Deadline Credibility and Trade Efficiency*

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Abstract

Many real-world negotiations are chronically delayed until deadlines, but hard deadlines are costly in generating separations. Must all deadlines in one-on-one market trades be perfectly credible? To refine the institutional role of deadlines, I propose a mechanism of an imperfectly credible soft deadline to facilitate the agreement. Employing a canonical seller–buyer dynamic bargaining model with a hard deadline, I analytically derive an optimal deadline credibility that the soft deadline elicits agreements without triggering separations and, consequently, maximizes the trade efficiency. Under a reasonably soft risk of breakdown, the seller is tempted to discount a price to secure a profit and the buyer is more likely to compromise right before the soft deadline, as the pricing resembles an ultimatum. The results of a laboratory experiment qualitatively support the mechanism's efficacy with even larger magnitudes.

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1 Introduction

Many negotiations are inexorably delayed. One classical institution used to limit endless lag is a deadline. Typical labor disputes close within several months, often followed by an institutional deadline of strikes or lockouts.[1] Many civil and criminal pretrial disputes reach eleventh-hour agreements right before a legal deadline to file a lawsuit.[2] Sovereign debt renegotiations often close just before the expiration of debt repayment.[3] At first glance, deadlines have virtues of enforcing agreements within a time limit[4]. By contrast, however, the same deadlines turn fatal if agreements are missed. Approximately 12% of labor disputes end in strikes and lockouts (Cramton and Tracy (1992)). Civil and criminal case enter costly formal trials after pretrial disputes. Sovereign debt renegotiations sometimes end with catastrophic defaults of the country.

Motivated by the substantial variety of last-minute agreements at the cost of breakdowns from hard deadlines, I explore a refined negotiation mechanism—a soft deadline—to improve the conventional hard deadline institutions under one-on-one trades. I begin with a seller–buyer bargaining model with one-sided, incomplete information under a hard deadline.[5] Consider a seller (he) bargains over a durable good with a buyer (she) with a private value within an exogenous N period hard deadline. The seller knows that the buyer's private value ranges from 0 to 1, and both know that the seller's marginal cost is 0. The seller offers a price in every period, and a buyer agrees or rejects. The trade continues until the buyer accepts; when the deadline arrives, both fall back to outside options 0. In a unique equilibrium, the price declines overtime without commitment to a single price (intrapersonal price competition, or simply, self-competition. See e.g., Güth (1994)) and a delay occurs as a screening of private information: lower-type buyers delay agreements and lowest-end buyers reject all offers, ending in separation.

[1] Using data of labor contract disputes during 1970-1989, Cramton and Tracy (1992) documented that holdouts are the most common form of disputes, running for approximately two months.

[2] See Williams (1983) for last-minute agreements in civil litigations and Spier (1992) and Sieg (2000) for cases in plea bargainings.

[3] In 2015, Greece was faced with the maturity of debt from international creditors, July 20, as a hard deadline. The negotiation narrowly closed eight days before the deadline. See Benjamin and Wright (2009) for a history of sovereign debt renegotiations and defaults.

[4] Experimental literature frames it as deadline effects (See Roth (1995) for a survey). Roth, Murnighan and Schoumaker (1988) state that "deadline effect appears to be quite robust, in that the distribution of agreements over time appears to be much less sensitive to experimental manipulations than is the distribution of the terms of agreement."

[5] See Fudenberg, Levine and Tirole (1985) and Sobel and Takahashi (1983). This bargaining framework with a deadline is not only for theoretical inquiry, but has been widely applied to real world bargaining scenarios, such as Tracy (1987), Hart (1989), Cramton and Tracy (1992) for labor disputes, Bebchuk (1984) and Silveira (2017) for plea bargaining, and Bai and Zhang (2012) for sovereign debt negotiations.

Suppose that an interim soft deadline is exogenously imposed on a specific intermediate day $n^* < N$. This complementary deadline serves as a stochastic "time bomb": if the agreement is not reached on the day, the pairs might separate with a conditional probability of $\alpha \in (0,1)$ and receive outside options of 0, but continue otherwise. The higher α makes a game resemble an ultimatum game.[6] At first glance, the imposition of "time bomb" would simply harm the trade efficiency. I propose, however, that the non-fatally soft deadline may be a catalyst for both parties to earlier agreements, and thus improve the trade efficiency. When both parties were sufficiently patient, I demonstrate that there exists an interior deadline credibility $\alpha^* \in (0,1)$, achieving the highest ex-ante efficiency, defined as the sum of both parties' ex-ante payoffs.[7]

To understand the mechanics behind, first consider the buyer's straightforward reaction to the soft deadline: she is likely to purchase earlier due to its potential breakdown loss. A parameterized model shows that agreements are disproportionately more likely to occur at the soft deadline instead of the hard deadline (see Figure 1, left). One could view this as a stochastic analog of the canonical deadline effect (Güth, Schmittberger and Schwarze (1982)).

What is non-trivial is the seller's price discounting: the price schedule could be discounted, exemplified by a lower opening price. The key mechanism is that a soft deadline would help screen out a low-end value buyer and facilitate self-competition of the seller. To understand this, suppose that a rejection occurs at the soft deadline with a reasonably large α. Then, the seller would immediately know that the buyer's private value is not high enough to induce a purchase, and his belief on the private value is substantially lower compared with when $\alpha = 0$ (see Figure 2, right for a purchase schedule across a variety of α). Therefore, the forward-looking seller is bound to discount from the beginning, which would further facilitate earlier agreements. This seller's discount is perhaps surprising in light of a standard ultimatum game, where the seller supposedly gains a larger incentive to exploit the buyer. Notably, this price discounting channel is absent in the conventional hard deadline framework.

My theoretical finding, founded on mathematically equivalent modeling of multi-buyer markets in the durable goods monopoly, revisits an accepted wisdom on the famous Coase (1972) conjecture, regarding bargaining horizon and market efficiency.[8] Coase contended that

[6] α is a conditional probability of breakdown when a price at period n^* is rejected. If $\alpha = 0$, this is nothing beyond an original setting. If $\alpha = 1$, this becomes shorter-horizon bargaining with a deadline on $N = n^*$.

[7] If α is sufficiently large, the game just resembles a short-sighted ultimatum game, and expectedly harm the efficiency.

[8] This conjecture is framed as "durability (or extended bargaining horizon) attenuates monopolistic distortion". See, for example, Güth and Ritzberger (1998). See Section 2.3 for greater detail.

one-sided asymmetric information without a deadline leads to an immediate agreement favorable to the informed buyers. Therefore, as the bargaining horizon extends, the efficiency is retrieved. Two polar cases succinctly characterize this intuition. In a one-shot ultimatum game,[9] bargaining undergoes the heaviest efficiency loss under the maximized monopolist's power. In contrast, under an infinite-horizon, as Coase conjectured, the monopolistic market achieves full efficiency with an immediate agreement. A soft deadline breaks the conventional link: the horizon appears *shorter*, but the efficiency may be enhanced in expectation.

As an initial step to obtain a proof of concept, I ran a controlled laboratory experiment to empirically test the validity of the soft deadline. Elaborating on the experimental literature on a seller–buyer multi-period bargaining experiment (*a la* Rapoport, Erev and Zwick (1995)), I implemented a simplified model in a computer laboratory and obtained approximately 1,200 pieces of trade data from 62 subjects. The subjects randomly engaged in a bilateral bargaining game ($N = 6$) under various credibility levels predetermined on the soft deadline ($n^* = 3$).

The experiment broadly supports a soft deadline's benefit. Consistent with key predictions of the model, I found that imposition of soft deadline enhances the trade efficiency, suppresses the pricing and favors the buyer. Intriguingly, even when the soft deadline became nearly credible, these effects were even more pronounced, contrary to the model. To see this, I contrasted the submitted prices and decisions of buyers with theoretical predictions. Under the hard deadline regime ($\alpha = 0$), most (89%) of buyers' reactions were reasonably justified, but notably, 59% of prices were framed as "demanding"—sometimes beyond the ultimatum price. This "demanding" pricing has been canonically reported by prior experiments with hard deadlines.

Under soft deadlines, I found that sellers discount the prices on the soft deadline much more saliently than the model—a novel in the literature, but reminiscent of an extremely well-established history of ultimatum game experiments (See e.g., Güth and Kocher (2014))[10]. Consequently, a significant fraction of seller's pricing, especially on the soft deadline, becomes theoretically reasonable, even "cooperative". Founded on the discussion of potential behavioral forces at play (See Section 4), I conclude that a soft deadline remedied the upward-biased pricing of sellers under hard deadlines and fueled the earlier agreements of buyers; consequently, it enhanced trade efficiency.

[9] My model with $N = 1$ can be framed as a variant of an ultimatum offer game under incomplete information.

[10] On average, ultimatum game experiments show a 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)).

Related literature: This paper proposes a mechanism of negotiations to complement the conventional deadline. First, by enriching a deadline structure, my paper theoretically and experimentally extends last minute agreements before a deadline (deadline effects) in one-on-one bargainings. My finite-horizon bargaining model originated from Sobel and Takahashi (1983) and Fudenberg and Tirole (1983), although the role of deadlines on the trade efficiency was not explicitly featured.[11] Regarding pretrial civil litigations, Spier (1992) uses a similar model to mine, deriving an agglomeration of trade at the deadline of the trial.[12] More recently, Fuchs and Skrzypacz (2013) theoretically explored the impact of outside options after breakups on deadline effects in the continuous time limit. Relative to Fuchs and Skrzypacz (2013), my model normalizes the outside options and features the efficiency implication of the proposed pre-deadline mechanism in discrete periods, which is directly tested in the laboratory.[13]

On the empirical front, my paper contributes to a stream of experimental bargaining literature with a deadline (surveyed by Roth (1995). More recent ones include Gneezy, Haruvy and Roth (2003); Karagözoğlu and Kocher (2019); Haruvy, Katok and Pavlov (2020)). In fact, deadline effects appear to be universally established across protocols of time horizons, decreasing pies and alternating roles. (Güth, Levati and Maciejovsky (2005)). My experiment bolsters the view that deadline effect emerges even if a deadline is soft; as a soft deadline became more credible, more trades closed on the soft deadline, which is consistent with the model. (Contrast a theoretical purchase schedule at the left of Figure 2 and agreement ratios in the laboratory at Table 1).

