Deadline Credibility, Protracted Trades and Market Efficiency*

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Abstract

Many real-world negotiations are chronically protracted until deadlines, but deadlines are costly in generating separations. Must all deadlines be perfectly credible in one-on-one market trades? To refine the institutional role of deadlines, I theoretically propose a mechanism of an imperfectly credible pre-deadline to facilitate the agreement. Employing a seller–buyer dynamic bargaining model with a deadline, I analytically show a possibility that the complementary pre-deadline elicits earlier agreements without triggering separations and, consequently, enhances the market efficiency. Under a well-designed threat of separation, the seller is tempted to discount a price as intertemporal price discrimination and the buyer is more likely to compromise right before the pre-deadline, as the pricing resembles an ultimatum. The results of a laboratory experiment broadly support the mechanism's efficacy.

JEL Classification: C78, C91

Keywords: bargaining, one-sided incomplete information, deadline effect, durable goods monopoly, market efficiency, laboratory experiment

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1 Introduction

Many negotiations are inexorably delayed under asymmetric information. One classical institution used for deterring endless lag is a deadline. For example, civil and criminal pretrial disputes entail a regulatory deadline to file a lawsuit. Consequently, 93% of medical malpractice disputes are settled by pretrial bargains (Sieg (2000)) and 94% of federal criminal cases are resolved by plea bargains[1] (Fisher (2003)) without formal lawsuits. In labor contract negotiations, holdouts (or on-the-job bargaining after the contract expiration)[2] are often bounded by a deadline of a union's strike or an employer' lockout, after which much bleaker disputes may begin. In international finance, many sovereign debt renegotiations close just before the expiration of debt repayment, which often implies de facto defaults of the country.[3]

Similar to Parkinson's Law (Parkinson (1957)),[4] real-world negotiations chronically delay to deadlines. Field evidence (for plea bargaining examples, see Spier (1992); for civil litigations, see Williams (1983)) and laboratory experiments (Roth, Murnighan and Schoumaker (1988)) reported the prevalence of last-minute agreements before deadlines as *deadline effects*.[5] At first glance, deadlines have virtues of enforcing agreements within a time limit. By contrast, however, the same deadlines turn fatal if agreements are missed. If pretrial bargainings in civil and criminal litigations passes its deadline, formal trials with expenses for lawyers on both sides may occur for years. For labor contract negotiations, 12% of disputes end in strikes and lockouts (Cramton and Tracy (1992)), generating substantive social harms (See e.g., Lee and Mas (2012)). When the default happens under sovereign debt disputes, post-default renegotiations are notoriously delayed—typically for more than 7 years—and the creditors ultimately lose, on average, 40% of the nominal debt burden (Benjamin and Wright (2009)). Across a wide range of negotiations in the field and laboratory settings, Roth (1995) summarized consistency of disagreement rates at approximately 15-45%.

[1] A plea bargain is a process for agreement of the prosecutor and the defendant pleading guilty to a crime without a trial in exchange for a reduction of sentence.

[2] 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.

[3] In 2015, Greece was faced with the maturity of debt from creditors (i.e.; the European Central Bank (ECB), the European Commission (EC) and the IMF), July 20, as a hard deadline, which de facto would induce a default of the country. The negotiation narrowly closed eight days before the deadline on July 12.

[4] Under the organizational context of bureaucracy, Parkinson's Law argues that volume of tasks in one project is dictated by its deadline.

[5] Roth and Ockenfels (2002) report last-minute agreements from the last minute biddings at eBay and Amazon Internet auctions.

Motivated by the substantial variety of eleventh-hour agreements at the cost of separations from hard deadlines, I sought to explore the possibility of a refined negotiation mechanism—a soft deadline—to improve the deadline institutions under a market of one-on-one trades. An implementation of this soft deadline is illustrated as follows. Suppose a hard deadline is set up at the start of the negotiation, either agreed upon or externally imposed. In parallel, suppose that a mechanism designer sets an earlier complementary soft deadline on a specific intermediate day. This complementary deadline serves as a stochastic "time bomb": if the agreement is not reached on the day, the bargaining pairs might break up with a probability of $\alpha \in (0,1)$, but continue with a probability of $1-\alpha$ (See Figure 1). Instead of the terminal hard deadline, I propose that the imperfect enforcement of an earlier, non-fatally soft deadline may be a catalyst to nudge both parties into making earlier progress towards deadlines.[6]

While admittedly speculative, the soft deadline system might operate as a discipline to complement hard deadline in various inefficient trades above.[7] 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. 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. Particularly in minor litigation cases, recent progress in artificial intelligence (AI) may allow some models or algorithms to serve as "robot judges" that suggest enforceable mediation plans, potentially simulated from historical precedents.[8]

To formalize the above concept, I begin with a seller–buyer bargaining model with one-sided, incomplete information under a deadline (*a la* Fudenberg, Levine and Tirole (1985); Sobel and Takahashi (1983)).[9] Consider an uninformed proposer selling a durable good with

[6]Perhaps more intuitively, outside the bargaining contexts in academics, for example, soft deadlines are adopted as an incentive system to induce consistent efforts before hard deadlines. For Ph.D. dissertation, a mid-term proposal is imposed as a soft deadline before a final defense. For college students, a midterm exam before a final exam serves as a soft deadline to help complete the curriculum.

[7]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.

[8]A.I. is already implemented for litigation settlement in Estonia (Niler (2019)) and China (Pillai (2019)). For recent theoretical and ethical discussions on "robot judges," see Sourdin (2018) and Casey and Niblett (2020).

[9]This bargaining framework with a deadline has been widely applicable 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.

buyers (”she”) with private values within N periods. A marginal cost is normalized to 0, and a private value ranges from 0 to 1. The marginal cost and the distribution of the values are common knowledge. The proposer can update a price in every period, and a buyer can react by agreement or rejection. The trade continues until the buyer accepts the price; when the deadline arrives, both fall back to outside options, which are also 0.

In equilibrium, instead of committing to a static monopolist price, the price declines overtime 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. In this setting, the market efficiency could be restored through both parties' reactions. Spoiled by multiple rounds of price revisions, a seller is tempted to make a compromise as intertemporal price discrimination, leading to earlier agreements; in contrast, the buyer compromises right before the deadline, as the pricing resembles an ultimatum.

