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Using a Soft Deadline to Counter Monopoly

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ABSTRACT

A monopolist often exploits a hard deadline to raise their commitment power. I explore whether a group of buyers can employ a soft deadline to counter the monopoly. Using a simple model of a durable goods monopolist under a deadline, I show that the buyers' imperfect commitment to exit early may elicit a big sale from the monopolist and generate the buyers' premium. The soft deadline partially restores the self-competition dynamics of the Coase conjecture, which was previously constrained by the hard deadline. In the conventional wisdom on the Coase conjecture, the shorter bargaining horizon (or, interpretably, less durability of goods) augments monopoly power. A soft deadline breaks this link: the horizon appears *shorter*, but the buyers may be better off in expectation.

JEL Classification: C78, C91

1 | Introduction

Across the developed economies, the monopoly power of leading firms is rising (see e.g., Loecker and Eeckhout [1]). Countering to the monopoly power is the central interest of negotiators. Consider starting a weekly negotiation with a monopolist who is pushing an ultimatum with a hard deadline of one month. The standard countermeasure is to form a collective bargaining unit and gently show a glimpse of the possibility of walking away from the bargaining table. In the procurement of electricity or semi-conductors, a group of small companies often forms a purchasing consortium.[1] At a weekly meeting, they may threaten to switch to another supplier. In labor disputes, workers form a labor union, often followed by a lockout deadline by an employer.[2] The labor union may dangle the plan of an earlier strike after two weeks have passed. Negotiators might use a predetermined political event to augment their bargaining power (Simsek and Yildiz [4]).[3] For example, a U.S. presidential election would significantly change the structure of an energy market or the business outlook for supply chains. Negotiators may exploit the political risk that nearly derails the negotiations.[4]

Guided by the real-world tactics of collective bargaining, this paper theoretically explores a new commitment device for a group of buyers—a soft deadline to counter the monopoly power. Specifically, employing a durable goods monopolist bargaining model (Stokey [7]; Bulow [8]; Sobel and Takahashi [9]) under the deadline, I show that the buyers' imperfect commitment to an earlier exit would create a novel motive for price discrimination, and thus eliciting a concession from the monopolist.

Consider that a monopolist (he) sells his goods of zero marginal costs to a continuum of buyers (she). Each buyer's valuation is private information with a public distribution ranging over $[0, 1]$. The monopolist can only commit to a price every period with a length $\Delta > 0$. Each buyer rejects every offer until the offer is accepted. Under no hard deadline, when both parties are sufficiently patient (i.e., goods are durable), the monopolistic power is severely lost by self-competition dynamics, just as in the long-known Coase conjecture (Coase [10]).

To circumvent the conjecture, one natural commitment device for a monopolist is a deadline. Suppose that a hard deadline is

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exogenously imposed at time T, and when the deadline passes, both get 0. Then, when a cost of delay is small, the monopolist power is drastically recovered by framing his offer as an "ultimatum" (see, e.g., Fershtman and Seidmann [11]; Güth and Ritzberger [12]). In the unique equilibrium, the asymmetric information generates a delay to screen the buyer; the price schedule is declining overtime (as a self-competition), and a lower-type buyer wait longer for a discounted price.

Let us introduce a soft deadline as a new commitment device for the buyers. Suppose that before the bargaining starts, a group of buyers announces a soft deadline at a specific earlier time t^* before the hard deadline. To maximize the expected buyers' surplus, the group announces its level of commitment to the deadline at $\alpha \in [0, 1]$, as a conditional probability of exit if the soft deadline passes (In Section 2, multiple number of soft deadlines are imposed). Intuitively, this soft deadline serves as an uncertain "time bomb" where the remaining lower-type buyers would stochastically leave the bargaining table (i.e., fall back to their outside options 0).

Consistent with the literature with a hard deadline with deadline effect (as tested in Roth et al. [13] and formalized in Fershtman and Seidmann [11]), in the limit case ($\Delta \to 0$), I first show that agreements of an atom of buyers occur just before the soft deadline, because sufficiently patient buyers care for the opportunity loss and rush for bargain. More intriguingly, however, I show that the surprisingly subtle imposition of the soft deadline elicits the monopolist's discount in a non-obvious way, but with intuitive appeal.

When the soft deadline safely passes ($t > t^*$), I show that the monopolist sharply performs a big sale, characterized as an atom of price cut, which is absent under the conventional hard deadline. After the big sale, remaining low-type buyers enjoy the discount, and more types of buyers trade compared to a hard deadline case. This big sale occurs as a direct consequence of the aforementioned agglomeration of purchases at the soft deadline; rejection at the soft deadline signals that the remaining buyer types are not high enough to agree before the "time bomb," the price-discriminating monopolist is tempted to discount a price.