Second, and more substantially, the paper theoretically revisits the conventional wisdom of the Coase conjecture (Coase (1972)) in the durable goods monopolist with a market of a continuum of buyers (from Stokey (1981); Bulow (1982), later formalized by Gul, Sonnenschein and Wilson (1986), Ausubel and Deneckere (1992) and Thépot (1998)).[14]The conjecture essentially

[11]Some theoretical works on deadlines explore the effect of strategic use of deadlines (Ma and Manove (1993); Fershtman and Seidmann (1993); Özyurt (2023)) In contrast, my paper seeks for improvement of the institutional role of deadlines, which is only set by a market designer.

[12]For different protocols with two-sided incomplete information, Ponsati (1995) and Damiano, Li and Suen (2012) derived an atom of the trade at the hard deadline in concession games.

[13]Using a reputation model by Abreu and Gul (2000), Fanning (2016) provided a foundation of deadline effects from reputation across a wide range of protocols. However, the one-sided, incomplete information in his model delivers no delay, making the bargaining efficient, which is not appropriate for the workforce model in my project. See the "Related Literature" section in Fanning (2016) for a comparison with one-sided, incomplete information models (e.g., Spier (1992); Fuchs and Skrzypacz (2013)).

[14]Departure from the conjecture is also a deep theoretical theme (e.g.; Bagnoli, Salant and Swierzbinski (1989); Fuchs and Skrzypacz (2010); Board and Pycia (2014)). Most of these papers adopt infinite horizon without deadlines. Once a deadline is imposed, the monopolist power is restored.

states that "durability hurts the monopoly power," suggesting a positive association between the time horizon (interpretable as durability) and market efficiency in the monopolistic market (See Güth and Ritzberger (1998), or Sobel and Takahashi (1983), Theorem 6).[15] An overall consensus of the literature is that the efficiency is significantly larger for longer bargaining rounds (or the infinite horizon at an extreme case) compared with a snapshot ultimatum game.[16] As a marked advancement in the literature, the soft deadline breaks this link: seemingly *shorter* bargaining periods deliver higher ex-ante trade efficiency (see Proposition 2).

Third, this paper borrows from, extends, and complements the experimental literature on seller–buyer durable goods monopoly trades[17] (Rapoport, Erev and Zwick (1995); Reynolds (2000); Cason and Reynolds (2005))[18]. Largely, the sellers' pricing in the experiments was inconsistently higher than predictions from rational selfish-player benchmark models.[19] Prior works have attempted to reconcile puzzling price decisions (especially, the level and comparative statics of opening price) via behavioral forces. My results under a hard deadline inherit the salient pricing behavior observed in the literature—particularly that the mean opening price is generally higher than the prediction and even higher than static monopolistic pricing.

As a novel finding, my experiment documents unreported behavioral regularities in the line of the literature above, which evokes, however, a history of well-established ultimatum game experiment results (for a survey, see Camerer (2003) and Güth and Kocher (2014)): as a soft deadline gets more credible, the seller's systematically demanding pricing is adjusted to a reasonable or even cooperative level (see Section 4). One may view that the soft deadline rectified the seller's systematic demanding bias reported in the previous hard deadline studies. After my experimental results are delivered, comparison to the existing experiment findings are provided in greater detail in Section 4.1.

[15] Bond and Samuelson (1984) also showed that if the good depreciates faster, the Coase conjecture can be evaded such that the monopolistic power revives.

[16] More recently, under repeated pie-split games with private information on fairness, Fanning and Kloosterman (2022) predicted the Coaseian outcomes of almost immediate agreements on an equal split, which is also supported by experimental evidence. The results are consistent with the conventional wisdom: in infinite horizon games than ultimatum games, efficiency and responder payoffs are significantly larger, while proposer payoffs were significantly smaller.

[17] Outside the durable goods trades, Sterbenz and Phillips (2001) introduced random delays to proposals, not random breakdown of trades as mine, in a pie-split game experiments. Bolton and Karagözoğlu (2016) also experimented pie-split games of varying commitment ability with hard leverage (binding commitment) in ultimatum vs. soft leverage (appealing to a focal point) in an unstructured bargaining.

[18] Other related experiments include Güth, Ockenfels and Ritzberger (1995), Cason and Sharma (2001), Srivastava (2001), and Güth, Kröger and Normann (2004).

[19] A notable exception is Güth, Kröger and Normann (2004), who found theoretically consistent price paths in two-period bargaining under the privately known patience.

Layout: The paper is organized as follows: Section 2 presents a soft deadline bargaining framework under a hard deadline and characterizes the unique equilibrium. Then, I explore the overall trade efficiency and distributional outcome's sensitivity with higher deadline credibility. Comparative statics of the ex-ante separation probability and delay until agreement are provided. Next, Section 3 presents the design and findings from the laboratory experiments. I compare the actions of both players with theoretical ones and provide behavioral interpretations to reconcile the gap. Then, I discuss implementation in the field beyond the laboratory. Section 4 concludes the paper. The Appendix provides proofs of theoretical results and delivers operational details and auxiliary analyses of experiments.

2 Model

To formalize the proposed mechanism, a natural candidate for a benchmark model should contain a hard deadline and generate an endogenous delay.[20] Below, I embed a soft deadline (or a series of soft deadlines for generality) on a seller–buyer bargaining model with one-sided incomplete information under a hard deadline (Sobel and Takahashi (1983); Fudenberg, Levine and Tirole (1985)).

2.1 Setup

A seller ("he") sells an indivisible durable good with a buyer ("she") with unknown private value $v \in [0,1]$ for the good[21]. I assume that v is distributed according to a publicly shared cumulative distribution function $F(v) = v^{\sigma}$ $(\sigma > 0)$.[22] Each good has a commonly known zero marginal cost.[23] Suppose that both are rational and risk-neutral.

Time is measured by discrete and finite periods with $n \in \{1,2,3,\cdots,N\}$ and a length $\Delta > 0$ for each bargaining round, where an exogenous institutionally-set hard deadline is set at period $N < \infty$. At the beginning of the period n, the seller proposes an offer P_n. The seller is allowed

[20]In the context of strikes in labor disputes, the classic Hicks Paradox (Hicks (1963)) features a puzzle that rational parties cannot reach a non-Pareto optimal outcome in a bargaining model under complete information. Embedding asymmetric information is a standard modeling solution.

[21]The model is isomorphic to a finite-horizon protocol of durable goods monopolist model of a product market filled with a sequence of infinitesimal buyers (Stokey (1981); Bulow (1982)).

[22]This distributional assumption is often taken due to analytical convenience to solve a dynamic bargaining game (See Ausubel and Deneckere (1992); Fuchs and Skrzypacz (2013)).

[23]A "no-gap" protocol is presumed such that marginal cost is no lower than the lower bound of the buyer's private value.

to commit to P_n only for a period of length Δ. Then, the buyer immediately accepts or rejects. If the buyer accepts the price at the end of period n, the game ends: the seller 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 the buyer keeps rejecting the price until $n = N$, the game also ends: both receive 0 as an outside option. The seller's strategy at period n, denoted as $p(\{P_t\}_{t=1}^{t=n-1}, N-n)$ is a mapping from the history of rejected prices, $\{P_t\}_{t=1}^{t=n-1}$, and remaining rounds $N-n$ to the current period offer, P_n.[24] The buyer of type v strategy at period n, denoted as $q(\{P_t\}_{t=1}^{t=n-1}, N-n)$, is a mapping from the history of prices, including the current one, and remaining rounds, to a discrete choice whether to accept or reject the current price, P_n.

soft deadlines Suppose that a series of exogenous M $(M < N)$ time soft deadlines are embedded on periods $n_d^* \in [1,N)$ $(d \in [1,2,\cdots,M]; d$ is an order of soft deadlines) before the hard deadline period N.[25] The deadline credibility is captured by a conditional separation risk $\alpha_d \in (0,1)$ when reaching the end of each soft deadline period n_d^*. This implies that if a proposal is rejected at period n_d^*, bargaining ends with probability α_d, and both receive outside options 0, but proceeds to period n_d^*+1 with probability $1-\alpha_d$.

$M > 0$ is for formal generalization: without loss of generality, the model with $M = 1$ is the simplest case sufficiently containing the model's insights, simulated below (Figure 2, 3, and 4), and tested in the laboratory. For simplicity, when $M = 1$, n_d^* and α_d^* are sometimes written as n^* and α^* without subscripts d.

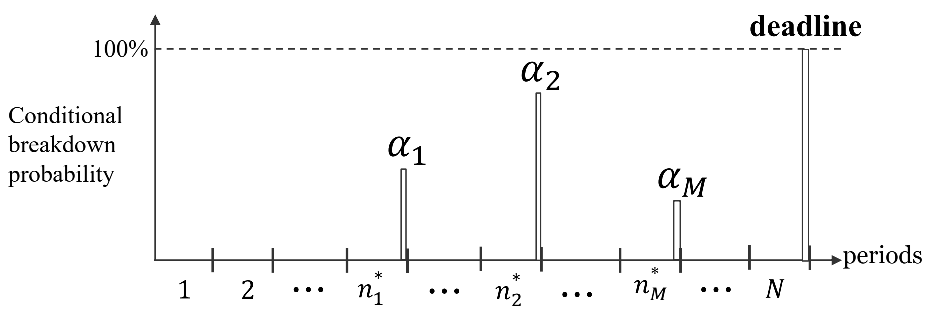

Figure 1: Multiple soft deadlines under the hard deadline

[24] At $n = 1$, no history of previous prices are available, so an opening price is simply $p(\phi, N-1)$.

[25] This setting corresponds to the general formulation of a random breakdown (e.g., Binmore, Rubinstein and Wolinsky (1986)).

2.2 Equilibrium

A complete strategy for the seller $\mathbf{P} = \{p(\{P_s\}_{s=1}^{s=t-1}, N-t)\}_{t=1}^{t=N}$ determines the prices to be offered in every period after any possible price history. In dynamic bargaining games, the types of buyer remaining after any history including off-the-equilibrium pricing form a truncated distribution. This stems from the famous skimming property[26], such that in any equilibrium for any current price P_n and after any history of offered prices $\{P_t\}_{t=1}^{t=n-1}$, there exists a cutoff type $C_n = c(P_n, \{P_s\}_{s=1}^{s=n-1}, N-n)$ such that the buyer accept if $v \geq C_n$ and rejects otherwise. Because it is more costly for high types to delay trade than it is for low types, the buyer's best responses must satisfy the skimming property. Therefore, without loss of generality, the buyers' strategy is reduced to a cutoff strategy by $\mathbf{C} = \{c(P_t, \{P_s\}_{s=1}^{s=t-1}, N-t)\}_{t=1}^{t=N}$.[27]

Let $K_n(\{P_s\}_{s=1}^{s=t-1}, N-n)$ as the highest remaining type in equilibrium in period n as a function of a history of prices and remaining periods (with $K_1(\phi, N-1) = 1$). Immediately from the buyer's cutoff strategy, the belief system $\mathbf{K} = \{K_t\}_{t=1}^{t=N} = \{\{P_s\}_{s=1}^{s=t-1}, N-t)\}_{t=1}^{t=N}$ are characterized by K_n such that

$$K_1 = 1, \;\; C_n = K_{n+1} \;\; (\forall n \in \{1, \cdots, N-1\}), \tag{1}$$

suggesting that cutoff at period n serves as an upper bound type at period $n+1$. Then, $[0, K_n(\{P_t\}_{t=1}^{t-1}, N-n))$ be a range of possible types at period n, and both players know K_n at period n as an upper bound of private value v. Then, employing $(\mathbf{P}, \mathbf{C})$ and $\mathbf{K}$, I introduce a perfect Bayesian equilibrium (for theoretical foundations, see Sobel and Takahashi (1983); Fudenberg, Levine and Tirole (1985)).