Then, suppose that a market designer imposes a soft deadline characterized by a probability of α at an earlier period $n^* < N$ (below, I call this the *threat period*; see Figure 1). 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.[10] Theoretically, an imposition of the time bomb would stimulate the two

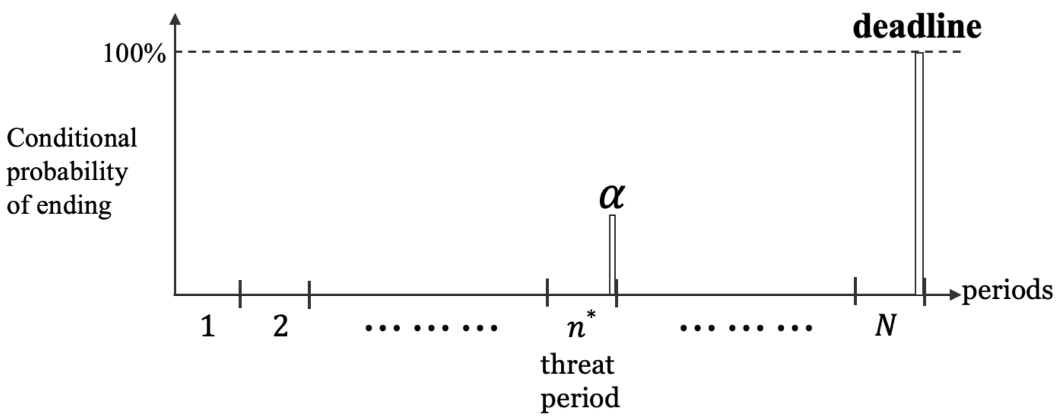

Figure 1: An imperfectly credible deadline under a deadline

Note: An intermediate deadline with a conditional separation 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 a probability α but continue with probability $1-\alpha$. In my full model, I allow for multiple threat periods for generality. For a laboratory experiment, by contrast, I use $n^* = 3$ and $N = 6$.

forces above. Intuitively, for the buyer's side, the buyer is more likely to make a compromise at the soft deadline due to the opportunity loss by potential separation. Consistent with the

[10] If $\alpha = 0$, this is nothing beyond an original setting. If $\alpha = 1$, this becomes shorter-horizon bargaining with a deadline on $N = n^*$.

experimental literature on deadline effect (Roth, Murnighan and Schoumaker (1988)), I show that agreements disproportionately occur at the soft deadline reallocated from the hard deadline. One could view that this buyer's compromise as a stochastic analog of the deadline effect.

For the seller, the compromise is non-trivial. Suppose the seller knows that the buyer provides a compromise at the soft deadline. In that case, the seller has a larger incentive to exploit the buyer, with the offer resembling a quasi-ultimatum. However, I show that a range of credibility α exists where the soft deadline facilitates the price discount. This stems from the buyer's deadline effect at the soft deadline; he is bound to compromise because rejection at the soft deadline signals that the opponent's private value is not decently high enough (see Figure 2, right). Because he foresees this intertemporal price discrimination after the threat period, a forward-looking seller would shift down the pre-threat price schedule with a lower opening price. Alternatively put, soft deadline serves as a signaling device for low-type buyers to induce price discrimination from sellers. Notably, in the conventional deadline framework, this price discounting channel is absent.

Suppose that a mechanism designer optimizes the market efficiency, defined as the sum of both parties' ex-ante payoffs of both parties. Given the two channels activated, does a soft deadline improve the market efficiency? When both parties were sufficiently patient, I find that an optimal threat $\alpha^* \in (0,1)$, which is characterized by bargaining primitives, achieves the highest ex-ante efficiency. This finding reflects a straightforward trade-off between shorter delays until agreements and a rising expected loss. If α is small, the risk relatively facilitates the compromise of both parties as an effective deterrence, as described above. However, if α is large, the game resembles a short-sighted ultimatum game. The expected separation cost from the rise of monopoly power dominates the efficiency benefit of risk-induced compromise. A parameterized model shows that a non-empty interval of imperfect credibility $\alpha \in (0,1)$ enhances the market efficiency without excessively fueling separations.

My theoretical finding, founded on mathematically equivalent modeling of multi-buyer markets, revisits an accepted wisdom regarding bargaining horizon and market efficiency based on the famous Coase (1972) conjecture in the durable goods monopoly. Coase contended that one-sided asymmetric information without a deadline leads to an immediate agreement favorable to the informed party (i.e., buyers). As the bargaining horizon extends (or as a good becomes more durable), the efficiency is retrieved. This well-known phenomenon is framed as "durability attenuates monopolistic distortion".[11] Two polar cases succinctly characterize this intuition. In a one-period ultimatum game,[12] bargaining undergoes the heaviest efficiency loss under the maximized monopolist's power. In contrast, under an infinite-horizon scenario given unlimited pricing periods, the monopolistic market is closer to Pareto-efficient with an immediate agreement as Coase conjectured. If one generalize the deadlines' time structure, the soft deadline breaks the conventional link: the model suggests that 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 (Rapoport, Erev and Zwick (1995); Reynolds (2000); Cason and Reynolds (2005)), I implemented a simplified version of my model in a computer laboratory. From this experiment, I obtained approximately 1,200 pieces of trade data from 62 subjects. The subjects were randomly chosen to engage in a bilateral bargaining game ($N = 6$) under various threat levels predetermined on the middle threat period ($n^* = 3$).

The experiment broadly evidences a soft deadline benefit in terms of efficiency. Expectedly, I found a highly robust agreement agglomeration on the soft deadline. As the soft deadline became harder, the magnitude of agreements would increase. Consequently, delays until agreements shrunk on average. Intriguingly, when the soft deadline became highly credible, the efficiency gain and the buyer's advantage were more pronounced despite a suggestive evidence of rising separations and contrary to the model predicting efficiency losses and disadvantages to buyers.

To discern the cause of the stronger efficacy for relatively higher credibility, I detected the behavioral deviations of subjects from the model. I contrasted the offered prices and decisions of buyers with theoretically-predicted ones. Under the hard deadline regime ($\alpha = 0$), most (89%) of buyers' reactions and few (12%) of the sellers' pricing decisions were reasonably justified. Notably, 59% of prices were framed as "demanding"—sometimes beyond the static ultimatum price. This pricing has been canonically reported and reconciled by the prior experimental literature without soft deadlines. As a soft deadline hardened, I found that sellers drop the mean prices on the threat period more saliently than the model—novel to this literature

[11] See, for example, Güth and Ritzberger (1998). See Section 2.4 for greater detail.
[12] My model with $N = 1$ can be framed as a variant of an ultimatum offer game under incomplete information.

but reminiscent of an extremely well-established history of ultimatum game experiments[13]. Consequently, a significant fraction of seller's pricing becomes theoretically reasonable, even cooperative, especially during the threat period. Founded on the discussion of potential behavioral forces at play (See Section 4) in contrast to the experimental literature, I conclude that a relatively higher deadline credibility remedied the upward-biased pricing of sellers and fueled the earlier agreements of buyers; consequently, it enhanced market efficiency.

Related literature: This paper proposes a mechanism of negotiations to complement the conventional deadline. Theoretically, it intersects with several streams of bargaining theories. First, it extends deadline effects in bargaining models by enriching a deadline structure. The finite-horizon bargaining model was formally built by Sobel and Takahashi (1983) and Fudenberg and Tirole (1983), although the role of deadlines on the market efficiency was not explicitly featured.[14]

Regarding pretrial civil litigations, Spier (1992) uses a similar one-sided incomplete-information model to mine, deriving an agglomeration of trade at the deadline of the trial date.[15] 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. 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.[16]

Second, my soft-deadline design is isomorphic to the random separation of bargaining (in alternating-offers game, see Rubinstein and Wolinsky (1985); in a decentralized market, see Binmore, Rubinstein and Wolinsky (1986)). Models in most of the early literature had no dead-

[13]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)).

[14]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.

[15]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.

[16]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)).

lines under complete information and, again, generated no delay (e.g., Muthoo (1999)). More recently, several studies (Fuchs and Skrzypacz (2010); Fanning (2016); Simsek and Yildiz (2016)) developed bargaining models with random breakdowns, where the *timing* of a deadline is uncertain and where separation can stochastically occur any time. By contrast, my model presumes a specific event (or events) of potential separation that a mechanism designer presets. Theoretically, this soft deadline signals low-type buyers to induce price discrimination from sellers, thereby enhancing market efficiency.