In addition to the big sale, given the poor expected revenue after the soft deadline, the sufficiently patient, forward-looking monopolist may irresistibly start with a cheaper opening price and drive down the earlier price schedule ($t \leq t^*$) to secure the revenue. One may view that a soft deadline partially restores the self-competition dynamics of Coase conjecture previously constrained by the hard deadline.

In the limit case, I formally demonstrate that there exists an optimal interior commitment $\hat{\alpha} \in (0, 1)$ to the soft deadline, maximizing the expected surplus of the buyers. If the commitment is too hard, however, the soft deadline resembles a short-sighted hard deadline, and just backfires to augment the monopolist's power. Interestingly, under some parameter values, buyers of all types are shown to be better-off because of, or at least indifferent to, the soft deadline, assuring a participation constraint to impose this commitment device.

The finding casts a new light on the conventional wisdom in Coase conjecture, regarding the bargaining horizon and the monopoly power in the durable goods monopoly. In a paper titled "durability and monopoly" Coase [10], claims that durability harms the monopoly power, indicating that longer bargaining horizon (or interpretably, durability of goods) favors the buyers and restores market efficiency.[5] To see this claim intuitively, consider two polar cases. Under a one-shot ultimatum game, the buyers suffer most under the strongest monopolist's power. In contrast, in an infinite horizon with limitless bargaining rounds, all the buyers enjoy near-competitive pricing and the bargaining achieves full-efficiency, aligned with the conjecture. The soft deadline breaks the link: the bargaining appears shorter, but the buyers are better off in expectation.

1.1 | Literature Review

The article contributes to the theoretical literature on the classic durable goods monopolist model (Stokey [7]; Bulow [8]; Gul et al. [14]).[6] Almost all of the literature on durable goods monopolies, whether theoretical or applied, is susceptible to the insights of Coasian dynamics,[7] launched in a seminal paper Coase [10], later established by Gul et al. [14], Ausubel and Deneckere [19], and Thépot [20]. Substantial theoretical attempts have been made to revive the monopolist's commitment through the depreciation of goods (Bond and Samuelson [21]), discrete demand (Bagnoli et al. [22]), the arrival of new buyers (Fuchs and Skrzypacz [23]), and the buyer's outside options (Board and Pycia [24]).

One simple solution to recover the monopolist power is to impose a hard deadline.[8] Generally put, the conventional wisdom of the Coase conjecture essentially proposes that a shorter horizon (or less durability of goods) augments the monopoly power (see Sobel and Takahashi [9], Theorem 6 or Güth and Ritzberger [12]).[9] As a key novelty of the paper, a soft deadline breaks the conventional link: the horizon appears shorter, but the ex-ante monopoly power may be harmed under the general deadline regime.

Most of the early theoretical literature on durable goods monopolist adopts an infinite horizon. This study also builds on theoretical bargaining works on the role of hard deadlines on last-minute agreements ("deadline effect"). In the context of pre-trial negotiations, Spier [29] uses a one-sided incomplete-information model similar to mine, deriving an agglomeration of trade at the deadline of a trial date Ponsati [30]. and Damiano et al. [31] derive a similar atom of trade at the hard deadline in concession games with two-sided incomplete information. My paper shows that deadline effect occurs even if the deadline is soft.[10]

Though outside the durable goods monopoly context, the closest precedent to using a deadline in the continuous time limit is Fuchs and Skrzypacz [34]. Fuchs and Skrzypacz study the effect of relative outside options on deadline effects in a hard deadline characterized by an atom of trades.[11] While standardizing outside options of both parties, my model conceptually diverges from theirs in two dimensions. First, I show a deadline effect under a generalized deadline structure. Second, my model provides the novel prediction of an atom of price discount as a result of the emergence of self-competition.