Definition 1. *A pair of strategies* $(\mathbf{P}, \mathbf{C})$ *and a belief system* $\mathbf{K}$ *constitutes a perfect Bayesian equilibrium of the game if their actions maximize their expected payoffs at all information sets and if a belief system is consistent with the Bayes rule whenever possible.*

The model is solved via backward induction from the hard deadline. As formally shown in the proof in Appendix, with my distributional assumptions, given any period and any upper bound type K_n induced by $(\mathbf{P}, \mathbf{C})$ and the history, the seller problem yields a unique pricing. Therefore, the continuation equilibrium is unique and depends on the history only via the state

[26] See e.g., Muthoo (1999), Lemma 9.3.

[27] Both parties are permitted to use mixed strategies, but in a unique equilibrium, the seller's pricing turns out to be deterministic and the buyer's mixed strategy is rationalizable only when the private value is equal to the cutoff.

variable K_n and the remaining rounds $N-n$. This conveniently simplifies the notation: the current price and cutoff is denoted by $P_n = p(K_n, N-n)$, $C_n = c(P_n, K_n, N-n)$, respectively, and K_n is specified by (1).

Let $V_n(K_n, N-n)$ be the expected continuation payoff of the seller given K_n with $N-n$ time remaining rounds at period n and the strategies $(\mathbf{P}, \mathbf{C})$. For $n < N$, $V_n(K_n, N-n)$ is recursively given as

$$V_n(K_n, N-n) = \underbrace{\left(\frac{F(K_n) - F(C_n)}{F(K_n)}\right)}_{\text{probability of agreement}} p(K_n, N-n) + \underbrace{\frac{F(C_n)}{F(K_n)}}_{\text{probability of rejection}} \eta_n \delta V_{n+1}(K_{n+1}, N-(n+1)) \tag{2}$$

where η_n is a risk-adjustment factor attached to a discount factor δ such that $\eta_n = 1 - \alpha_d$ $(n = n_d^*)$ and $\eta_n = 1$ $(n \neq n_d^*)$. At a hard deadline $n = N$,

$$V_N(K_N, 0) = \underbrace{\left(\frac{F(K_N) - F(C_N)}{F(K_N)}\right)}_{\text{probability of agreement}} p(K_N, 0) \tag{3}$$

Given the expected path of prices, the buyer's strategy c must satisfy the following as a best response:

$$\text{For } n < N, \quad \underbrace{C_n - P_n(K_n, N-n)}_{\text{payoff of agreement today}} = \eta_n \delta \underbrace{(C_n - P_{n+1}(K_{n+1}, N-(n+1)))}_{\text{payoff of agreement tomorrow}} \tag{4}$$

$$\text{For } n = N, \quad \underbrace{C_N - P_N(K_N, 0)}_{\text{payoff of agreement at the hard deadline}} = \underbrace{0}_{\text{outside option}} . \tag{5}$$

Intuitively, (4) implies that a marginal buyer with a value $v = C_n$ is indifferent between buying today and tomorrow.[28] Following the proof strategy of Sobel and Takahashi (1983) and Fuchs and Skrzypacz (2013), the action schedules $\{(P_n, C_n)\}$ of players are periodically determined by a pair of their bargaining powers, captured by sequences $\{(A_n, B_n)\}$ as follows.

Proposition 1. [Unique equilibrium paths and bargaining powers]

The game has a unique Perfect Bayesian equilibrium. Given the state variable $\{K_n\}$ at period n, the equilibrium path of $\{(P_n, C_n)\}$ $(n \in \{1, \cdots, N\})$ uniquely exists and is sequentially characterized as

[28]One can see that skimming property holds such that a relative benefit of buying today than tomorrow (i.e., a difference of left hand side and right hand side in (4)) is strictly increasing in C_n.

$$P_n = A_n K_n \text{ and } C_n = B_n P_n \tag{6}$$

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

$$\begin{cases} A_n = ((\sigma+1) - \sigma\eta_n\delta A_{n+1}B_n)^{\frac{-1}{\sigma}}/B_n & (n \in \{1,\cdots,N-1\}) \\ B_n = \{1-\eta_n\delta(1-A_{n+1})\}^{-1} & (n \in \{1,\cdots,N-1\}) \\ A_N = (1+\sigma)^{\frac{-1}{\sigma}};\ B_N = 1 \end{cases}, \tag{7}$$

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

$$V_n = A_n K_n \mathbb{E}(v),\ \ W_n = (1 - \frac{\sigma+2}{\sigma+1}A_n)K_n\mathbb{E}(v) \tag{8}$$

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

[Proof] See the Appendix.

Due to the model's recursive structure, the seller and buyer chooses P_n and cutoffs C_n based solely on a periodic state variable K_n, regardless of historical actions under the equilibrium. Furthermore, 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, which are derived as functions of primitives $\delta, \sigma, \alpha_d, n_d^*, N$ (see the Appendix for the explicit recursive formula).

Intuitively, A_n and B_n are periodic bargaining powers of the seller and buyer, respectively. Higher A_n raises a price and higher B_n increases a cutoff at period n. Analogous to prices and cutoffs, the value functions V_n, W_n of sellers and buyers are also linear in the state variable K_n. V_1 and W_1 capture the ex-ante surplus of both players, derived from the ex-ante maximum gains from the trade $\mathbb{E}(v) = \dfrac{\sigma}{\sigma+1}$. Accordingly, given the equilibrium paths, how do both players behave?

Purchase schedule: The buyer's purchase decision is characterized by the cutoff C_n or the minimum value she is willing to accept given the price P_n. Figure 2 (left) illustrates simulated paths of cutoffs under a parameterized model $(N = 6, M = 1, n_1^* = 3, \delta = 0.98, \sigma = 1)$. Its results show that buyers with private values higher than the cutoff curve are willing to purchase. The buyer's cutoff curve sharply drops not only at $n = 6$ (the canonical *deadline effect*) but also at $n = 3$, when $\alpha > 0$. The one at $n_1^* = 3$ may represent a deadline effect at the soft deadline. When the soft deadline gets hardens, the magnitude of compromise expands: a buyer of a given private value is likelier to agree on the soft deadline.[29]

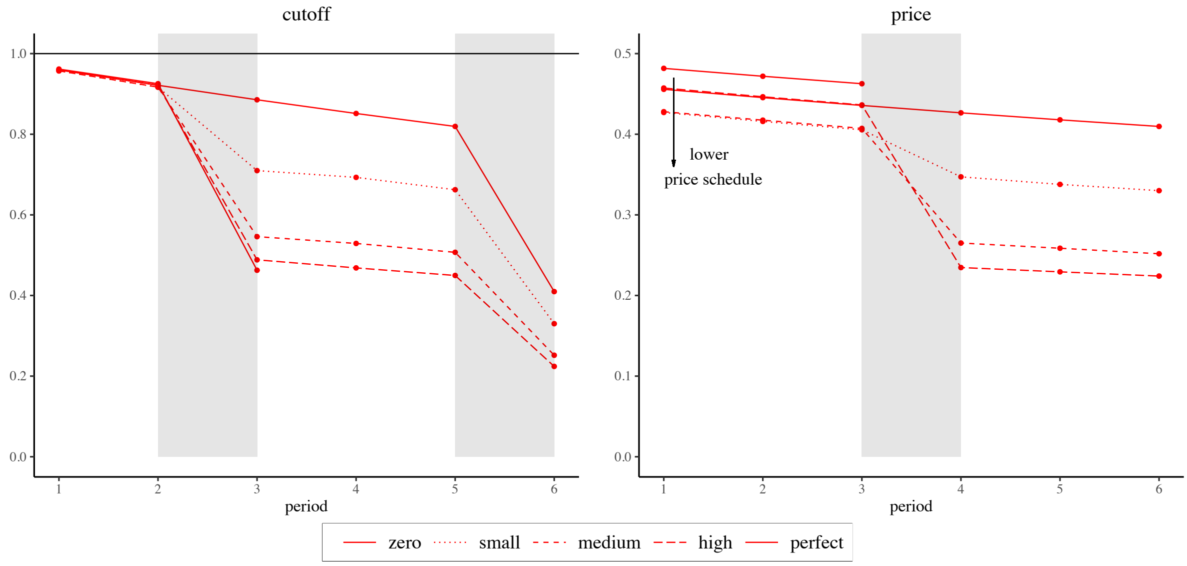

Figure 2: Equilibrium dynamics across the levels of deadline credibility (left: cutoff; right: price)

Note: The model is simulated under an experimental setting ($N = 6$; $M = 1$; $n_1^* = 3$) and baseline parameters ($\delta = 0.98$; $\sigma = 1$). See Figure 1.) A threat is zero if $\alpha = 0$, small if $\alpha \in \{0.05, 0.1, 0.2, 0.3\}$, medium if $\alpha \in \{0.4, 0.5, 0.6\}$, large if $\alpha \in \{0.7, 0.8, 0.9\}$ and perfect if $\alpha = 1$. I simulate 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 shades feature deadline effects for a buyer at $n = 3, 6$ (left), and a conspicuous sale at $n = 4$ (right).