Third, and most 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)).[17] The conjecture's essence lies in the proposition that "durability hurts the monopoly power," suggesting a positive association between the time horizon (interpretable as durability) and market efficiency in the monopolistic market.[18] More recently, under the different, but mathematically equivalent protocol of repeated ultimatum games with private information on fairness, Fanning and Kloosterman (2022), supported by experimental evidence, predicted the Coaseian outcomes of almost immediate agreements on an equal split, conditional on sufficient players' patience. Compared with a snapshot ultimatum case, the efficiency is again, significantly larger in the infinite horizon. As a marked advancement in the literature literature, the soft deadline breaks this link: seemingly *shorter* bargaining periods deliver higher ex-ante market efficiency (see Proposition 2). Reframing the durability of goods with players' patience (or less bargaining friction[19]), the Coase conjecture also implies that players' higher patience shrinks the monopolistic distortion.[20] As varying deadline credibility corresponds with adjusting players' patience, my primary result may also shed new light on the proposition.

[17]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.

[18]See Sobel and Takahashi (1983), Theorem 6, or Güth and Ritzberger (1998). Bond and Samuelson (1984) also showed that if the good depreciates faster, the Coase conjecture can be evaded such that the monopolistic power revives.

[19]In the bargaining model, patience is often viewed as bargaining friction (e.g., the setup cost for meetings or cost of crafting a proposal and making a decision).

[20]Related to this statement, Stokey (1981) showed that shorter intervals between offers ($\Delta \to 0$) harm the monopolistic power with more frequent offer revision. Observe that as discounting factor is typically formulated by $\delta = \exp(-\gamma\Delta)$ (γ is an instantaneous discount rate), a limit case ($\Delta \to 0$) implies a higher patience ($\delta \to 1$). Güth and Ritzberger (1998) showed that sufficiently high patience is a requisite for intertemporal price discrimination in the Coase conjecture.

Employing experimental data, this paper relates to two strands of experimental literature on bilateral bargaining. First, the paper builds on instances of experimental bargaining with deadlines in parallel to bargaining models with deadline effects. In a laboratory experiment, Roth, Murnighan and Schoumaker (1988) documented highly robust deadline effects across different bargaining protocols; about half of all agreements were reached within the final 30 seconds.[21] Güth, Levati and Maciejovsky (2005)'s work further supports this robustness across protocols of time horizons, decreasing pies and alternating roles. Overall, experimental deadline effects appear to be universally established across bargaining models. My experiment, which generalizes a deadline structure, bolsters the view that deadline effect emerges even if a deadline is soft; as a soft deadline becomes more credible, more trades close on the threat period.

Second, this paper borrows from, extends, and complements the experimental literature on seller–buyer durable goods trades with one-sided, incomplete information. Largely, the sellers' pricing in the experiments was inconsistently higher than predictions from rational selfish-player benchmark models.[22] Scholars in the literature have attempted to reconcile puzzling price decisions (especially, the level and comparative statics of opening price) via behavioral forces. Below, I contrast my paper with its closest precedents.

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 3), 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

[21] 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."

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

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 pre-threat period ($n \in \{1,2,3\}$). 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 threat period ($D = 1$), 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 ($v \in \{0.18, 0.54\}$).[23] 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.

My results under a hard deadline inherit the similar pricing behavior already 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 value-added finding, my experiment documents unreported behavioral regularities in the line of the literature above, which evokes, however, well-established ultimatum game experiment results (for a survey, see Camerer (2003)): 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 studies.

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 market 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 interpreta-

[23] 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.

tions to reconcile the gap. Section 4 concludes the paper. The Appendix provides proofs of theoretical results and delivers operational details and auxiliary analyses of experiments.

2 Bargaining with Imperfectly Credible Deadlines

To formalize the proposed mechanism, a natural candidate for a benchmark model should contain a deadline and generate an endogenous delay.[24] Below, I enrich a screening-type seller–buyer bargaining model under a hard deadline (Sobel and Takahashi (1983); Fudenberg, Levine and Tirole (1985))[25] by embedding intermediate soft deadlines.

2.1 Setup

A seller ("he") sells a durable good with a buyer ("she") with unknown private values. The market has no supply shortage; each good has a commonly known zero marginal cost. Each infinitesimal buyer has her private value $v \in [0,1]$ for the good.[26] I assume that v is distributed according to the shared cumulative distribution function $F(v) = v^{\sigma}\,(\sigma > 0)$.[27] Suppose that both are rational and risk-neutral.

Time is measured by discrete and finite periods with $n = 1,2,3\cdots$ and a length $\Delta > 0$ for each bargaining round. Suppose that the seller credibly imposes a deadline at period N.[28] At the beginning of the period n, the seller 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 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 $n = N$, she and the seller both receive 0 as an outside option.

[24] 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 solution.

[25] 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)).

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

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

[28] In the durable goods monopolist context, the monopolist supposedly has larger reputational concerns that encourage commitment to a hard deadline. As a micro-foundation of one-sided offer protocol, Ausubel and Deneckere (1992) demonstrated the Silence Theorem under alternating-offer games with one-sided incomplete information: the informed party endogenously never made any serious offers when Δ was sufficiently short; only the uninformed party made offers.

Suppose that a market designer embeds a series of soft deadlines at an earlier period $n^*_d \in [1, N)$ $(d \in [1, \cdots, D])$, which I call a *threat period*.[29] (For simplicity, the subscript d is omitted throughout the paper, especially when only one threat period is imposed, i.e., $D = 1$). The threat's credibility is captured by a conditional separation risk $\alpha_d \in (0, 1)$ at the end of each threat period n^*_d. (See Figure 1) This implies that if a proposal is rejected at period n^*_d, bargaining ends with probability α, and both receive outside options, but proceeds to period $n^*_d + 1$ with probability $1 - \alpha$.

The seller's problem 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 the probability of the agreement at period n if the seller offers P_n. V_n is his value function at period n; 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 buyer's problem is to choose the acceptance period $\widehat{n}$ given the seller'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. 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

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

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

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 introduced a standard perfect Bayesian equilibrium (for theoretical foundations, see Sobel and Takahashi (1983); Fudenberg, Levine and Tirole (1985)).

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

2.3 Equilibrium Paths

The model is solved via backward induction from the hard deadline. 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. [Equilibrium paths 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 seller's and the buyer's respective value functions, V_n and W_n, are characterized as follows by $\{A_n\}$:

$$V_n = A_n K_n \mathbb{E}(v), \ \ W_n = (1 - \frac{\sigma+2}{\sigma+1} A_n) K_n \mathbb{E}(v) \tag{5}$$

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 posterior 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 formula).

Intuitively, A_n is monopolistic and B_n is the buyer's bargaining power, such that higher A_n, B_n raises prices and cutoffs, respectively. 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 $\mathbb{E}(v) = \dfrac{\sigma}{\sigma+1}$. The overall market efficiency—of central interest in the paper—is characterized by the sum of the value functions at the initial period, $V_1 + W_1$. 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 $(N = 6, D = 1, n^* = 3, \delta = 0.98, \sigma = 1)$. 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 $n^* = 3$ 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 threat period.[30]

Price schedule: Considering the buyer's compromise in the face of the soft deadline, the seller would presumably jack up the price in a strategic interaction. This inference appears justified, considering that the soft deadline generates a quasi-ultimatum offer in the last period, which raises the question of how the price schedule appears.

