ = 0.98)		-0.046		**-0.029**
		(0.059)		(0.006)
patience δ	**0.377**	**0.429**	**0.334**	**0.367**
	(0.081)	(0.105)	(0.008)	(0.011)
preference σ	**0.190**	**0.190**	**0.164**	**0.164**
	(0.024)	(0.024)	(0.002)	(0.002)
adjusted R-squared	0.111	0.110	0.09	0.09
mean deviation (p.p.)	13.9	13.9	10.6	10.6
observations	1,161	1,161	116,100	116,100

Table 5: Threat effect on breakdown and efficiency (raw data and replicated experiments)

Note: Parentheses contain standard errors. **Red bold** and **black bold** figures show $p < 1\%$ and $p < 10\%$, respectively. A deviation from the model is computed as the mean deviation ratio of the predicted outcome from the analytical formula across the entire range of threats. Monte Carlo (MC) simulation repeats the experiment 100 times. (See Appendix for detail.) OLS regressions include constants.

either (-0.046, $p > 10\%$).

The analysis of breakdown and efficiency is presumably hindered by the sample limit of each environment e, so I complement my analysis with 100-time replication of experiments by Monte Carlo simulation (See Appendix for details). Reassuringly, however, the simulated experiment above improved the model's fit with a larger power. The results are summarized in (3), (4) for the breakdown, and (7) and (8) for the efficiency in Table 5B. (4) exhibits a significantly positive $(0.304, p < 1\%)$ quadratic coefficient interacted with a sufficient patience. Numerically, this indicates a U-shape sensitivity such that when $\alpha < \acute{\alpha} = 0.112$, the breakdown probability *decreases* by 0.07 $p.p.$, but when $\alpha \geq \acute{\alpha}$, it *increases* by 0.58 $p.p.$ for each 10 $p.p.$

rise in the threat.[15] Analogously, (8) gives a significantly negative $(-0.029, p < 1\%)$ quadratic coefficient under sufficient patience. The recovered prediction from the estimates suggests an inverted-U sensitivity such that when $\alpha < \alpha^* = 0.709$, the efficiency *improves* by $0.21\,p.p.$, but when $\alpha \geq \alpha^*$, it *deteriorates* by $0.09\,p.p.$ per $10\,p.p.$ rise in the threat.[16] Figure 10 depicts the recovered sensitivity of the ex-ante breakdown probability and efficiency with a threat. The observation that an estimated inflection point α^* is larger than the model ($\alpha^* = 0.28$) is consistent with the observation that the deterrence effect is further propelled by the behavioral bias. (4) and (8) in Table 5 serves as evidence for Hypotheses 3 and 4, respectively.

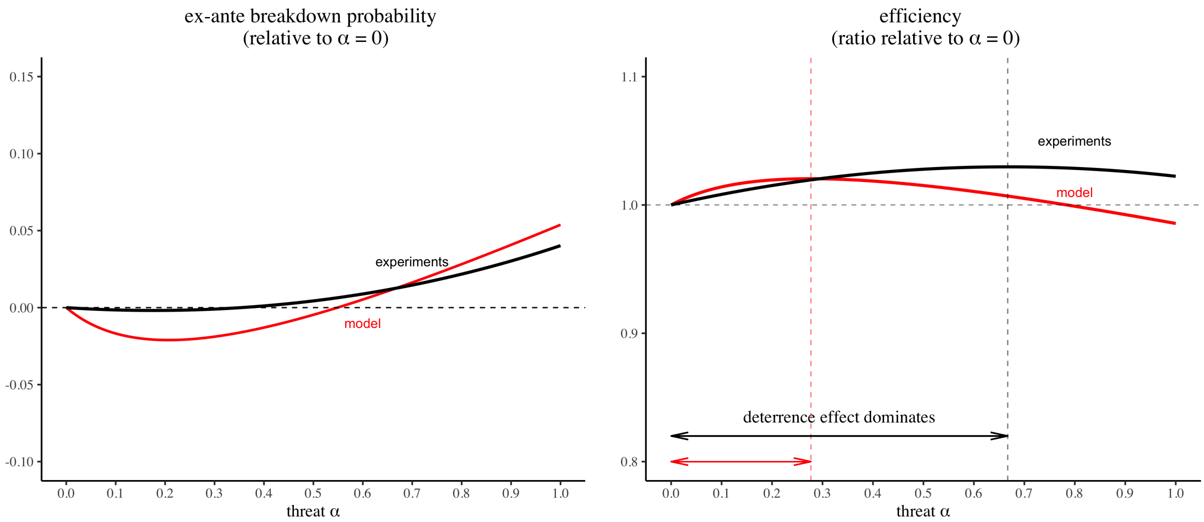

Figure 10: Estimated sensitivity of ex-ante breakdown probability and efficiency regarding a threat

Note: The data corresponds with replicated experiments by 100 times. (See Appendix for detail.) The value is computed on the baseline parameters $(\delta = 0.98, \sigma = 1)$ relative to the non-threat case.