Price schedule: Given the buyer's compromise in the face of the soft deadline, one would simply expect that the seller would jack up the price as a quasi-ultimatum offer under a strategic interaction. Using the same parameterized model, Figure 2 (right) documents the simulated price path. Saliently, the seller performs a conspicuous compromise just after the soft deadline $n = 4$. This big sale is novel to my soft deadline regime as a direct consequence of the deadline effect at the soft deadline stated above. As the seller knows that the buyer's cutoff drops at $n^* = 3$, he infers that the remaining buyer's value at $n = 4$ is significantly lower than $\alpha = 0$ (Recall that $K_4 = C_3$ per (1)). As lower type buyers are screened out from deadline effects (Figure 2 (left)), the seller responds by dropping the price as a self-competition: the second half prices (P_4, P_5, P_6) monotonically decline with higher credibility. In other words, the soft

[29]In the context of durable goods monopoly under product market of continuum value of buyers, this cutoff drop could be interpreted as distinctly larger distribution of purchase.

deadline serves as a signaling device of low private value, once the offer at the soft deadline is rejected. Therefore, the forward-looking seller starts with a cheaper opening price, shifting the total price schedule downward. Compared to the hard deadline ($\alpha = 0$), Figure 2 (right) shows that the seller discounted the opening price for small and medium credibility. In fact, the simulation showed that for most in a range of imperfectly credible soft deadlines ($\alpha \in (0, 0.789]$), the seller's first-half prices (P_1, P_2, P_3) were lowered compared to those in the hard deadline regime ($\alpha = 0$). However, when a soft deadline is close to a hard one, the canonical strategic interaction dominates: The seller raises the price at the soft deadline. This insight is formalized as follows.

Lemma 1. [The seller's opening price] *Suppose that the players are sufficiently patient. Then,* $\widehat{\alpha}_d \in (0,1)$ *uniquely minimizes an opening price* P_1 *s.t.*

$$\widehat{\alpha}_d = \frac{\delta A^2_{n^*_d+1} - (1-\delta)\{(1+\sigma) - (2+\sigma)A_{n^*_d+1}\}}{\delta(1-A_{n^*_d+1})(1+\sigma-A_{n^*_d+1})}. \tag{9}$$

where $A_{n^*_d}$ *is recursively characterized by function of primitives* $A_n\delta, \sigma, \alpha_d, n^*_d$ *and* N *for* $d = 1, 2, \cdots, M$ *by* (7).

[*Sketch of the Proof*] First, one obtains the first-order condition (F.O.C.) as

$$\frac{dP_1}{d\alpha_d} \underset{\text{Recall } P_1 = A_1}{=} \frac{dA_1}{d\alpha_d} = -\frac{\mathbb{E}(v)}{(\sigma+1)^2} \underbrace{\frac{dA_1}{dA_{n^*_d}}}_{(>0)\text{ See Appendix}} \frac{dA_{n^*_d}}{d\alpha_d} = 0. \tag{10}$$

The F.O.C. (10) is reduced to $\frac{dA_{n^*_d}}{d\alpha_d} = 0$. By solving for α_d, one attains the desired $\widehat{\alpha}_d$ in (9). Moreover, the second-order condition (S.O.C.) also holds such that

$$\frac{d^2P_1}{d\alpha_d^2} = -\frac{\mathbb{E}(v)}{(\sigma+1)^2} \underbrace{\frac{dA_1}{dA_{n^*_d}}}_{\text{independent of } \alpha_d} \frac{d^2A_{n^*_d}}{d\alpha_d^2} < 0 \tag{11}$$

□ (the detailed derivation of F.O.C. and S.O.C. is in the Appendix.)

As the opening price captures the seller's ex-ante bargaining power (recall that $P_1 = A_1$), the theorem indicates a possibility that some range of imperfect credibility suppresses the monopoly power. As illustrated at Figure 2 (right), the non-linearity reflects two forces at work. The first is self-competition after soft deadlines. If the seller foresees that he must discount a price if the risk is unrealized, he is tempted to reduce the price at the outset. As the soft deadline hardens and the game resembles an ultimatum, however, a conventional, exploitive strategic interaction dominates, leading to the monopolist power being gradually restored.[30] A parameterized model in Figure 2 suggests that pricing is discounted across periods for a substantial range of the deadline credibility.

2.3 Efficiency

The key theoretical question is how the overall trade efficiency responds to the intensity of the deadline credibility. The overall trade efficiency—of central interest in the paper—is characterized by the sum of the value functions at the opening period, $V_1 + W_1$, formally introduced as follows[31].

Definition 2. [Trade Efficiency]

The ex-ante trade efficiency U is defined as the sum of the players' ex-ante expected payoffs such that $U \equiv V_1 + W_1$.

As an immediate consequence of Lemma 1, the paper's key theoretical finding of the paper is given below.

Proposition 2. [Efficiency gain from imperfect deadline credibility]

Suppose that the players are sufficiently patient. Then, $\widehat{\alpha}_d \in (0,1)$ uniquely maximizes the efficiency U, as well as level W_1, and distributional share W_1/U of buyers' expected surplus.

[*Proof*] Using (8), one can see that the efficiency U and the level of buyers' expected surplus W_1 are shown to strictly decrease in the opening price P_1 such that

$$U \equiv V_1 + W_1 = (1 - \frac{P_1}{\sigma+1})\mathbb{E}(v) \qquad W_1 = (1 - \frac{\sigma+2}{\sigma+1}P_1)\mathbb{E}(v). \tag{12}$$

[30] When players are not sufficiently patient, however, self-competition is always dominated by an exploitive strategic interaction. This is because if the bargaining gets more frictional, sellers care less for the future market and exploit the current market myopically. Consequently, the opening price is monotonically increasing with credibility. The insight is aligned with Güth and Ritzberger (1998), showing that the Coase conjecture does not hold for low patience of players.

[31] In the durable goods monopoly with a demand pool of buyers, V_1, W_1 is interpreted as the ex-ante monopoly surplus and collective consumer surplus, respectively.

The share of the buyer's expected surplus is $W_1/U = \dfrac{(\sigma+1)-(\sigma+2)P_1}{(\sigma+1)-P_1}$. W_1/U is also strictly decreasing in P_1 because

$$\frac{d(W_1/U)}{dA_1} = -(\sigma+1)^2 < 0$$

holds. The desired results immediately derive from the Proof of Lemma 1. □

The theorem states that given the specific soft deadline on n_d^*, the imperfect credibility of the soft deadline maximizes the overall trade efficiency and ex-ante buyers' advantage. This implies that the non-zero threat of separation could *enhance* the trade efficiency by suppressing the monopoly power compared to the hard deadline regime. In Figure 3, a parameterized model finds that the overall efficiency is maximized at an interior credibility $\widehat{\alpha} = 0.28$, suggesting that efficiency is enhanced in the majority of credibility range ($\alpha \in (0, 0.789]$) compared to the hard deadline regime ($\alpha = 0$). Intuitively, this non-linearity of efficiency stems from a dynamic trade-off between the deterrence benefit (efficiency gain by facilitated compromises) and the separation cost (efficiency loss by termination). When the deterrence benefit outweighs the direct separation cost, well-designed deadline credibility restores a part of trade efficiency.[32]

Although this study highlights the soft deadline's role as an intervention to restore efficiency, the model provides an intriguing distributional implication. As the model relates the overall efficiency as a share and the level of buyers' expected payoff, the non-linear implication is also inherited to the buyer's advantage as well.[33]

The theoretical results revisit the conventional wisdom on the link between a time horizon specified by a hard deadline and market efficiency in the literature on durable goods monopolists. Alined with the Coase conjecture (Coase (1972)), in the unlimited horizon without the backup of the hard deadline, the monopolist loses the bulk of the bargaining power. In my model, this corresponds with the extreme case where, under an infinite horizon ($N \to \infty$), U increases to the maximum portion of the total gains from trade $\mathbb{E}(v)$.[34] In the other extreme of a one-period ultimatum game ($N = 1$), the monopolist gains the strongest bargaining power

[32] When players are not sufficiently patient, however, the efficiency is monotonically decreasing with the threat because the threat does not serve as an effective deterrent if both parties care less for after-threat option value.

[33] Alternatively, one may interpret that the sensitivity of buyer's advantage is conversely shaped by the response of monopolistic power in Lemma 1 under the non-cooperative bargaining.

[34] Under $\delta = 0.98, \sigma = 1$, and $N \to \infty$, the efficiency U increases to 0.469, closest to the total potential gains from trade $\mathbb{E}(v) = 0.5$. The monopolist power A_1 decreases to the lowest 0.124, in contrast to the static ultimatum maximum of 0.5 (see the Appendix for a simulation when $N \to \infty$).

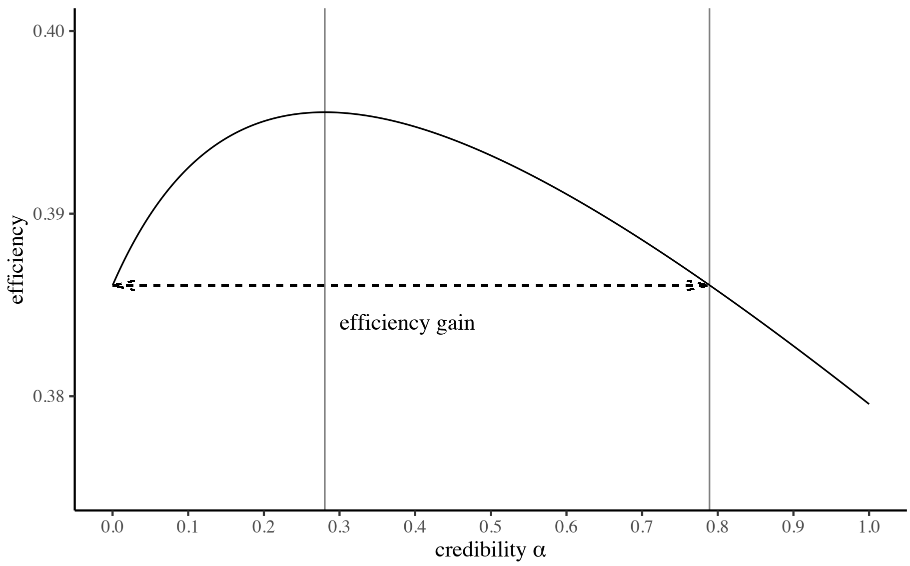

Figure 3: The efficiency curve in regard to deadline credibility

Note: The efficiency is computed by $V_1 + W_1$ based on (12). A model was simulated based on the analytical formula with a baseline parameter of experiments $N = 6$, $M = 1$, $\sigma = 1$, $\delta = 0.98$, and a single soft deadline is set on $n_1^* = 3$. The vertical line is the optimal threat $\widehat{\alpha} = 0.28$ and the upper bound of imperfect credibility to enhance the efficiency $\alpha = 0.789$.

and minimizes efficiency. Note that when a buyer's value is uniformly distributed ($\sigma = 1$), and perhaps surprisingly high, precisely half of the buyer cannot trade (as the price and cutoff is both $1/2$). My model shows that under a multi-stage game $(1 < N < \infty)$, a seemingly shorter time horizon with imperfect credibility $\alpha \in (0,1)$ in the soft deadline would partially recover the trade efficiency to facilitate compromises from both parties.