Using the same parameterized model, Figure 2 (right) documents the simulated price path. Obviously, in contrast to committed monopolistic prices, the price schedule decreases over periods. Saliently, the seller performs a conspicuous compromise just after the threat period

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

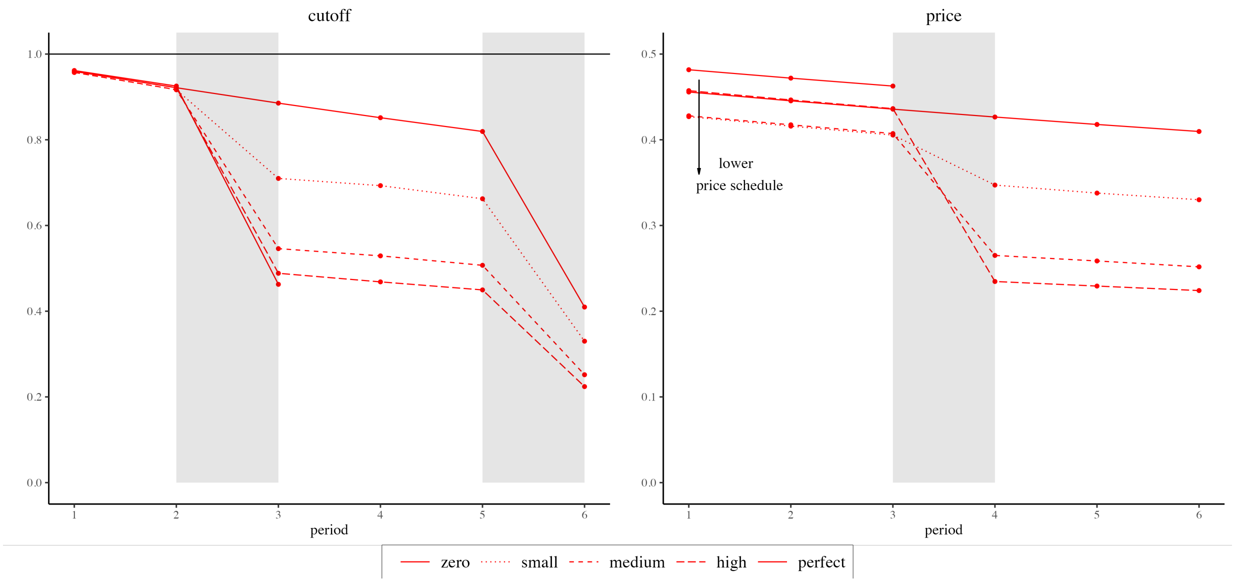

Figure 2: Equilibrium dynamics across the levels of credibility (left: cutoff; right: price)
Note: The model is simulated under an experimental setting ($n^* = 3; N = 6; D = 1$) and baseline parameters ($\delta = 0.98; \sigma = 1$). See Figure 1.) A threat is zero if $\alpha = 0$, small if $\alpha \in \{0.05, 0.1, 0.2, 0.3\}$, medium if $\alpha \in \{0.4, 0.5, 0.6\}$, large if $\alpha \in \{0.7, 0.8, 0.9\}$ and complete 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).

$n = 4$ (especially when $\delta = 0.98$). 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 bounded from above (Recall that $K_4 = C_3$ per (2)). Due to deadline effects (shown above), after-threat prices (P_4, P_5, P_6) monotonically decline with higher credibility. Catering to the diminished asymmetric information, the seller drops the price as an intertemporal price discrimination. In other words, the soft deadline is a signaling device of low private value, once the offer at the threat period is rejected. Therefore, the forward-looking seller offers with a cheaper opening price, shifting the total price schedule downward. Compared to the no-threat case, Figure 2 (right) shows that the seller shifted 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 seller7s 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,*

$\alpha_d^* \in (0,1)$ *uniquely minimizes an opening price* P_1 *s.t.*

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

where $A_{n_d^*}$ *is recursively characterized by function of primitives* $A_n \delta, \sigma, \alpha_d, n_d^*$ *and* N *for* $d = 1, 2, \cdots, D$ *by* (4).

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

$$\frac{dP_1}{d\alpha_d} \underset{\text{Recall } P_1 = A_1}{=} \frac{dA_1}{d\alpha_d} = -\frac{\mathbb{E}(v)}{(\sigma+1)^2} \underbrace{\frac{dA_1}{dA_{n_d^*}}}_{(>0) \text{ Appendix}} \frac{dA_{n_d^*}}{d\alpha_d} = 0. \tag{7}$$

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

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

By solving for α_d, one attains the desired α_d^* in (6) (the detailed derivation and the S.O.C. are shown in the 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

$$\delta^* = \frac{(1+\sigma)-(2+\sigma)A_{n_d^*+1}}{(1+\sigma-A_{n_d^*+1})(1-A_{n_d^*+1})}. \tag{8}$$

Suppose $\alpha_d^* \geq 1$. Then by (6), $A_{n_d^*+1} \geq \dfrac{1+\sigma}{2+\sigma}$ must hold. Accordingly, 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, $\alpha_d^* < 1$. □

As the opening price captures the seller's ex-ante bargaining power (recall that$P_1 = A_1$), the theorem indicates a theoretical possibility that some range of imperfect credibility suppresses the monopoly power. The non-linearity reflects two forces at work, shaping the monopoly power. The first is intertemporal price discrimination during post-threat periods, as stated above. If the seller foresees that he must discount a price if the threat 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 force dominates, leading to the monopolist power being gradually restored. [31] A parameterized simulation in Figure 2 that combines responses of opening prices (or pre-threat prices) P_1, P_2, P_3 and monotonically declining post-threat prices P_4, P_5, P_6 with credibility, suggests that pricing is discounted across periods for most of the deadline credibility.

2.4 Efficiency

The central theoretical question is how the overall market efficiency responds to the intensity of the deadline credibility. To determine 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 ($U \equiv V_1 + W_1$).[32] 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 such that $\delta \geq \delta^*$, as defined by (8). Then, $\alpha_d^* \in (0,1)$ uniquely maximizes the efficiency U, as well as level W_1, and share W_1/U of buyers' expected surplus.