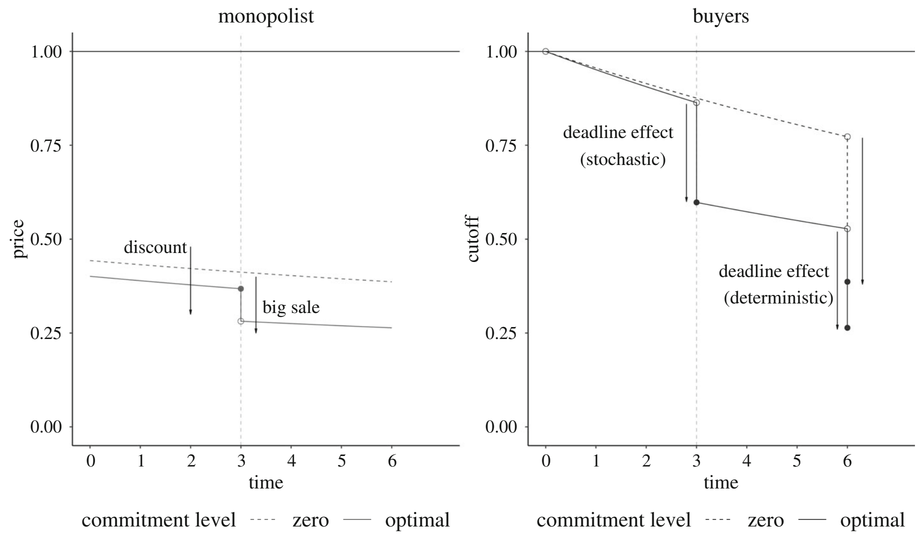

FIGURE 1 | Bargaining dynamics in equilibrium (baseline vs. optimal commitment). The schedules of the players are simulated in the continuous-time model, where a soft deadline with $\widehat{\alpha}_1 = 0.274$ is imposed at $t_1^* = 3$ out of the time horizon $T = 6$. The bargaining might end at $t_1^* = 3$ with probability α_1, but it might continue with probability $1 - \alpha_1$. *Notes:* [Colour figure can be viewed at wileyonlinelibrary.com]

The characterization of soft deadlines is isomorphic to the idea of a random breakdown Binmore et al. [36]. introduced the risk of breakdown in the alternating-offers model (Rubinstein [37]). Rubinstein and Wolinsky [38] embed the risk in the model of decentralized market. The early models include no asymmetric information, and thus, generating no costly delays in equilibrium.

However, later studies build models with incomplete information and random breakdown, where the timing of breakdown is uncertain under a continuous deadline distribution (Fuchs and Skrzypacz [23]; Fanning [32]; Simsek and Yildiz [4]). In contrast, my model assumes that the occurrence of a breakdown is uncertain for a given event, which is designed to capture a realistic feature of bargaining institutions. If breakdown comes with a continuous arrival rate, the agglomeration of trades (deadline effects) or the price drop cannot be measured by atoms as in my paper (see Figure 1 and Proposition 2).

1.2 | Outline

The article is organized as follows: Section 2 presents a bargaining framework with an imperfectly committed deadline and characterizes the unique equilibrium. Section 3 shows that the monopolist performs a price discount before and after the soft deadline. Next, Section 4 demonstrates that the buyers enjoy a premium. The sensitivity of the overall efficiency is explored regarding the commitment intensity of the buyers. Section 6 concludes the paper. All the proofs of the results except Corollary 3 are provided in the Supporting Information.

2 | Model

I start with a durable goods monopolist model, where an uninformed monopolist screens a pool of buyers under a hard deadline.

2.1 | Setup

A monopolist (he) sells an indivisible durable good with a group of infinitesimal buyers (she). All are risk-neutral and forward-looking expected payoff maximizers. Each buyer has her private value $v \in [0, 1]$ for the good and I assume that v is distributed according to the commonly known cumulative distribution function $F(v) = v^{\sigma}$ $(\sigma > 0)$.[12]

The monopolist's marginal cost is normalized to 0[13] with no shortage of supply,[14] and it is common knowledge. Time is continuous with $t \in [0, T]$, but broken into $n \in \{1, \ldots, N\}$ periods with a period length $\Delta > 0$ such that nth round start at $t = (n-1)\Delta$; The first bargaining round starts at $t = 0$, the second starts at $t = \Delta$, so does the final round at $t = N\Delta \leq T$, and so on.

Suppose that a hard deadline is exogenously imposed at the time T.[15] At each round n, the monopolist proposes an offer P_n.[16] The monopolist is allowed to commit to P_n only for a period of length Δ. Then, each buyer immediately either accepts or rejects.[17] If she accepts the price, the game ends with this outcome: the monopolist gets $e^{-\gamma(n-1)\Delta} P_n$, and each buyer gets $e^{-\gamma(n-1)\Delta}(v - P_n)$, where γ is a common instantaneous discount rate. If she keeps rejecting the price until the final round $n = N$, both get 0 as an outside option.

The monopolist's strategy at some start of the period n, denoted as $p(\{P_i\}_{i=1}^{i=n-1}, N-n)$ is a mapping from the history of rejected prices, $\{P_i\}_{i=1}^{i=n-1}$, and remaining rounds $N - n$ to the current period offer, P_n.[18] A buyer of type v strategy at period n, denoted as $q_v\left(\{P_i\}_{i=1}^{i=n-1}, N-n\right)$, is a mapping from the history of prices, including the current one, and remaining periods, to a binary choice whether to accept or reject the current price, P_n.