2.4 Efficiency loss

The preceding section showed that a well-designed threat of separation augments the trade efficiency. Nevertheless, the outcome remains below the Pareto optimality. This section complements the efficiency analysis by examining how the sources of efficiency loss varied with credibility. The source of trade inefficiency stemmed from a deadline interacted with by asymmetric information.[35] Operationally, I formally defined the pair of efficiency loss from potential separation and frictional delay as follows.

Definition 3. [Ex-ante separation probability and delay until agreement]

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

The ex-ante separation probability for a buyer is defined by

$$\underbrace{\alpha_d C_{n_1^*}}_{\text{first threat period } (d=1)} + \underbrace{\sum_{d=2}^{M}\left(\left(\prod_{d'=2}^{M}(1-\alpha_{d'-1})\right)\alpha_d C_{n_d^*}\right)}_{\text{following threat periods } (d\geq 2)} + \underbrace{\prod_{d=1}^{M}(1-\alpha_d)C_N}_{\text{terminal period}}. \tag{13}$$

The ex-ante delay until agreement is defined by

$$\sum_{n=1}^{N} n\left(\prod_{l=1}^{n}\eta_l\right)\underbrace{(K_n - C_n)}_{\text{ratio of buyers of agreement at } n}. \tag{14}$$

where C_n and K_n are a function of bargaining primitives, sequentially characterized by (6) *and* (7).

Based on Definition 3, the sensitivity of these two sources of inefficiency with the credibility is simulated, as shown in Figure 4. The parameterized model shows that the ex-ante separation

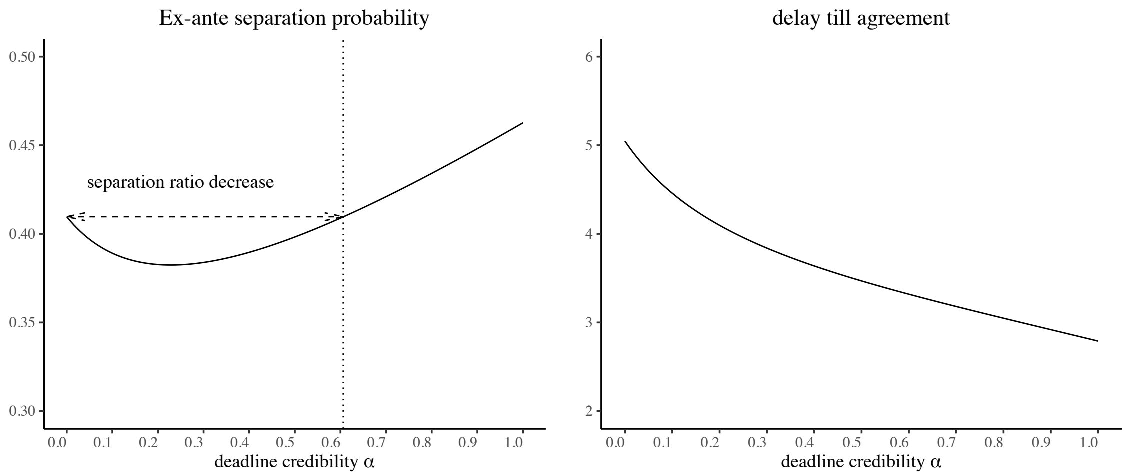

Figure 4: Ex-ante separation probability and delay until agreement (simulation)

Note: (13) and (14) are simulated with $N = 6$, $M = 1$, $\sigma = 1$, $\delta \in \{0.7, 0.98\}$, and a single soft deadline is set on $n_1^* = 3$. When $M = 1$, (13) is reduced to $C_{n_1^*}\alpha_{n_1^*} + (1-\alpha_{n_1^*})C_N$.

probability would exhibit a non-linear sensitivity. Aligned with the non-linear sensitivity of trade efficiency concerning α, as shown in Proposition 2, an appropriately designed deadline credibility would induce compromised agreements to avoid separations, generating a lowered probability of separation. Intriguingly, for most of the range $\alpha \in (0, 0.606]$, the separation probability is *lower* than under the hard deadline regime $(\alpha = 0)$. However, if the soft deadline resembles a hard deadline, the separation occurs beyond the role of deterrence.[36]

Another proxy to capture trade friction is the expected duration until reaching agreements, as shown in Figure 4 (right). As delays were only defined in the samples reaching agreements, an ex-ante bargaining duration until an agreements is expectedly decreasing in α, regardless of discount factors, contributing to another efficiency gain from the soft deadline. The response of the proxies was also tested in laboratory experiments, as discussed in the following section.[37]

3 Laboratory Experiments

In the previous section, my model delivers a theoretical possibility: embedding an intermediate, imperfectly credible deadline may restore trade efficiency on the conventional deadline regime. To obtain a proof of concept of the proposed mechanism, I ran a simple laboratory experiment, following the prior experiments on multi-period durable good trades (Rapoport, Erev and Zwick (1995); Reynolds (2000); Cason and Reynolds (2005)).

3.1 Setup

Experiments were conducted over four days at the Missouri Social Science Experimental Laboratory (MISSEL). The laboratory is exclusively designed for computer experiments in social science. Each desk was partitioned for privacy, and each participant was identified by their ID. The program in research operations was written in z-Tree, a C++-based software package by the University of Zurich (Fischbacher (2007)).[38] All the games' actions and outcomes were aggregated in the central host computer.

In total, 62 subjects participated in the experiments. Before the experiments each day, subjects practiced unrecorded trades as sellers and buyers that would not affect their scores. Operationally, I divided the subjects into two groups, with each taking turns as sellers or buyers. To exclude reputation formation or potential coordination with the same opponent, subjects were randomly matched with a different subject across groups in every trade.[39] Only individ-

[36] When players are not sufficiently patient, however, the separation probability is increasing with credibility, aligned with Proposition 2, because the breakdown risk cannot serve as a strong deterrent.

[37] The analysis for delay until agreements are provided in the Appendix, Table B.2.

[38] I thank Xiaozhang Pan for writing an experimental computer program, Keh-Kuan Sun for his recruiting support, and my Washington University in St. Louis (WUSTL) colleagues for operating experiments.

[39] Although I cannot reject the possibility that some sellers form reputation of becoming a demanding seller, it is difficult to imagine the reputation was formed within two hours. Each group has no collective incentive, and

ual payoffs earned during the day were exchanged for their monetary compensation under a linear conversion rate: 30 points corresponded to 1 US dollar. Each daily experiment took approximately two hours, and subjects got 29.6 dollars on average.[40]

Subjects played a simplified model with one soft deadline ($M = 1, n_1^* = 3$) out of six periods ($N = 6$). As I wrote in Section 2.1, n_1^* and α_1^* are written as n^* and α^* for brevity. An environment for each trade was characterized by its unique set of three game primitives $\{\alpha, \sigma, \delta\}$. To identify the effect of deadline credibility, I let the credibility α vary from $\alpha \in \{0.1m, 0.05\}$, $(m \in \{0, 1, \cdots, 10\})$[41] within each session of a given $(\sigma, \delta) \in \{(1, 0.98), (2, 0.98), (1, 0.7)\}$. Seven to eight sessions of different (σ, δ) were operated during the day. Table 1A tabulates the number of trades across the environments of 1,161 trade samples.

Before each trade, both parties were informed of their role (seller or buyer) and the environment. A private value for a buyer was drawn from the shape parameter $\sigma \in \{1, 2\}$, generating a uniformly distributed or an upward-biased distribution of private value. The history of prices was displayed to ensure participants' perfect memory at the start of each period at $n \geq 2$.[42] To help their decisions be as consistent as possible, subjects were encouraged to record all their actions and results on paper each time they completed a trade.

Table 1B summarizes key descriptive statistics on prices, agreements and bargaining outcomes. Four points are worth noting alongside the model's prediction.[43]

First, consistent with the model, most offered prices declined over the periods; stubborn commitment to a single price or raised pricing was minor.[44] However, opening prices under hard deadlines with $\alpha = 0$ (mean 63.7) were higher than the prediction (mean 44.3) and even higher than a theoretical one-period price (mean 52.2), aligned with the prior literature.

Second, despite the higher opening prices P_1, an agreement ratio in the first period (23.6% of pairs agree in the first period) was on average far larger than the model (14.5%), suggesting that some buyers cooperatively accepted during the opening period.[45] Deviations of players' behaviors from theoretical predictions will be tested and discussed in Section 4.

players were random matched under perfect anonymity split in each partitioned desk.

[40] Instructions used in this study are available on request.

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

[42] Trades in offered prices above private values, generating negative profits, are not allowed by design.

[43] The simulated value in this page (opening price, agreement ratio, and the share of buyer's surplus) is computed along the formula (6)-(8), weighted with samples of each environment in the experiment.

[44] Out of 2,407 pairwise prices (i.e.; P_n and P_{n+1} $(n = 1, \cdots, 5)$), 2,050 (85.2%) discounted prices, 270 (11.2%) kept pricing and 87 (3.6%) raised pricing.

[45] Simulation suggests that an agreement ratio in the opening period ranges in approximately 12-15%, while the ratio consistently exceeds 20% in the experiment.

Third, consistent with the simulation in Figure 2 (left), as deadline credibility increases, an agreement ratio is disproportionately increasing at the soft deadline $(n = 3)$ instead of the hard deadline $(n = 6)$.[46]

Fourth, the mean distributional share of the buyer's surplus in the sum of the pair's payoffs excluding separations [47] is 34.8%—systematically lower than 50% across credibility level, indicating a seller's advantage in the game. This share is even lower than the model's counterpart ex-ante surplus share for buyers (44.4%), consistent with the seemingly cooperative purchase behavior in the opening period.

3.2 Testing the efficiency benefit

Armed with the laboratory data and guided by theoretical insights from the model, I empirically assessed testable statements of three effects of an imperfectly credible deadline. Given my random assignment of deadline credibility, I take a simple identification strategy to extract the effect of deadline credibility on bargaining outcomes (e.g., prices, efficiencies and payoffs) by controlling bargaining primitives (δ, σ) in ordinary least squares. Although treatment is random by design, each trade sample would not be independent. To address potential intratemporal- and auto-correlation of trade samples, error terms were clustered across each session by day,[48] along with individual player-fixed effects as seller and buyers. Moreover, to isolate the learning effect from trade experience, I also controlled the order of trade and session-fixed effects within a day. These econometric safeguards are inherited throughout the analysis.