[*Proof*] Using (5), 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

$$U \equiv V_1 + W_1 = (1 - \frac{P_1}{\sigma + 1})\mathbb{E}(v) \quad W_1 = (1 - \frac{\sigma + 2}{\sigma + 1} P_1)\mathbb{E}(v). \tag{9}$$

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. □

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

[32] 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 theorem states that given the specific threat period n_d^*, the imperfect credibility of a soft deadline maximizes the overall bargaining efficiency and ex-ante buyers' advantage. This implies that the non-zero threat of separation could *enhance* the market efficiency by suppressing the monopoly power compared to the hard deadline regime. In Figure 3, a simulation of a model parameterized model finds that the overall efficiency is maximized at an imperfect credibility $\alpha^* = 0.28$, 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, the non-linearity stems from a dynamic trade-off between the deterrence effect (efficiency gain by facilitated compromises) and the separation effect (efficiency loss by termination). When the efficiency benefits from avoided separation and smaller discounting outweigh the direct separation loss, imperfectly designed credibility restores a part of efficiency.[33]

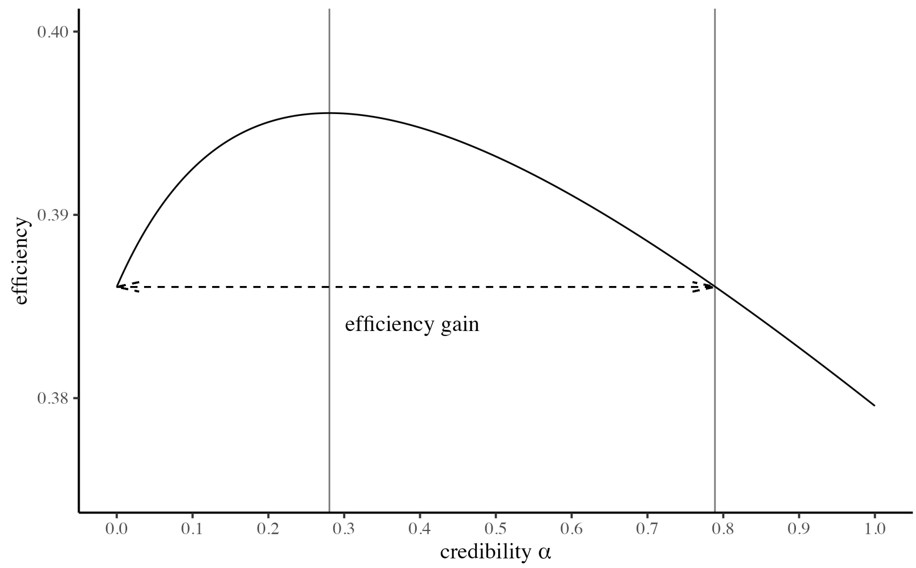

Figure 3: The efficiency curve in regard to deadline credibility

Note: The efficiency is computed by $V_1 + W_1$ based on (9). A model was simulated based on the analytical formula with a baseline parameter of experiments $N = 6$, $\sigma = 1$, $\delta = 0.98$, and a single threat period set on $n^* = 3$. The vertical line is the optimal threat $\alpha^* = 0.28$ and the upper-bound value of imperfect credibility to enhance the efficiency $\alpha = 0.789$.

Although this study highlights the soft deadline's role as a countermeasure for trade inefficiency, 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.[34]

[33]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.

[34]Alternatively, one may interpret that the sensitivity of buyer's advantage is conversely shaped by the response

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 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 $\mathbb{E}(v)$.[35]

In the other extreme of a one-period ultimatum game ($N = 1$), the monopolist gains the strongest bargaining power 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 purchase (as the price and cutoff is both $1/2$). My model's results showed 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 market efficiency to facilitate compromises from both parties.

2.5 Efficiency loss

The preceding section showed that a well-designed threat of separation augments the 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.[36] Operationally, I formally defined the pair of efficiency loss from potential separation and frictional delay as follows.

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

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

$$\underbrace{\alpha_d C_{n_1^*}}_{\text{first threat period } (d=1)} + \underbrace{\sum_{d=2}^{D}\left(\left(\prod_{d'=2}^{D}(1-\alpha_{d'-1})\right)\alpha_d C_{n_d^*}\right)}_{\text{following threat periods } (d\geq 2)} + \underbrace{\prod_{d=1}^{D}(1-\alpha_d) C_N}_{\text{terminal period}}. \tag{10}$$

of monopolistic power in Lemma (1) under the non-cooperative bargaining.

[35]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 $N \to \infty$).

[36]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 delay until agreement is defined by

$$\mathbb{E}(\widehat{n}) = \sum_{n=1}^{N} n \left(\prod_{l=1}^{n} \eta_l \right) \underbrace{(K_n - C_n)}_{\text{ratio of buyers of agreement at } n} . \tag{11}$$

Based on Definition 2, the sensitivity of these two sources of inefficiency with the credibility is simulated, as shown in Figure 4.

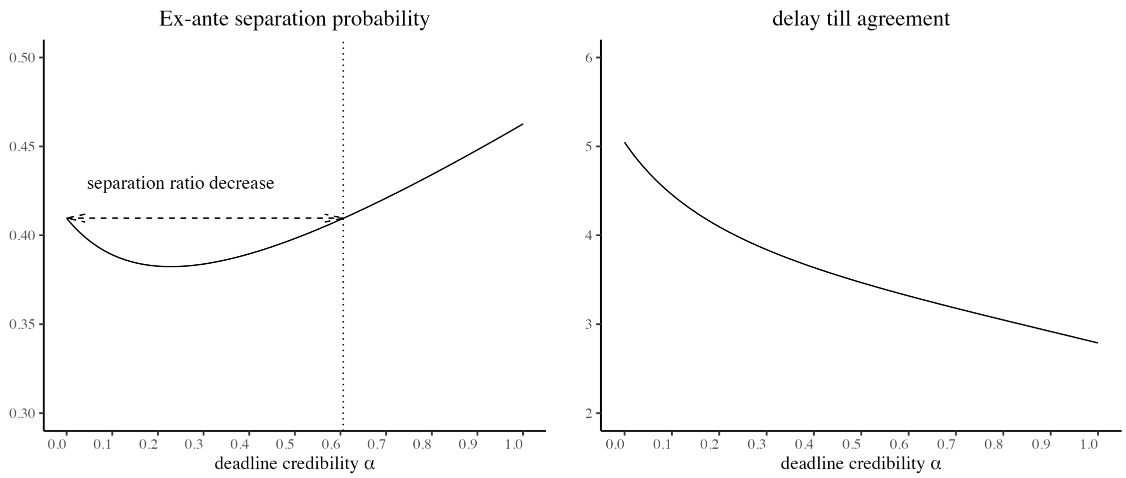

Figure 4: Ex-ante separation probability and delay until agreement (simulation)

Note: (10) and (11) are simulated with $N = 6$, $\sigma = 1$, $\delta \in \{0.7, 0.98\}$, and a single threat period set on $n^* = 3$. When $D = 1$, (10) is reduced to $C_{n^*}\alpha_{n^*} + (1 - \alpha_{n^*})C_N$.

The parameterized model simulation showed that the ex-ante separation probability would exhibit a non-linear sensitivity. Aligned with the non-linear sensitivity of market efficiency concerning α, as shown in Proposition 2, an appropriately designed separation risk 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.[37]

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 threat. The response of proxy pairs was tested in laboratory experiments, as discussed in the following section.

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

3 Laboratory Experiments

Building on the conventional deadline regime, this study's model delivers a theoretical possibility: embedding an intermediate, imperfectly credible deadline may restore market efficiency. 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 recorded 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 individual 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 version of my model with one threat period $(D = 1, n^* = 3)$ out of six periods $(N = 6)$. 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

[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 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.

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.[42] 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 $n \geq 2$.[43] 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. Three points are worth noting alongside the model's prediction.[44] First, consistent with the model, most offered prices declined over the trade periods; stubborn commitment to a single price or raised pricing was minor.[45] However, aligned with the prior experimental literature under hard deadlines, opening prices (mean 63.7) were higher than the model's prediction (mean 44.3) and even higher than a simulated static monopoly price (mean 52.2).

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.[46] Deviations of players' behaviors from theoretical predictions will be tested and discussed in Section 4.