3.3.4 Fairer distribution

As the simulation (left of Figure 5) and descriptive statistics (Table 1) suggest, this game favors the monopolist under reasonable parameters. I examine whether the threat contributes to the fair distribution and enhances the buyer's expected surplus, as summarized in Table 6. In

[15] Using the coefficients of α and α^2, β, β', respectively, an inflection point is computed as $\acute{\alpha} = \left|\frac{\beta}{2\beta'}\right| \sim 0.112$. I compute the average marginal probability effect (AMPE) as an average of MPE within subsamples split by the inflection point $\acute{\alpha}$.

[16] Using the coefficients of α and α^2, β, β', respectively, I compute the inflection point as Footnote 15. Then, the mean effect is computed by $\beta + 2 \times \beta' \times \frac{\beta}{2\beta'} = 2.1\,p.p.$, $\beta + 2 \times \beta' \times (1 - \frac{\beta}{2\beta'}) = -0.9\,p.p.$. The results are normalized by a $10\,p.p.$ rise in the threat.

	dependent variable					
	buyer's surplus (share)		buyer's surplus (level)			
	OLS					
	raw data	MC data	raw data		MC data	
	(1)	(2)	(3)	(4)	(5)	(6)
threat α	**0.032**	**0.010**	0.037	0.038	**0.017**	**0.022**
	(0.018)	(0.002)	(0.015)	(0.025)	(0.001)	(0.002)
α-squared × (δ = 0.98)				-0.002		**-0.008**
				(0.030)		(0.03)
patience δ	-0.018	**-0.031**	0.110	0.112	**0.101**	**0.110**
	(0.056)	(0.005)	(0.044)	(0.055)	(0.004)	(0.005)
preference σ	0.001	**-0.009**	**0.074**	**0.074**	**0.053**	**0.053**
	(0.018)	(0.002)	(0.015)	(0.015)	(0.001)	(0.001)
fixed effects of players	Yes	Yes	Yes	Yes	Yes	Yes
adjusted R-squared	0.180	0.248	0.063	0.062	0.071	0.071
observations	861	82,650	1,161	1,161	116,100	116,100

Table 6: Threat effect on distributional outcomes (raw data and replicated experiments)

Note: Parentheses contain standard errors. **Red bold** and **black bold** figures show $p < 1\%$ and $p < 10\%$, respectively. $\times$ indicates an interaction with a dummy of $\delta = 0.98$. Monte Carlo (MC) simulation repeats the experiment 100 times. (See Appendix for detail.) OLS regressions include constants. I include fixed effects of monopolists and buyers. The buyer's surplus share is computed only for pairs reaching agreements.

(1) and (2), I regress a *share* of buyers' surplus with respect to the threat α, controlling for δ, σ and fixed effect of players. α term shows a significantly positive estimate across the raw and simulated datasets, indicating the stronger efficacy of the threat. Guided by Corollary 1, I include an α^2 term interacted with a dummy of $\delta = 0.98$ into (1) and (2), however, they does not show a significant estimate. As discussed in Table 2, I interpret that a monopolist's fairness excessively facilitates compromise before the threat; even if α becomes large enough to leverage their position, the monopolists did not exercise their power. Likewise, in (3) and (5), both the raw data and simulated data show a positive effect of 0.037 and 0.017 on the *level* of buyer's surplus, respectively. This suggests that a 10% rise in threat increases the expected buyer's surplus by 0.37% and 0.17%, respectively. In (4) and (6), I include an α^2 term that interacted with a dummy of $\delta = 0.98$. The raw and simulated datasets show an expected sign of negative quadratic sensitivity, but the magnitude is insufficient to generate non-monotonicity. Plausibly augmented by the psychic bias from the proposers, the monotonic impact of the threat intensity on the buyer's share and level of the expected surplus provides even more substantial evidence of the responders' gain of Hypothesis 5.

4 Concluding Remarks

A monopoly often exploits a deadline to generate unfair distribution under non-Pareto optimality. Experimental literature shows, however, significant compromises on ultimatums before deadlines. This paper explores whether designing a threat of ending at the earlier period can induce fairness of the monopolist under the context of durable goods monopolist negotiations. I built a benchmark model where the threat of ending induces even a rational monopolist to compromise from the ex-post motive of price discrimination.

To test the validity of the threat design, I ran a laboratory experiment. Consistent with the literature, the monopolists showed robust cooperative behaviors with a flavor of *fairness* during the threat period and at the terminal deadline. Observing that the monopolist's behavioral bias even fuels the device's efficacy, I conclude that my rational monopolist model provides a lower bound of the efficacy of the buyer's threat. Other key features of the model are broadly replicated.

Nevertheless, to export the insights from these laboratory experiments to the real world, one must be careful of how much fairness applies to each bargaining context. Display of fairness appears to be highly dependent on the institutional setting; while a large body of experimental evidence and field evidence (e.g. Backus et al. (2020)) on one-on-one bargaining reports fairness, it is plausibly less prevalent among cutthroat business deals or cross-country negotiations.[17] These findings may help market designers concerned with the efficiency of the platform transactions in any social arena.

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[17]Guided by an empirical paradox on the dictatorship game (i.e., a simplified ultimatum game without the veto power of the responder), List (2007) argues that one needs a strong caution for the external validity of laboratory experiments.

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