Compromised offers: As an indirect channel to restore the trade efficiency, the model predicted that non-zero credibility of the soft deadline might, on the sellers' side, induce a discount in the price schedule. Lemma 1 shows that opening prices may drop for some imperfect credibility. Figure 2 (right) shows a case under under the base parameter $(\delta = 0.98, \sigma = 1)$ where the first half prices on $n \in \{1,2,3\}$ decreased for most imperfect credibility $(\alpha \in (0, 0.789])$,

[46] A formal statistical test to estimate a sensitivity of agreement ratios with deadline credibility is provided in Appendix, Table B2.

[47] This is an averaged share of a buyer's surplus within trades reaching agreements. Table 1B documents an alternative proxy, a buyer's surplus share including separations: the ratio of sum of all buyers' surpluses to the sum of efficiencies of all trades. This proxy recorded a similar level of 35.7% , which is again lower than its simulation counterpart, 44.8%.

[48] Recall that each session gives a common (σ, δ) with different magnitudes of credibility α.

Table 1A: trades across environments

sessions		σ = 1, δ = 0.98	σ = 2, δ = 0.98	σ = 1, δ = 0.7	total
credibility level	zero	35	27	27	89
	small	159	110	136	405
	medium	115	80	85	280
	high	115	81	100	296
	perfect	39	27	25	91
sum		463	325	373	1,161

Table 1B: descriptive statistics

sellers' actions		price						
		n = 1	n = 2	n = 3	n = 4	n = 5	n = 6	average
credibility level	zero	67.1	61.7	53.5	48.2	44.4	32.5	54.2
	small	64.5	56.9	47.8	42.3	36.7	28.4	51.0
	medium	61.9	53.8	41.7	39.0	35.6	28.7	51.3
	high	60.6	53.1	38.9	32.1	30.4	23.5	51.0
	perfect	59.4	53.9	36.0	-	-	-	52.2
average		62.7	55.4	44.0	42.2	37.7	28.9	51.5

buyers' actions		agreement ratio						
		n = 1	n = 2	n = 3	n = 4	n = 5	n = 6	total
credibility level	zero	21.3%	2.3%	13.5%	5.6%	14.6%	21.3%	78.6%
	small	19.8%	9.6%	14.3%	8.4%	9.4%	14.8%	76.3%
	medium	24.3%	15.7%	23.9%	6.4%	3.9%	3.2%	77.5%
	high	24.3%	12.8%	29.7%	0.7%	1.0%	1.7%	70.2%
	perfect	38.5%	9.9%	33.0%	-	-	-	81.4%
average		23.6%	11.4%	22.0%	5.1%	5.6%	8.0%	75.7%

outcomes		delay until agreement	separation	efficiency	buyer's surplus: level, separations excluded	buyer's surplus: level, separations included	buyer's surplus: share, separations excluded	buyer's surplus: share, separations included
credibility level	zero	3.69	21.3%	43.0	19.9	15.2	33.9%	35.4%
	small	3.29	23.7%	42.8	20.2	15.2	34.6%	35.5%
	medium	2.48	22.5%	46.4	20.1	15.2	32.8%	32.9%
	high	2.24	29.7%	43.6	23.2	16.0	34.9%	36.6%
	perfect	1.93	18.7%	56.2	29.5	23.7	41.7%	42.2%
average		2.76	24.4%	44.9	21.6	16.1	34.8%	35.7%

Table 1: Descriptive statistics

Note: A deadline credibility is zero if $\alpha = 0$, small if $\alpha \in \{0.05, 0.1, 0.2, 0.3\}$, medium if $\alpha \in \{0.4, 0.5, 0.6\}$, large if $\alpha \in \{0.7, 0.8, 0.9\}$ and perfect if $\alpha = 1$. A dash denotes a value unavailable by design ($\alpha = 1$). Delay until agreement is defined within samples reaching agreements. Separations consist of cases both at $n = 3$ and $n = 6$. Efficiency is the sum of the payoffs of both players. The buyer's surplus share (separations excluded) is an averaged share of a buyer's surplus within trades reaching agreements. The buyer's surplus share (separations included) is the share of the sum of all buyers' surpluses in the sum of trade efficiencies, including separations.

compared with the hard deadline regime ($\alpha = 0$). Moreover, recall that reflecting on the expanding deadline effects with credibility, the second half prices on $n \in \{4, 5, 6\}$ monotonically decreased because a remaining buyer in the post-soft deadline was much likelier to have lower private value than $\alpha = 0$. (See Figure 2 (right)) Guided by these overall pricing behaviors, I test whether a soft deadline system induces sellers' compromises, as discussed below.

Effect 1 [Compromised offers] *In contrast to the hard deadline regime, a soft deadline decreases a pricing. (Lemma 1)*

Table 2 reports the estimated sensitivity of a periodic price with deadline credibility.[49] Columns (1)-(3) shows the negative sensitivity of pricing at $n \in \{1,2,3\}$. $(-0.076, -0.076, -0.174; p < 0.1\%)$ [50] After the soft deadline, the price schedule monotonically decreases with credi-

	price level (normalized to a unit) (OLS)					
	n = 1	**n = 2**	**n = 3**	**n = 4**	**n = 5**	**n = 6**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
credibility α	-0.076 ****	-0.076 ****	-0.174 ****	-0.153 ****	-0.095 **	-0.059
	(0.013)	(0.015)	(0.017)	(0.040)	(0.044)	(0.053)
value σ	0.067 ****	0.069 ****	0.083 ****	0.073 **	0.100 **	0.102 ***
	(0.015)	(0.014)	(0.016)	(0.033)	-(0.042)	(0.039)
patience δ	0.163 ***	0.212 ****	0.169 ***	0.261 ****	0.199 *	0.153 *
	(0.050)	(0.051)	(0.053)	(0.063)	(0.105)	(0.090)
fixed effects of sellers and buyers	Yes	Yes	Yes	Yes	Yes	Yes
trade experience	Yes	Yes	Yes	Yes	Yes	Yes
observations	1161	887	755	316	257	192

Table 2: Credibility effect on price schedules

Note: Parentheses contain standard errors, clustered by day and sessions. ****, ***, **, and * show $p < 0.1\%$, $p < 1\%$, $p < 5\%$ and $p < 10\%$, respectively. Trade experience controls the order of trades and session fixed effects within a day.

bility on period $n \in \{4,5\}$ $(-0.146; p < 0.1\%$ in (4) and $-0.089; p < 5\%$ in (5)), consistently with the model. At $n = 6$, the point estimate is negative but not statistically significant in (6) (-0.059, $p = 27.1\%$), plausibly due to limited survivors.

Efficiency and distribution: If higher deadline credibility suppresses prices (Effect 1), does it also enhance the trade efficiency? Moreover, who benefited from the soft deadline? Founded on Proposition 2, this subsection tests the sensitivity of efficiency and that of a buyer's surplus.

Effect 2 [Restored trade efficiency] *In contrast to the hard deadline regime, a soft deadline improves the trade efficiency. (Proposition 2)*

[49] Aligned with Rapoport, Erev and Zwick (1995) (infinite horizon), I found similar inconsistencies of opening prices (P_1). For a higher discount factor ($\delta = 0.98$), a mean opening price was higher than the lower discount factor case ($\delta = 0.7$) and above the static ultimatum price, inconsistent with the model.

[50] Observe that this drop is most notable on the soft deadline period ($n = 3$), conjuring up ultimatum game experiments. I discuss more on the drivers of this finding in Section 4.

Effect 3 [Advantage for the responder] *In contrast to the hard deadline regime, a soft deadline yields a larger level and distributional share of the buyer's surplus. (Proposition 2)*

To test Effect 3, Column (1) of Table 3 regressed the efficiency U (or the sum of the players' realized payoffs), revealing that a coefficient of credibility α was mildly significantly positive (0.057 with $p < 10\%$). This finding indicates that higher breakdown risk on average *enhances* the efficiency. It suggests that an anticipated side effect of a soft deadline—separation costs—would not increase to the degree of harming overall trade efficiency. Guided by this inference, I investigated the potential rise of separations, by testing whether higher deadline credibility induced separations compared to the hard deadline regime. In column (2), I estimated the effect of higher credibility on a binary outcome of separation via a logit model. Perhaps surprisingly, higher credibility did not significantly facilitate the separation ($+0.286$, $p = 20.7\%$). While its positive point estimate would suggest that higher credibility is likelier to bring separations, the effects was not large enough to harm the efficiency or reduce separations.[51]

	dependent variables					
			buyer's surplus			
			level		share	
	efficiency	separation	separations excluded	separations included	separations excluded	separations included
	OLS	logit	OLS	OLS	OLS	OLS
	(1)	(2)	(3)	(4)	(5)	(6)
credibility α	0.057 *	0.286	0.064 ****	0.035 **	0.031	0.040 *
	(0.032)	(0.227)	(0.018)	(0.017)	(0.020)	(0.014)
preference σ	0.376 ****	-1.34 ****	0.200 ****	0.103 ***	-0.015	0.005
	(0.067)	(0.240)	(0.050)	(0.036)	(0.072)	(0.017)
patience δ	0.217 ****	0.511	0.037 **	0.076 ****	0.001	-0.100
	(0.017)	(0.778)	(0.016)	(0.012)	(0.020)	(0.065)
fixed effects of sellers and buyers	Yes	Yes	Yes	Yes	Yes	-
trade experience	Yes	Yes	Yes	Yes	Yes	-
observations	1,161	1,120	861	1,161	861	138

Table 3: Credibility effect on bargaining outcomes

Note: Parentheses contain standard errors, clustered by day and sessions in (1)-(5) and by day (6). ****, ***, **, and * show $p < 0.1\%$, $p < 1\%$, $p < 5\%$ and $p < 10\%$, respectively. Trade experience controls the order of trades and session-fixed effects within a day. In (1), 41 samples were dropped after including fixed effects. The buyer's surplus share (separations excluded) is a mean share of the buyer's surplus within trades reaching agreements. The buyer's surplus share (separations included) is the share of the sum of all buyers' surpluses in the sum of trade efficiencies including separations. In (6), a unit of observation is an environment by day and includes day-fixed effects.

Then, I examine whether imperfect credibility contributes to advantage for the buyers. In columns (3)–(6), I examined the sensitivity of a level and share of buyers' surplus. I con-

[51] A weakly significant positive estimate appears to be consistent with the simulation in the left of Figure 4.

sidered the surplus level and share of buyers with separation cases as included and excluded, respectively.[52] As the model relates the overall efficiency with the level and share of buyer's surplus (see Proposition 2), we should expect that all columns (3)–(6) regarding buyer's surplus exhibit similar patterns—the actual result. Columns (3)-(6) suggest that a 10-$p.p.$ rise in credibility significantly increases the expected buyer's surplus by 0.64 $p.p.$ (level; $p < 5\%$), 0.35 $p.p.$ (level; $p < 5\%$), 0.31 $p.p.$ (share; $p = 12\%$), and 0.40 $p.p.$(share; $p < 10\%$), respectively. Positive estimates of these α terms indicate that a soft deadline could also serve as a countermeasure to the monopoly power.