Third, the aggregate share of the buyer's surplus including separations,[47] is 35.7%—systematically lower than 50%, indicating a monopolist's advantage in the game. This share is even lower than the model's counterpart ex-ante surplus share for buyers (44.8%), consistent with the seemingly cooperative purchase behavior in the initial period.

[42] See the Appendix for a detailed schedule of sessions each day.

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

[44] The simulated value in this page (opening price, agreement ratio, and the share of buyer's surplus) is computed along the formula (3)-(5), weighted with samples of each environment in the experiment.

[45] 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.

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

[47] This aggregate share of buyer's surplus is calculated as the share of sum of all buyers' surpluses in the sum of trade efficiencies including separations. Table 1B documents an alternative proxy, computed as an averaged share of a buyer's surplus within trades reaching agreements (excluding separations) as a similar level of 34.8% ,while its simulation counterpart is 44.4%.

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 complete 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.

3.2 Testing the efficiency benefit

Guided by theoretical insights from the model and having employed the laboratory data, I empirically assessed testable statements of four effects of an imperfectly credible deadline, as detailed in the subsections below.

Deadline effect: The direct channel to enhance the market efficiency is buyers' compromises in the face of earlier separation risk. As illustrated in Figure 2, the proposed mechanism reallocated the agreement agglomeration from a hard deadline to a soft one. Figure 5 (top) shows that as the credibility increases from 0 to 1, the agreement ratio is sensitive at each deadline, as measured by the number of pairs reaching an agreement out of all the pairs. One can see that as the credibility rises, the agreement ratio at $n = 3$ and the one at $n = 6$ increases and decreasing, respectively, a finding roughly consistent with the model.

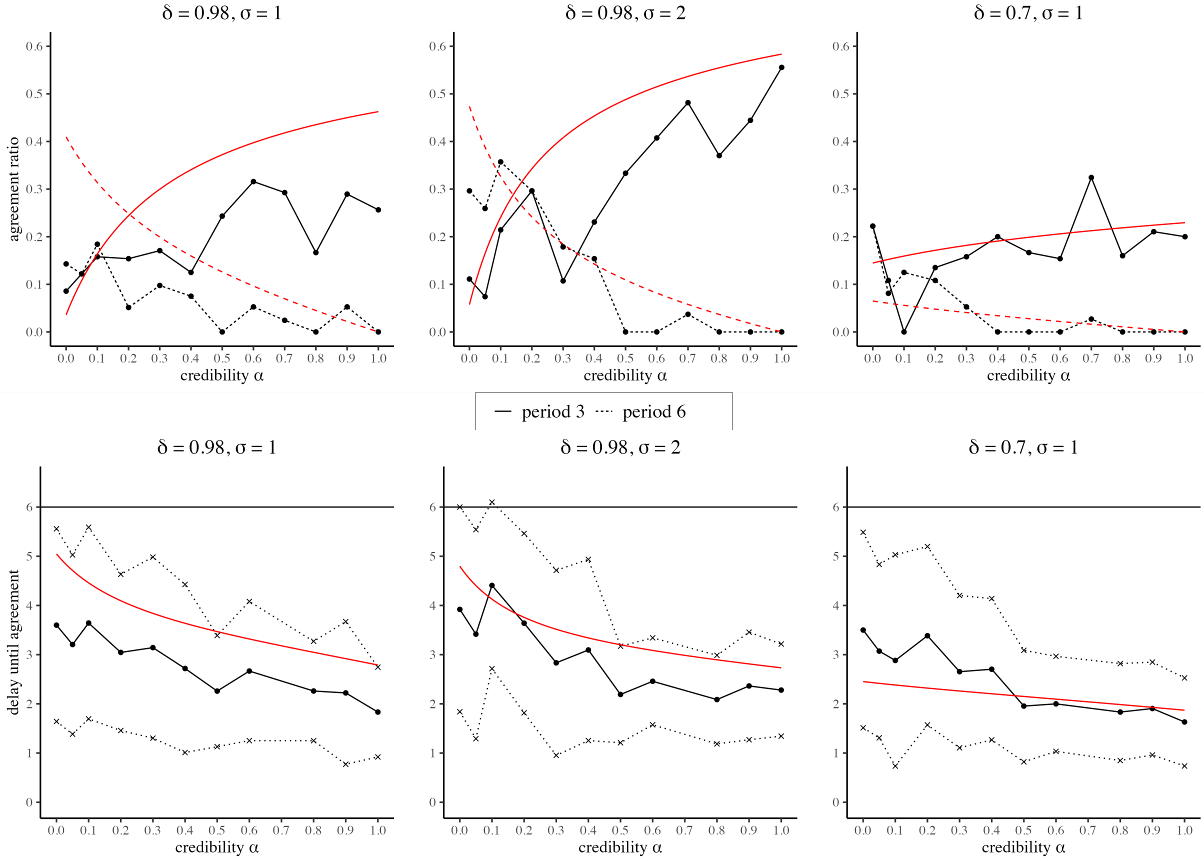

Figure 5: The sensitivity of the agreement ratio and the mean delay until agreement

Note: The top shows the sensitivity of the agreement ratio at soft ($n = 3$) vs. hard deadlines ($n = 6$) (black: experiment vs. red: model); An agreement ratio is the number of pairs reaching agreements divided by total number of pairs reaching the $n = 3$ or $n = 6$, respectively. The bottom shows the sensitivity of the mean delay until agreement (black: experiment, red: model) The delay until agreement is only defined within samples reaching agreements. The black dots are standard deviations.

Motivated by the agreement agglomeration at the soft deadline, this first subsection tests the expanding deadline effect at the soft deadline, as formalized below.

Effect 1 [The deadline effect] *In contrast to the hard deadline regime, imperfect credibility increases the agglomeration of agreements on the threat period relative to the pre-threat periods* (left in Figure 2).

Following the literature on deadline effects, I proxied deadline effect at the soft deadline as the relative occurrence of agreements on the threat period ($n = 3$) relative to each pre-threat period ($n \in \{1,2\}$). More comprehensively, Table 2 (1) analyzes how an agreement distribution is regulated by the deadline credibility.[48] Setting a binary agreement outcome each period, I

	dependent variables						
	agreement (multinomial logit)						delay until agreement (OLS)
	(1)						(2)
	n = 1	n = 2	n = 3	n = 4	n = 5	n = 6	
credibility α	0.57 *	0.63	1.03 ***	-3.44 ****	-4.92 ****	-6.03 ****	-0.284 ****
	(0.29)	(0.39)	(0.32)	(0.70)	(0.80)	(1.25)	(0.025)
value σ	1.03 ****	1.32 ****	1.54 ****	1.23 ****	1.18 **	2.02 ***	0.029
	(0.30)	(0.28)	(0.24)	(0.29)	(0.59)	(0.62)	(0.019)
patience δ	-1.56 *	-1.39	0.02	-1.16	2.00 **	0.58	0.218 ****
	(0.91)	(1.12)	(0.77)	(1.17)	(1.00)	(1.86)	(0.054)
fixed effects of sellers and buyers	Yes	Yes	Yes	Yes	Yes	Yes	Yes
trade experience	Yes	Yes	Yes	Yes	Yes	Yes	Yes
observations	1,161						878
AMPE (p.p.) per 10 p.p. credibility α	0.788	0.533	1.37	-1.30	-1.88	-2.66	-2.84

Table 2: Credibility effects on agreement distributions

*Note:*Parentheses contain standard errors, clustered by day and sessions. Trade experience controls the order of trades and session-fixed effects within a day. Delay until agreement is normalized to a unit interval within 878 trades reaching agreements. ****, ***, **, and * show $p < 0.1\%$, $p < 1\%$, $p < 5\%$ and $p < 10\%$, respectively. AMPE (average marginal probability effect) for a multinomial logit is computed as an average of the MPE (marginal probability effect) of each observation.

jointly estimated a multinomial logit model. Of course, each of observation would not be independent: autocorrelation and individual-subject learning effects might hinder the analysis. To address the autocorrelation, error terms were clustered across each session by day,[49] along with player-fixed effects of seller and buyers. To capture the learning effect, I controlled the order of trade and session-fixed effects within a day. These econometric safeguards are inherited

[48] In (1), larger σ is shown to significantly facilitate agreements across all periods as intuitively interpreted; higher-type buyers buy the good earlier and are more likely to evade the separations.