Suppose that the buyers' group imposes a series of D time soft deadlines at a subset of bargaining rounds $n_d \in \{2, \ldots, N-1\}$ (d is the order of soft deadlines, with $d \in \{1, \ldots, D\}$) with some imperfect commitment, captured by a conditional breakdown risk $\alpha_d \in (0,1)$ at round n_d. For simplicity, I assume that participation in the buyer group occurs before the valuations are known to the buyers, to avoid signaling problems. Later, I will discuss the ex-post incentive to join the group for each type of buyer in Figure 3.

This implies that if the proposal is rejected at round n_d, the bargaining ends with probability α_d and both get 0, but it proceeds to round $n_d + 1$ with probability $1 - \alpha_d$.[19] Observe that if $\alpha_d = 1$ for some d, the soft deadline is reduced to a hard deadline. One may frame the soft deadline as an application of commitment to the deadline.[20] For generality, I allow the model to incorporate D soft deadlines at round n_d ($d \in \{1, 2, \dots, D\}$). However, a single soft deadline model with $D = 1$ would sufficiently replicate the model's insights.

2.2 | Equilibrium

A complete strategy for the monopolist $\mathbf{P} = \left\{ p\left(\{P_i\}_{i=1}^{i=n-1}, N-n \right) \right\}_{n=1}^{n=N}$ determines the prices to be offered in every round after any possible price history. Because it is more costly for high types to delay trade than it is for low types, the buyers' best responses must satisfy the famous skimming property[21] in dynamic bargaining games, suggesting that in any equilibrium for any current price P_n and after any history of offered prices $\{P_i\}_{i=1}^{i=n-1}$, there exists a cutoff type $C_n = c(P_n, \{P_i\}_{i=1}^{i=n-1}, N-n)$ such that each buyer accept if $v \geq C_n$ and rejects otherwise. The buyers' strategy is reduced to a cutoff strategy by $\mathbf{C} = \left\{ c\left(P_i, \{P_i\}_{i=1}^{i=n-1}, N-n \right) \right\}_{n=1}^{n=N}$.

Let $K_n(\{P_i\}_{i=1}^{i=n-1}, N-n)$ as the highest remaining type in equilibrium at round n as a function of a history of prices and remaining rounds. Immediately from the buyer's cutoff strategy, the belief system $\mathbf{K} = \{K_i\}_{i=1}^{i=N} = \left\{ K_n\left(\{P_i\}_{i=1}^{i=n-1}, N-n \right) \right\}_{n=1}^{n=N}$ are characterized by K_n such that

$$K_n = C_{n-1} \quad (\forall n \in \{2, \dots, N\}) \quad \text{and} \quad K_1(\phi, N-1) = 1 \quad (1)$$

suggesting that the cutoff today is a supremum value of the buyers tomorrow. Then, $[0,\ K_n(\{P_i\}_{i=1}^{i=n-1}, N-n))$ be a range of possible types at round n, and both players know K_n as an upper bound of private value v. Then, employing $(\mathbf{P}, \mathbf{C})$ and $\mathbf{K}$, I introduce a perfect Bayesian equilibrium (for theoretical foundations, see Sobel and Takahashi [9]; Fudenberg et al. [44]).

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

The model is solved via backward induction from the hard deadline. As formally shown in the proof in the Supporting Information, given any period and any upper bound type K_n induced by $(\mathbf{P}, \mathbf{C})$ and the history, the monopolist's problem yields a unique pricing. Therefore, the continuation equilibrium is unique and depends on the history only via the state variable K_n and the remaining rounds $N - n$. This greatly simplifies the notation: the current price and cutoff is denoted by $P_n = p(K_n, N-n)$, $C_n = c(P_n, K_n, N-n)$, respectively, and K_n is specified by (1).