Overall, Tables 2 and 3 suggest even more straightforward efficacy (Effects 2–4) of the soft deadline than the benchmark model with non-linear implications of deadline credibility: higher deadline credibility discounts the seller's pricing, enhances the trade efficiency without severely inducing separations, and augments the buyer's advantage.[53] This result suggests that a soft deadline is an affordable deterrent albeit not an empty threat. In the following, I further proceed to interpret the stronger efficacy.

4 Discussion

4.1 Interpretation on the results

As shown in Section 3, the experiments demonstrated a more robust efficacy of the soft deadline than the model predicted. Higher credibility of the soft deadline suppresses offered prices, augments the efficiency, and yields the buyer's advantage, albeit with an empirically ambiguous rise in the separation rate. I shall next investigate the source of deviations from the model to discuss how the results could be interpreted.

To detect the deviations from the model, I started by assessing sellers' pricing and buyers' purchasing decisions by the following criteria. A periodic price in some environments is *reasonable* if it is within $\pm 20\%$ range of its theoretical price of the environment and is *demanding* (or *cooperative*) if it is above (or below) its theoretical price, respectively.[54] The buyer's agree-

[52] As a distribution share of separated pairs cannot be computed, (6) adopts an environment by day as the unit of analysis and includes day-fixed effects.

[53] Contrasting with the model's non-linear implications, where the benefits and drawbacks of soft deadline are comparable, I directly tested the non-linearity via a quadratic model. However, a qualitative implication is largely unchanged to the simpler linear model. Results are available on request.

[54] Pricing at the final period cannot be cooperative by design ($v < C_6$). Recall that $C_6 = P_6$ holds in the terminal period ($n = 6$). Then, cooperative pricing yields a negative profit, which is not allowed in the experiment.

ment or disagreement in period n of an environment was *reasonable* if she followed a cutoff rule to accept if $v \geq C_n$ and reject if $v < C_n$, where C_n is a cutoff computed in each environment (see Section 2.2). Analogously, if $v < C_n$, the acceptance was *cooperative*, and if $v > C_n$, the rejection was *demanding*.

Table 4A documents the benchmark share of pricing across 3 postures under the hard deadline regime ($\alpha = 0$). Most (59%) of the pricing (especially, 74% of initial pricing) was framed as *demanding,* which is even higher than the static monopoly price (consistent with prior works). Relatively fewer pricing decision—29%—were *cooperative*. However, the ratio of *cooperative* pricing gradually rose with periods from 1% ($n = 1$) to 12% ($n = 5$) and spiked to 42% ($n = 6$). The last-minute price discounting appears to be novel in the context of multi-period trade experiments with one-sided incomplete information[55] but resembles ultimatum games (discussed below). For the buyers' side, a much larger portion of decisions were *cooperative* (11%) than *demand withholding* (2.7%). This marked contrast of postures between sellers and buyers seemingly resulted in the inferior buyer's share in the experiment compared to the model (35.7% in the experiment vs. 44.8% in the model, including separations).

To analyze the sensitivity of pricing and purchase posture with deadline credibility, Table 4B and 4D report the within-player estimate of sensitivity with deadline credibility. Each estimate was a coefficient of a logit model, setting each posture as an outcome variable and including player-fixed effects[56]. Consistent with Table 2, pricing in periods $n \in \{1,2,3\}$ becomes less *demanding*, more *reasonable*, and even more *cooperative*. This result is most salient at the soft deadline period ($n = 3$), as indicated by its large, robust estimates: -4.37 ($p < 1\%$) for *demanding* and 3.92 ($p < 1\%$) for *cooperative* pricing. The soft deadline potentially remedied for the upward-biased opening price, consistent with Effect 3 (i.e., the soft deadline augments the buyer's bargaining power).

Plausibly thanks to discounted prices, the buyers enjoyed more *reasonable acceptance* replacing *reasonable rejections* in periods $n \in \{1,2,3\}$, though the buyer got slightly more *cooperative* $(0.40, 0.64; p < 10\%)$ pre-soft deadline periods ($n \in \{1,2\}$). Most saliently, in the soft deadline period ($n = 3$), the buyers became significantly less *cooperative* $(-1.12, p < 1\%)$, a

[55]The previous works—Reynolds (2000) in a six-period case and Rapoport, Erev and Zwick (1995) with an infinite horizon one—reported a puzzling *rise* of near-end prices. To explain this, they adopted fairness but in the opposite direction as my explanation: the seller is no longer motivated to discount prices after a series of rejections from the buyer.

[56]In Table 4, I use fixed effects of either sellers or buyers of interest, because a part of estimates are unavailable due to lack of variation within fixed effects.

	period						aggregate
	n = 1	n = 2	n = 3	n = 4	n = 5	n = 6	
Seller's pricing							
Table 4A: base ratio of pricing (α = 0)							
reasonable	25%	16%	28%	43%	47%	21%	29%
demanding	74%	79%	62%	41%	41%	37%	59%
cooperative	1.1%	5.7%	10%	16%	12%	42%	12%
sample	89	70	68	56	51	38	372
dependent variable — **Table 4B: within-seller estimates of deadline credibility (logit: posture dummy at period)**							
reasonable	1.27 ****	1.95 ****	0.54 *	-0.16	-1.63	-1.41	0.84 ****
	(0.22)	(0.34)	(0.32)	(1.02)	(1.22)	(1.17)	(0.16)
demanding	-1.86 ****	-2.79 ****	-4.37 ****	1.40	2.78 **	4.01 **	-1.87 ****
	(0.20)	(0.40)	(0.61)	(1.15)	(1.20)	(2.03)	(0.21)
cooperative	2.64 ****	1.06 *	3.92 ****	-1.12	-1.19	-0.33	1.95 ****
	(0.70)	(0.56)	(0.61)	(1.56)	(2.70)	(2.91)	(0.33)
maximum observation	1,161	887	755	316	257	192	3,568
Buyer's decision							
Table 4C: base ratio of decisions (α = 0)							
reasonably accept	1.1%	0.0%	5.9%	1.8%	7.8%	50%	7.8%
reasonably reject	79%	97%	82%	86%	63%	47%	79%
demanding	0.0%	0.0%	0.0%	5.4%	12%	2.6%	2.7%
cooperative	20%	2.9%	12%	7.1%	18%	-	11%
sample	89	70	68	56	51	38	372
dependent variable — **Table 4D: within-buyer estimates of deadline credibility (logit: posture dummy at period)**							
reasonable accept	1.39 ****	1.87 ***	3.72 ****	1.85	-0.74	-1.37	2.27 ****
	(0.33)	(0.61)	(0.46)	(1.86)	(1.93)	(1.51)	(0.28)
reasonably reject	-0.76 ****	-1.00 ***	-2.44 ****	-0.12	0.58	0.89	-1.15 ****
	(0.19)	(0.36)	(0.38)	(0.96)	(0.84)	(1.29)	(0.17)
demanding	1.08	1.076	0.91 *	-5.99 *	-2.83	NA	0.72 *
	(0.88)	(1.02)	(0.51)	(3.30)	(2.29)		(0.40)
cooperative	0.40 *	0.64 *	-1.12 ***	0.51	0.27	-	0.28 *
	(0.22)	(0.38)	(0.40)	(1.15)	(1.03)		(0.15)
maximum observation	1,161	887	755	316	257	192	3,568

Table 4: Deviation from the model and their sensitivities with deadline credibility

Note: For definitions of behavioral postures (for sellers: reasonable; demanding; cooperative; for buyers: reasonably accept; reasonably reject; demanding; cooperative), see the main text. Setting each posture of players as an outcome variable, Table 4B and 4D report within-player estimates of logit models with deadline credibility α, controlling for other primitives (δ, σ), the order of trades, session-fixed effects within a day, and player-fixed effect of sellers or buyers, respectively. – shows an unavailable value by design. NA denotes an unavailable estimate from a lack of variation under fixed effects. The aggregate analysis of actions in all periods adds period-fixed effects. Parentheses contain standard errors, clustered by day and sessions. ****, ***, **, and * show $p < 0.1\%$, $p < 1\%$, $p < 5\%$, and $p < 10\%$, respectively.

posture mirrored by the seller's *cooperative* discount in the period. As the change in buyer's posture well aligned with the seller's more affordable pricing, I interpret that higher deadline credibility remedied sellers' systematically *demanding* biases and facilitated the buyers' *reasonable agreements*, thereby enhancing the trade efficiency.

Still, a question remains of why more sellers become *cooperative* chiefly during the soft deadline period $(n = 3)$ and modestly in earlier periods $(n \in \{1,2\})$, as the soft deadline hardens (as reported in Table 2). Below, I discuss four behavioral mechanisms related to my context: fairness, bounded rationality, ill-updated belief, and risk aversion.

Fairness: The soft deadline is reminiscent of the canonical ultimatum games. In ultimatum games, rationality dictates an incredibly selfish proposal to be accepted by an opponent. Hundreds of experiments, however, show a well-known behavioral regularities: an average proposer offers between 30% and 50% of the money, and more than half of the opponents reject the proposal with a share under 20% (Camerer (2003)). The literature has adopted the proposer's fairness[57] as a central explanation (e.g., Fehr and Schmidt (1999); Bolton and Ockenfels (2000)). Observing the protocol's similarity, one may regard sellers' systematic cooperation before the threat as their display of fairness.[58] Consistently, in the terminal period $(n = 6)$ of the hard deadline regime $(\alpha = 0)$, similarly high cooperative pricing (42%) was observed where a monopolistic ultimatum behavior would be optimal. Instead of strategically leveraging the buyer's compromise as a first mover, the psychological bias seemingly encouraged the sellers to concede in the face of threat.

Bounded rationality: Given the similarity with ultimatum games, the fairness explanation is appealing. However, the fairness concern could be mitigated under asymmetric information.[59] Because a higher price might be unfair to lower-type buyers, but fair to higher-type buyers, rejection in this game does not immediately imply inequality aversion (Güth, Ockenfels and Ritzberger (1995)). Moreover, provided the alternating roles of sellers and buyers, the social norms for fairness might be diluted. If subjects take turns occupying an advantaged seller position, the seller would have less guilt in exercising his privilege.