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

throughout this section.

The estimates accord with detail of Figure 5; as credibility rises, the last-minute agreements at $n = 3$ occur more frequently $(1.03,\ p < 1\%)$, while ones at $n = 6$ before the final deadline happen less often $(-6.03,\ p < 0.1\%)$. The α's estimate at $n = 3$ indicates a 1.37 $p.p.$ higher average marginal probability effect (AMPE) of agreement ratio from a 10-$p.p.$ rise in credibility. Given estimates at $n \in \{1,2\}$ are both smaller with less precision $(0.57,\ p = 5.2\%$ and $0.63,\ p = 10.7\%)$ than the estimate $(1.03, p < 1\%)$ at $n = 3$, the results suggest an emerging deadline effect at the soft deadline. By contrast, when the conventional deadline effect is defined as agreements just on the deadline $(n = 6)$ relative to each prior period $(n \in \{4,5\})$, comparing -6.03 $p.p.$ $(p < 0.1\%, n = 6)$ with -3.44 $p.p.$ $(p < 0.1\%, n = 4)$ and -4.92 $p.p.$ $(p < 0.1\%, n = 5)$ shows fading deadline effect at the hard deadline. As the soft deadline becomes harder, Table 2(1) jointly illustrates the transition of deadline effects from the hard to soft deadlines.

An immediate consequence of higher deadline credibility is shrinking delay until agreements by mechanically reallocating the distribution of agreements from post-threat periods $(n \in \{4,5,6\})$ to pre-threat $(n \in \{1,2\})$ and threat period $(n = 3)$. To illustrate this, Figure 5 (bottom) draws a mean duration that is conditional on agreement across environments, compared with the simulation (red lines computed by (11)). Roughly consistent with the simulation, delay until agreements monotonically decreased with higher credibility. Formally, Table 2(2) shows a response of a unit-normalized bargaining duration until an agreement with higher credibility. The coefficient of credibility was found to be significantly negative $(-0.284, p < 1\%)$, indicating that a $10 - p.p.$ rise in credibility shortens the delay by an average of $2.8 p.p.$ (i.e., 0.17 periods out of 6 periods), enhancing the market efficiency.[50]

Compromised offers: As an indirect channel to restore the market efficiency, the model predicted that non-zero credibility of the soft deadline might, on the sellers' side, induce a compromise 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 pre-threat and threat prices on $n \in \{1,2,3\}$ decreased for most imperfect credibility $(\alpha \in (0, 0.789])$, compared with the hard deadline regime $(\alpha = 0)$. Moreover, reflecting on

[50]The coefficient on δ is found to be significantly positive, consistent with the theory; the seller's bargaining power rises and buyers permit a longer delay to seek a cheaper pricing.

the expanding deadline effects with credibility, the post-threat prices on $n \in \{4,5,6\}$ monotonically decreased (Figure 2 (right)) because a remaining buyer in the post-threat period was likelier to have lower private value. Guided by these overall pricing behaviors, I test whether a soft deadline system induces sellers' compromises, as discussed below.

Effect 2 [Compromised offers] *In contrast to the hard deadline regime, imperfect credibility decreases .*

Table 3 reports the estimated sensitivity of a periodic price with deadline credibility.[51] Columns (1)-(3) shows the negative sensitivity of pre-threat and threat periods. $(-0.076, -0.076, -0.174; p < 0.1\%)$ [52] For post-threat periods, the price schedule monotonically decreases with

	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 3: Credibility effect on price schedules

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

credibility 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.

More rigorously, to directly capture the non-linear response of opening prices P_1 that are conditional on sufficient patience (Corollary 1), I employed a less parsimonious quadratic

[51] 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.

[52] Observe that this drop is most notable on the threat period ($n = 3$). To complement the analysis, I test the sensitivity of inter-period price ratios and find that only a coefficient of $\frac{P_3}{P_2}$ is negatively the largest with robust statistically significance (see the Appendix), conjuring up ultimatum offer experiments. I discuss more on the drivers of this finding in Section 4.

model. However, the implications are similar to the linear model in Table 3 (see the Appendix for additional details). I will reserve the discussion on backgrounds of monotonic sensitivity for Section 4, after the analysis of outcomes is provided.

Efficiency and distribution: If higher deadline credibility suppresses prices (Effect 2) and facilitates earlier agreements (Table 2), does it also enhance the market efficiency? Moreover, who benefited from the intervention in the laboratory? Founded on Proposition 2, this subsection tests the sensitivity of efficiency as the central question and that of a buyer's surplus.

Effect 3 [Restored market efficiency] *In contrast to the hard deadline regime, imperfect credibility improves the market efficiency.*

Effect 4 [Advantage for the responder] *In contrast to the hard deadline regime, imperfect credibility yields a larger level and share of the buyer's surplus.*

To test Effect 3, Column (1) of Table 4 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 separation risk typically *enhances* the efficiency. It suggests that an anticipated side effect of embedding a soft deadline—mean separation cost—would not increase to the degree of harming overall market efficiency. Guided by this inference, I investigated the potential rise of separations, as partially suggested by the model (Figure 4 (left)), by test whether higher deadline credibility induces separations compared to the hard deadline regime. In column (2), I set a binary outcome of a separation as an outcome variable, estimating the effect of higher credibility via a logit model. Perhaps surprisingly, a coefficient of credibility α did not yield much precision ($p = 20.7\%$). While its point estimate of 0.286 and 95% confidence interval $[-0.158, 0.730]$ would suggest that higher credibility is likelier to bring separations, the effects was not large enough to harm the efficiency or reduce separations.[53]

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 considered

[53] Both an increase or decrease of breakdown probability is partially consistent with the simulation (Figure 4 (left)). Alternatively, direct testing of the model's non-linear implication by a quadratic model found complementary evidence of a rise in separation probability, capturing an anticipated downside of the soft deadline. Analogously, the rise in separation probability is not large enough to overturn the efficiency implication trade, either (see the Appendix for additional detail.)