Given K_n with $N - n$ remaining rounds and the strategies $(\mathbf{P}, \mathbf{C})$, let $\widehat{V}_n(K_n, N-n)$, $\widehat{W}_n(K_n, N-n)$ be the expected continuation payoff of the monopolist and buyers, respectively. For non-terminal rounds $n < N$, $\widehat{V}_n(K_n, N-n)$ is recursively given as

$$\hat{V}_n(K_n, N-n) = \underbrace{\left(\frac{F(K_n) - F(C_n)}{F(K_n)} \right)}_{\text{probability of agreement}} P_n(K_n, N-n) + \underbrace{\frac{F(C_n)}{F(K_n)}}_{\text{probability of rejection}} \eta_n e^{-\gamma\Delta} \hat{V}_{n+1}(K_{n+1}, N-(n+1)) \quad (2)$$

where η_n is an adjustment factor attached to a discount factor $e^{-\gamma\Delta}$ such that

$$\eta_n = \begin{cases} 1 - \alpha_d & (n = n_d) \\ 1 & (n \neq n_d) \end{cases} \quad (3)$$

Equation (2) is the value function of the monopolist, which consists of the expected payoff in the current period if the price is agreed immediately, and the expected payoffs in the future if the price is rejected. Note that the buyers' commitment to the soft deadlines are incorporated as η_n to discount the after-threat expected payoffs.

At a hard deadline $n = N$, the monopolist proposes an ultimatum. Therefore, the value function equals to a single period expected payoff as

$$\hat{V}_N(K_N, 0) = \underbrace{\left(\frac{F(K_N) - F(C_N)}{F(K_N)} \right)}_{\text{probability of agreement}} P(K_N, 0) \quad (4)$$

On the demand side, given the expected path of prices, each buyer's strategy c must satisfy the condition for optimality (Equation (5)) as a best response.[22] This necessary condition turns out to be sufficient due to the well-known skimming property (i.e., the higher types trade earlier than the lower types).

$$\text{For } n < N, \quad \underbrace{C_n(P_n, K_n, N-n) - P_n(K_n, N-n)}_{\text{payoff of agreement today}} = \underbrace{\eta_n e^{-\gamma\Delta}(C_n(P_n, K_n, N-n) - P_{n+1}(K_{n+1}, N-(n+1))}_{\text{payoff of agreement tomorrow}} \quad (5)$$

must hold. Intuitively, equation (5) suggests that the marginal buyer with a value $v = C_n$ is indifferent between buying today or tomorrow. In the last period $n = N$, the decision making is the same as an ultimatum receiver such that

$$\text{For } n = N, \underbrace{C_N(P_N, K_N, 0) - P_N(K_N, 0)}_{\text{payoff of agreement at the hard deadline}} = \underbrace{0}_{\text{outside option}} \quad (6)$$

Therefore, at any round n, the buyer's optimal strategy is to accept P_n if $v \geq C_n$, and rejects if $v < C_n$. Based on this cutoff strategy, the collective buyers' continuation value $\widehat{W}_n(K_n, N-n)$ is defined recursively in an analogous way to the monopolist (see Supporting Information for value functions). Mathematically put, readers may notice that this is nothing but adjusting a discount factor by η_n in the subset of rounds n_d (see equation (3)).[23] I show below that this surprisingly simple formulation of commitment intensity regarding the deadline generates a perhaps unintended consequence for surplus division.

2.3 | Dynamic Schedules

I solve the model backward. The distributional assumption $F(v) = v^{\sigma}$ ($\sigma > 0$) assures that truncated versions of the distribution have an isomorphic shape as the original distribution, giving a periodic stationarity of the problem in backward induction. In a general distribution, there might be multiple optimal pricing. By contrast, the distribution makes the monopolist's problem strictly concave, and a unique pricing is specified with a closed form (see Sobel and Takahashi [9]; Fuchs and Skrzypacz [34]).

Given the state variable $\{K_n\}$ at round n, the equilibrium path of $\{(P_n, C_n)\}$ $n \in \left\{1, \dots, N = \left\lceil \frac{T}{\Delta} \right\rceil \right\}$ is sequentially characterized by $\{A_n\}$ and $\{B_n\}$ as follows:

$$P_n = A_n K_n \text{ and } C_n = B_n P_n \tag{7}$$

where $\{A_n\}$ and $\{B_n\}$ are recursively characterized by the following difference equations:

$$\begin{cases} A_n = \{(\sigma+1) - \sigma \eta_n e^{-\gamma\Delta} A_{n+1} B_n\}^{\frac{-1}{\sigma}} / B_n, & (n < N) \\ B_n = \{1 - \eta_n e^{-\gamma\Delta}(1 - A_{n+1})\}^{-1} & (n < N), \\ A_N = (1+\sigma)^{\frac{-1}{\sigma}}; \; B_N = 1. \end{cases} \tag{8}$$

In equilibrium, regardless of the history of prices, that is, $\{P_1, \dots, P_{n-1}\}$, the monopolist turns out to choose P_n only based on K_n and the buyer chooses C_n depending only on the current price P_n. Intuitively, A_n and B_n capture the monopolist's and the buyer's bargaining power, respectively. Especially, A_0 captures the ex-ante monopoly power.