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

[58] To rationalize the failure of the Coase conjecture in the laboratory, Fanning (2022) built a behavioral model with preference for fairness in line with Fehr and Schmidt (1999) and proposed distaste to disadvantageous pricing (i.e.; monopolists prefer not to offer unfavorable competitive pricing) as an explanation. In contrast, my usage of fairness for the sellers has an opposite meaning (i.e.; monopolists do not prefer too demanding pricing).

[59] Comparing experimental results of dictatorship games and ultimatum games, Forsythe et al. (1994) showed that fairness is not an exclusive factor in rationalizing the compromises in ultimatum games.

Aside from fairness, another compelling explanation is a version of bounded rationality[60], stemming from Selten (1978), who argued that a multi-period setting impedes subjects from performing rational decision-making. Particularly, in my experiment of six periods, subjects' capability to correctly infer the best responses of opponents by running backward induction was dubious.[61] In face of the soft deadline, sellers potentially did not accurately infer that the buyers would make a compromise in response to the threat. At the same time, their attentions was primarily drawn to more intuitive separation losses. Therefore, sellers failed to leverage the soft deadline under strategic interaction, indicating that higher credibility monotonically hinders their bargaining power. I conjecture that this form of bounded rationality and fairness triggered the sellers' compromises at the soft deadline.

Ill-updated beliefs: The previous two biases supposedly limit the monopoly power. Alternatively, the sellers might have failed to update the Bayesian beliefs: K_{n^*}. (c.f. "Homemade Priors" by Camerer and Weigelt (1988)).[62]The experimental protocol forced all subjects to share the initial beliefs of private values, but subjects might have substantially lowered their beliefs in the soft deadline period for any reason. Although I cannot decisively reject the possibility that K_{n^*} was substantially low, I suspect that the low beliefs is unlikely to be the primary driver for the compromise. Suppose that K_{n^*} was substantially low to explain the price drop. Then, because the belief is driven by previous cutoffs, $K_{n^*} = C_{n^*-1}$, as α increases, equally increasing share of trades must be agreed in $n \in \{1,2\}$ in the laboratory. This is incongruent with the observed change in the distribution of agreements; the rise of agreements on the pre-soft deadline period $n \in \{1,2\}$ with deadline credibility is much smaller relative to the rise of agreements on the soft deadline period $(n = 3)$[63]. No particular reasons support the belief that the belief K_n drops at $n = 3$ instead of $n = 4$.[64]

[60]Reynolds (2000) and Cason and Reynolds (2005) proposed bounded rationality to rationalize the puzzlingly high opening price, a different focus of pricing with my paper.

[61]Especially in later trades within a day, most of the subjects did not spend much time to submit each action (roughly with 5-10 seconds). As calculating a Perfect Bayesian equilibrium path in different environments must take much more time, the role of a heuristic rule of thumb appeared dominant.

[62]To track the reasoning formally, recall that sellers' pricing is formulated as $P_n = A_n K_n$, where A_n is a periodic monopoly power and K_n is (the sellers' inference of) the upper bound of their opponents' types. Therefore, lower P_{n^*} stems from either lower bargaining power A_{n^*} or lower K_{n^*}.

[63]See Table 1 for change of agreement ratio as α increases. Rigorously, the multinomial logit sensitivity of agreement with credibility is 0.57, 0.63, 1.03 for $n \in \{1,2,3\}$, respectively. (See Table B.2 in the Appendix.)

[64]Theoretically, recall that updating the belief on an opponent's value induces a conspicuous price drop from $n = 3$ to 4. On the fourth period $(n = 4)$, the remaining buyer, who have rejected the offer in the face of threat, demonstrably have lower value. (See discussions on price schedule around Figure 2).

Risk aversion: The model assumes both parties' risk neutrality; subjects' risk preferences were not controlled in the experiment. Sellers' risk aversion in the face of increasing risk seems to explain the findings. Although it is a temptingly simple explanation, I suspect that risk posture itself cannot account for monotonically shrinking seller's power with deadline credibility. Since typical pricing is classified as *demanding*, pricing is consistent with risk-seeking sellers—opposite to the preceding explanation. Moreover, as buyers' purchasing behavior are more inclined to be *cooperative* than *demanding*, this purchasing behavior is consistent with risk-averse buyers. There could be no reason to presume that the risk posture of subjects flips with their bargaining role on the same day (see Rapoport, Erev and Zwick (1995)).

4.2 Related experiments

Given experimental results and interpretations provided, I contrast my paper with its three closest precedents for readers interested more in experimental protocols and findings relative to prior works. Rapoport, Erev and Zwick (1995) ran infinite horizon experiments of durable goods trades with changing time discounting. They found that the higher the discount factor, the higher the average opening prices, inconsistent with the infinite-horizon model. In contrast, my experiments confirm this relationship of prices across all periods (See Table 2), consistent with a finite-horizon model. In addition, Rapoport, Erev and Zwick (1995) reported mean opening prices that were far above the static ultimatum price and that buyers accepted prices higher than the model, which was also observed in my study. Bounded rationality and the fairness of buyers were proposed as primary explanations.

Reynolds (2000) ran finite-horizon experiments similar to mine under a hard deadline ($\alpha = 0$) with one (bargaining) or five buyers (market), given a constant discount factor. Regarding one buyer bargaining regime, opening prices were higher when the time horizon became longer, from one, two, to six periods, contrary to the model. My experiments showed that as a soft deadline hardens (or the expected horizon "shortens"), the opening prices shrink, as partially rationalized by my model (Lemma 1). However, aligned with Reynolds (2000), who compared three ($\alpha = 1$) and six ($\alpha = 0$) periods, I find that a shorter horizon induces a lower opening price in the initial periods ($n \in \{1,2,3\}$). Relative to potential behavioral factors (e.g., risk aversion, fairness, prior beliefs), Reynolds (2000) argued that bounded rationality is a promising candidate to rationalize pricing.

Cason and Reynolds (2005) ran finite-horizon experiments with the closest formulation to my soft deadline protocol. In my model's language, their model is a special case, with two periods ($N = 2$), one soft deadline ($M = 1$), four treatments of separation probability ($\alpha \in \{0\%, 10\%, 40\%, 70\%\}$), perfect patience ($\delta = 1$) and ten restricted grids of pricing and two types of value ($v \in \{0.18, 0.54\}$).[65] Lemma 1 in my paper formalizes their numeric examples of perfect Bayesian equilibrium paths. In contrast to my experiments, Cason and Reynolds (2005) reported that opening prices were not significantly responsive to separation probability. Based on discussions of Reynolds (2000), the central interest of this prior study was in building behavioral models with bounded rationality to reconcile the deviations from the model.

4.3 Implementation in the field

Overall, I suspect that a combination of fairness and a version of bounded rationality (i.e.; lack of strategic interaction) forms a pricing rule of thumb for sellers. Based on the behavioral interpretations, what insights from these laboratory experiments could be exported to the real world? Admittedly, exporting the system to the naturally occurring market will be challenging because the laboratory almost inevitably abstracts many important real-world institutions[66]. However, based on the potential behavioral mechanism at work, one may infer that the finding in the laboratory is relatively more exportable to a peer-to-peer (P2P) bargaining scenario in the field compared to the business-to-business (B2B) negotiations.

If fairness is a principal behavioral force as discussed above, then the soft deadline might potentially skew the model's benchmark prediction in favor of the buyers, as in the laboratory. Recent field evidence shows widespread cooperative behaviors in P2P bargainings consistent with fairness. Keniston et al. (2021) document cooperations in various bargaining contexts (e.g., automobile prices negotiations, insurance claims, and TV game shows). Backus et al. (2020) demonstrate similar behavioral regularities in the millions of negotiations on eBay.[67]

[65] Due to their very short periods ($N = 2$), their model is not designed to capture the deadline effects, which are observed in a distribution of agreements across periods.

[66] For example, imbalanced outside options (currently, normalized to zero in both a model and experiments) might violate the participation constraints of either player. A comprehensive discussion on implementation is, however, beyond the scope of the paper.

[67] Although deadline effects have been observed in some renowned B2B trade anecdotes (e.g., a fiscal cliff at congressional negotiations; trading in professional sports), there is supposedly little room at work in cutthroat business deals or political fields for fairness where collective benefits of firms or countries are at stake. If negotiations are repeated in the long run, however, bargaining may be better framed as repeated games so that some cooperation emerge out of rational dynamic concerns.

If bounded rationality is a primary behavioral driver, the result is analogously more likely to apply to P2P trades. B2B deals are typically negotiated by experienced professionals, armed with a richer knowledge of the best responses of opponents than consumers in P2P trades.[68]

As an admittedly speculative policy implication, however, the soft deadline system might operate as a discipline to complement hard deadline in various inefficient trades listed at the introduction. In civil litigations, a private or public mediator (e.g., insurance firms or courts) may intervene sometime earlier than the deadline as a preliminary injunction.[69] Before the labor contract disputes, each party could formulate an ex-ante negotiation rule that an intermediator (e.g., stakeholders) could potentially clears up the bargaining at an earlier negotiation. For sovereign debt negotiations, a group of creditors and a debtor may join a commitment in which a third party (e.g., the International Court of Justice) may intervene in negotiations.

5 Concluding Remarks

Many instances of real-world bargainings are protracted until deadlines. However, conventional deadlines are far from the perfect institution, by ruthlessly generating costly separations. In this setting, must all deadlines be perfectly credible? Guided by the disproportionate agglomeration of eleventh hour agreements on deadlines, I explore redesigning the conventional deadline structure by embedding an earlier soft deadline to restore ex-ante trade efficiency.

Enriching a seller-buyer bargaining model under a hard deadline with a non-fatally soft deadline at an intermediate date, I theoretically demonstrated a potential that an imperfectly credible soft deadline might enhance ex-ante efficiency. Using a laboratory experiment, I show primitive evidence of the soft deadline's benefit. The overall results suggest an even stronger efficacy than the model's prediction, potentially due to earlier agreements being fueled by the cooperative pricing of sellers. The paper's findings could offer a new perspective to assist market designers concerned with trade efficiency.

[68] The literature on real-world games report that professionals play game-theoretic best responses. In the board games, professional players increasingly play A.I.-suggested best moves (Strittmatter, Sunde and Zegners (2020) for chess; Shin et al. (2023) for go). Using the data from professional games, players follow the game-theoretic strategy founded by mutual best responses. Some examples include Chiappori, Levitt and Groseclose (2002) for penalty kicks at soccer and Walker and Wooders (2001) for serves at tennis.

[69] In FOA (final offer arbitration) in legal proceedings, each party submits a proposal to an arbitrator and the arbitrator selects one of the two proposals. The soft deadline mechanism may serve as an intermediate possibility of FOA mediation.

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