	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 4: Credibility effect on bargaining outcomes

Note: Parentheses contain standard errors, clustered by day and sessions in (1)-(5) and by day (6). Trade experience controls the order of trades and session-fixed effects within a day. In (1), 41 samples were dropped after including fixed effects. ****, ***, **, and * show $p < 0.1\%$, $p < 1\%$, $p < 5\%$ and $p < 10\%$, respectively. The buyer's surplus share (separations excluded) is a mean share of As 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.

the surplus level and share of buyers with separation cases as included and excluded, respectively. As documented in Table 1, the buyer's surplus share, excluding separations (addressed in (3) and (5)), is an averaged share within trades reaching agreements; the buyer's share, including separations (addressed in (4) and (6)), is an aggregate share of all buyers in the sum of trade efficiencies including separations. (6) adopts an environment by day as the unit of analysis and includes day-fixed effects. 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) 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.

So far, readers might notice that Tables 3 and 4 suggest even more robust efficacy (Effects 2–4) of the soft deadline than the benchmark model: higher deadline credibility shrinks the monopolistic pressure and enhances the efficiency without severely inducing separations. This result suggests that a soft deadline is an affordable deterrent albeit not an empty threat. Contrasting with the model's non-linear implication, where the benefits and drawbacks of the higher threat are comparable, I directly tested the non-linearity via a quadratic model. However, the qualitative implication is largely stable (see the Appendix for an auxiliary analysis). In the following, I further explore the root cause of the findings.

4 Discussion

As shown in Section 3, the experiments demonstrated a more straightforward efficacy of the soft deadline than the model predicted. Higher credibility of the soft deadline suppresses offered prices, augments the efficiency, and yields the responder'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 ±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 agreement 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 5A documents the base share of pricing across 3 pricing 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

[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.

[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.

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). Table 1 in Section 3.1 is relevant to this finding.

To analyze the sensitivity of pricing and purchase posture with deadline credibility, Table 5B and 5D 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 3, pricing in periods $n \in \{1,2,3\}$ becomes less *demanding*, more *reasonable*, and even more *cooperative*. This result is most salient in the threat 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 4 (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* $(0.40, 0.64; p < 10\%)$ in the pre-threat periods $(n \in \{1,2\})$. Most saliently, in the threat period $(n = 3)$, the buyers became significantly less *cooperative* $(-1.12, p < 1\%)$, a posture mirrored by the seller's *cooperative* discount in the period. As the change in buyer's posture well aligned with the seller's softening pricing, I interpret that higher deadline credibility remedied sellers' systematically *demanding* biases and facilitated the buyers' *reasonable agreements*, thereby enhancing the market efficiency.

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

Fairness: The threat period is straightforwardly 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 adopts

[56]In Table 5, 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.

	n = 1	n = 2	n = 3	n = 4	n = 5	n = 6	aggregate
Seller's pricing							
	period						
Table 5A: 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
Table 5B: within-seller estimates of deadline credibility (logit: posture dummy at period)							
dependent variable							
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							
	period						
	n = 1	n = 2	n = 3	n = 4	n = 5	n = 6	aggregate
Table 5C: 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
Table 5D: within-buyer estimates of deadline credibility (logit: posture dummy at period)							
dependent variable							
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 5: 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 5B and 5D 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.

the proposer's fairness[57] as a central explanation (e.g., Fehr and Schmidt (1999); Bolton and

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

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.

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 monopoly power.[62] I conjecture that this form of bounded rationality and fairness triggered the sellers' compromises at the soft deadline.

[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.

[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 put both forces in perspective, it is insightful to map each in my bargaining framework. The lower

Ill-updated beliefs: The previous two biases supposedly limit the monopoly power. Alternatively, the sellers might have failed to update the Bayesian posterior: K_{n^*}. (c.f. "Homemade Priors" by Camerer and Weigelt (1988)).[63] The experimental protocol forced all subjects to share the initial beliefs of private values, but subjects might have substantially lowered their posterior in the threat period for any reason. Although I cannot decisively reject the possibility that K_{n^*} was substantially low, I suspect that the low posterior is unlikely to be the primary driver for the compromise. Suppose that K_{n^*} was substantially low to explain the price drop. Then, because commonly shared posterior K_n should be shaped by the frequency of agreements in the previous periods, similarly increasing the portion of trades must be agreed in $n = 1,2$. This is incongruent with the observed change in the distribution of agreements; the rise of agreements on the pre-threat period $n = 1,2$ with deadline credibility is much smaller relative to the rise of agreements on the threat period $(n = 3)$ (see the multinomial logit coefficients of 0.57, 0.63, 1.03 in columns (1)-(3) of Table 2). No particular reasons support the belief that the posterior drops at $n = 3$ instead of $n = 4$.[64]

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 tempting 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

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monopoly power A_{n^*} is decomposed as

$$\underbrace{\frac{dA_{n^*}(B_{n^*},\alpha)}{d\alpha}}_{\text{change in monopoly power}} = \underbrace{\overbrace{\frac{dA_{n^*}}{dB_{n^*}}}^{\text{monopolist's exploitation }(<0)} \overbrace{\frac{dB_{n^*}}{d\alpha}}^{\text{buyer's compromise }(<0)}}_{\text{strategic interaction}} + \underbrace{\overbrace{\frac{\partial A_{n^*}}{\partial \alpha}}^{\text{monopolist's compromise }(<0)}}_{\text{price discrimination}}$$

Fairness contributes to a negatively larger $\frac{\partial A_{n^*}}{\partial \alpha}$ and/or a negatively small $\frac{dA_{n^*}}{dB_{n^*}}$. Because $\frac{dA_{n^*}}{dB_{n^*}}$ does not depend on the risk α, fairness is supposed to work only at $\frac{\partial A_{n^*}}{\partial \alpha}$ by fueling the price discrimination. Bounded rationality is captured by near-zero $\frac{dB_{n^*}}{d\alpha}$.

[63] 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 posterior. Therefore, lower P_{n^*} stems from either lower bargaining power A_{n^*} or lower K_{n^*}.

[64] Theoretically, recall that updating the posterior 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).

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)).

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? Presently, the implementation of soft bargaining to the "naturally occurring" market remains challenging (e.g., incentive compatibility of both parties[65]). However, based on the potential behavioral mechanism at work, one may infer that the finding in the laboratory is relatively more smoothly exportable to a peer-to-peer (P2P) bargaining scenario in the field compared to the business-to-business (B2B) negotiations.

Recently, small yet burgeoning field evidence shows widespread cooperative behaviors 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. If fairness is a principal behavioral force, then the efficacy of the soft deadline might potentially skew the model's benchmark prediction in favor of the responders, as in the laboratory. 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—despite those very settings being where collective benefits of firms or countries are at stake.[66] Analogously, if bounded rationality is a primary behavioral driver, the result is less likely to apply to B2B trades. Such deals are typically negotiated by experienced professionals, armed with a richer knowledge of the best responses of opponents than consumers in P2P trades.[67]

[65]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.

[66]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.

[67]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

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 market efficiency.

Enriching a seller-buyer screening-type bargaining model under a deadline with random separation at an intermediate date, I theoretically demonstrated a potential that an imperfectly credible earlier deadline might enhance ex-ante efficiency. Using a laboratory experiment conducted with sixty-two subjects, 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.

Admittedly, from a mechanism design perspective, exporting the system beyond the laboratory will be challenging. The stringent control over the environment in the laboratory almost inevitably abstracts many real-world institutions that motivate the research and may limit the external validity of the findings (Harrison and List (2004); List (2007)). Nevertheless, the paper's findings could offer a new perspective to assist market designers concerned with efficiency.

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