Given the strategies of both players, we are ready to characterize the equilibrium.

Proposition 1 (Equilibrium). *A unique Perfect Bayesian Equilibrium path of $\{(P_n, C_n)\}$ is characterized by (1), (3), (7), and (8).*

Proof. See the Supporting Information.

By straightforward induction, value functions of both players are pinned down in the limit case as follows. □

Corollary 1 (Monopolist's bargaining power and value functions). *The monopolist's and the buyer's value functions $\widehat{V}_n$ and $\widehat{W}_n$, respectively, are characterized by the monopolist's bargaining power $\{A_n\}$:*

$$\widehat{V}_n = \frac{\sigma}{\sigma+1} A_n K_n, \quad \widehat{W}_n = \left\{ \frac{\sigma}{\sigma+1} \left(1 - \frac{\sigma+2}{\sigma+1} A_n\right) \right\} K_n$$

Proof. See the Supporting Information.

Analogous to prices and cutoffs, the value functions of both the monopolist and the buyer are also linear with respect to the state variable K_n. The value functions are used to characterize the ex-ante expected surplus of each party: when $n = 1$, $\widehat{V}_1$ and $\widehat{W}_1$ captures an ex-ante monopolist's and consumer surplus, respectively, both of which are linear in the ex ante monopoly power A_1. The formulations of surpluses are utilized in Section 4.1 and the bargaining efficiency in Section 5 in the limit case. □

3 | Price and Purchase Schedules

In this section, I show that the monopolist as well as the buyers make some concessions due to the soft deadline. To rigorously characterize the sizes of such concessions, I extend the framework in the limit case as $\Delta \to 0$, following the similar techniques of Fuchs and Skrzypacz [34] under boundary conditions of the soft and hard deadlines. I start by rewriting P_n, C_n, K_n, A_n, X_n, V_n, W_n based on discrete periods $n \in \{1, \dots, N\}$ to notations in continuous time $t \in [0, T]$. Rigorously, pick up any $t \in [0, T]$ when a nth ($n \geq 1$) round occurs and let $t = (n-1)\Delta$, where a length of a period $\Delta > 0$. Then, one can define $N \equiv \lceil \frac{T}{\Delta} + 1 \rceil$, where $\lceil x \rceil$ is the largest integer that satisfies $\lceil x \rceil \leq x$. The timings of soft deadline is rewritten at $t_d = (n_d - 1)\Delta \in (0, T)$ ($d \in \{1, \dots, D\}$) Then, given that $n = \frac{t}{\Delta} + 1$, the variables at P_n, C_n, K_n, A_n, X_n, V_n, W_n are function of $\frac{t}{\Delta}$ (see Figure A1 in Supporting Information for illustration of constructing continuous-time variables). As a period interval between rounds shrinks (i.e., $\Delta \to 0$), all variables are redefined in the continuous time limit as follows.

Definition 2 (Variables in continuous time limit). $\{p_t\}$, $\{c_t\}$, $\{k_t\}$, $\{a_t\}$, $\{x_t\}$, $\{V_t\}$, $\{W_t\}$ are defined for all $t \in [0, T]$:

$$p_t \equiv \lim_{\Delta \to 0} P_n\left(\frac{t}{\Delta}\right), c_t \equiv \lim_{\Delta \to 0} C_n\left(\frac{t}{\Delta}\right), k_t \equiv \lim_{\Delta \to 0} K_n\left(\frac{t}{\Delta}\right)$$

$$a_t \equiv \lim_{\Delta \to 0} A_n\left(\frac{t}{\Delta}\right) \quad x_t \equiv \lim_{\Delta \to 0} X_n\left(\frac{t}{\Delta}\right),$$

$$V_t \equiv \lim_{\Delta \to 0} \widehat{V}_n\left(\frac{t}{\Delta}\right), \quad W_t \equiv \lim_{\Delta \to 0} \widehat{W}_n\left(\frac{t}{\Delta}\right).$$

where $t = (n-1)\Delta$, and n is a non-negative integer.

From now on, I use these continuous time notations. Note that even when the monopolist's commitment to each price decays (i.e., $\Delta \to 0$), a costly delay remains under the hard deadline. Given that the bargaining has a delay, how does the threat of exit change players' behaviors before and after the soft deadline?

Figure 1 illustrates that both the cutoff and price schedules discontinuously drop around the soft deadline. In the limit case ($\Delta \to 0$), I analytically pin down the atom of each drop with bargaining primitives γ, σ, α, T and t_d^*. Before the monopolist's big sale occurs, one can see that the cutoff schedule sharply drops, suggesting the buyers' agglomeration of purchase just before the soft deadline. Under the single soft deadline ($D = 1$), an instantaneous flow of trade occurs at $t \in [0, t_1^*)$ and $t \in (t_1^*, T)$, but an *atom of trade* occurs at $t = t_1^*$ as well as at $t = T$. Moreover, I show that the commitment (larger α_1) monotonically expands the drop (see Supporting Information, Lemma 1 for a formal presentation under D soft deadlines). This is very intuitive: when each buyer faces the "time bomb", she responds by dropping the cutoff sharply, leading to agglomeration of trades. This drop can be viewed as a stochastic analog of the deadline effect (tested by Roth et al. [13] and formalized by Spier [29] and Fuchs and Skrzypacz [34]) The next result follows directly from this cutoff drop.

Proposition 2 (Big sale after the soft deadline). *In the limit as $\Delta \to 0$, the monopolist's price schedule p_t is continuous at $t \in [0, t_1]$, $t \in (t_d, t_{d+1}]$ ($\forall d \in \{1, \ldots, D-1\}$), and $t \in (t_D, T]$, but p_t discontinuously drops at $t = t_d$ ($\forall\, d \in \{1, \ldots, D\}$). Moreover, the degree of price discount at $t = t_d$ is strictly increasing in α_d ($\forall\, d \in \{1, \ldots, D\}$).*

Proof. See the Supporting Information. □

Proposition 2 states that when $\alpha_d \in (0, 1)$, an atom of price discount occurs at each soft deadline. Moreover, the degree of the price discount expands with the commitment intensity of the buyers. In fact, this is a direct consequence of the stochastic deadline effect; because rejections at the soft deadline credibly signal the low level of their valuations, the monopolist is forced to discount the post-threat price sharply, adapting to the upper-bounded types of buyers. One may view that the soft deadline serves as a self-screening device of private information at the cost of expected breakdown. Intriguingly, planning his big sale at the beginning, the forward-looking monopolist offers a cheaper pre-threat price schedule, formally stated as follows.

Corollary 2 (Discount before the soft deadline). *Suppose that $D = 1$. In the limit as $\Delta \to 0$, there exists some $\overline{\alpha} \in (0, 1)$ such that for $\alpha_1 \in (0, \overline{\alpha}]$, the monopolist offers a uniformly lower price schedule $p_t(\alpha_1) < p_t(\alpha_1 = 0)$ for all $t \in [0, t_1^*]$.*

Proof. See the Supporting Information. □

Consider a simple single soft deadline case ($D = 1$).[24] Corollary 2 posits a possibility that a monopolist offers a discounted price before the soft deadline ($\alpha_1 > 0$), starting with a cheaper opening price p_0, than the hard deadline case ($\alpha_1 = 0$). Notably, a soft deadline ($\alpha_1 \in (0, 1)$) makes a monopolist's cost–benefit accounting qualitatively different from a hard deadline ($\alpha_1 = 0$). In the face of the soft deadline, the monopolist weighs securing the current expected payoff by myopically leveraging the buyers' rush before the soft deadline at $t \in [0, t_1^*]$ against a market value after the soft deadline at $t \in (t_1^*, T]$. Observe that a new trade-off emerges between leveraging the buyers' concessions by raising a price (strategic interaction) vs. securing trades by discounting a price (self-competition).[25] As the threat of exit increases, the monopolist projects that the after-threat market is likely to dissipate. Thus, through the self-competition across before- and after-soft deadline, he may be tempted to start with a cheaper opening price.

4 | Monopoly Power and Consumer Surplus

4.1 | Buyers' Premium From the Soft Deadline

Based on price discounting induced by the soft deadline, I present the main result of the study; an optimally designed soft deadline yields a premium to the buyers' group, achieving their maximum expected surplus.

Proposition 3 (Buyers' premium from the soft deadline). *In the limit as $\Delta \to 0$, there exists a vector of $\widehat{\alpha_d} \in (0, 1)(\forall d \in \{1, \ldots, D\})$ that uniquely maximizes W_0 and a distributional share of the buyers $\dfrac{W_0}{V_0 + W_0}$ s.t.*

$$\widehat{\alpha_d} = \frac{(\lim_{t \downarrow t_d} a_t)^2}{(1 - \lim_{t \downarrow t_d} a_t)(1 + \sigma - \lim_{t \downarrow t_d} a_t)} \tag{9}$$

where $\lim_{t \downarrow t_d} a_t$ is recursively characterized by bargaining primitives γ, T, t_d and α_d s.t.

$$a_T = (1 + \sigma)^{\frac{-1}{\sigma}}, \ \lim_{t \downarrow t_d} a_t = e^{-\gamma(T - t_d)} a_{t_{d+1}}, \text{ and}$$

$$a_{t_{d+1}} = \left(\frac{\{\alpha_{d+1} + (1 - \alpha_{d+1}) \lim_{t \downarrow t_{d+1}} a_t\}^{1+\sigma}}{(1 + \sigma)\alpha_{d+1} + (1 - \alpha_{d+1}) \lim_{t \downarrow t_{d+1}} a_t} \right)^{\frac{1}{\sigma}}$$

holds.[26]

[Sketch of the Proof]. From Corollary 1, the buyers' expected payoff and distributional share are given by $W_0 = \dfrac{\sigma}{\sigma + 1}(1 - \dfrac{\sigma + 2}{\sigma + 1} a_0)$ and $\dfrac{W_0}{V_0 + W_0} = \dfrac{(\sigma + 1) - (\sigma + 2) a_0}{(\sigma + 1) - a_0}$, respectively. Differentiating W_0 with respect to credibility of soft deadline α_d, one gets a first-order condition

$$\frac{dW_0}{d\alpha_d} = -\frac{\sigma(\sigma + 2)}{(\sigma + 1)^2} \frac{da_0}{d\alpha_d} = 0,$$
$$\frac{d(W_0/(W_0 + V_0))}{d\alpha_d} = -\frac{(\sigma + 1)^2}{((\sigma + 1) - a_0)^2} \frac{da_0}{d\alpha_d} = 0. \tag{10}$$

One can see that consumer surplus W_0 and consumers' distributional share responds opposite to the monopolist power a_0. Solving for the first-order condition $\dfrac{da_0(b_{t_d}, \alpha_d)}{d\alpha_d} = 0$, one gets $\widehat{\alpha_d}$. The second-order condition is also satisfied. This procedure is repeated for each dth soft deadline (see the Supporting Information for details). □

This proposition states that imperfect non-zero commitment to a vector of soft deadlines maximizes the consumer surplus.[27] Recall thatthe ex-ante consumer surplus W_0 decreases with the ex-ante monopoly power a_0 (Corollary 1), which is affected by the monopoly power at the dth soft deadline a_{t_d} of interest. Recall also that the non-linear response of the monopoly power at each soft deadline t_d^* is due to two forces: a first-mover advantage of exploitation (strategic interaction) and an irresistible discount to secure the pre-threat agreement (self-competition). As the soft deadline gets harder, the response for self-competition decreases and the one for strategic interaction increases. At the optimal

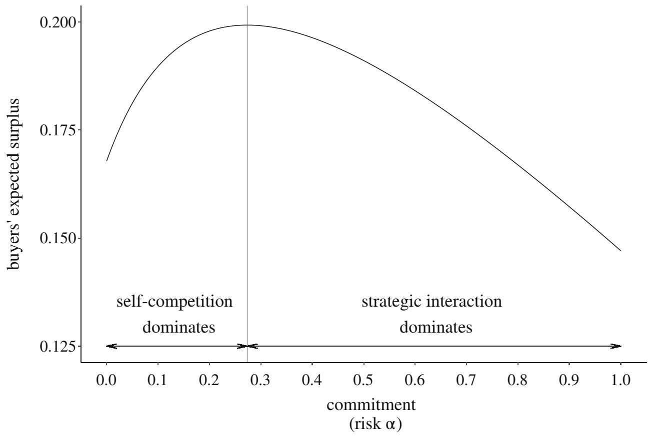

FIGURE 2 | Commitment to the deadline and the buyer's expected surplus. A model is simulated with $T = 6$, $\sigma = 1$, $\gamma = -\ln(0.98)$, and a single soft deadline is set at $t_1^* = 3$. The vertical line is the optimal commitment $\hat{\alpha}_1 = 0.274$.

commitment $\widehat{\alpha_d}$, the relative dominance of self-competition is maximized.

If the soft deadline becomes hard ($\alpha_d = 1$), the optimization is reduced to an ultimatum game, and the monopolist exclusively exploits the buyers. Under some moderate threat of exit, however, as the monopolist runs a big sale after the soft deadline (Proposition 2), he may be tempted to concede at the beginning. One may observe that the buyers' rush for trades (deadline effect) at soft deadlines generates a self-competition dynamics previously restrained under the hard deadline. As the buyer's expected surplus is higher than in the non-commitment case ($\alpha = 0$ or 1), the buyers' group enjoys a premium at the cost of expected breakdown. Figure 2 shows the inverted-U sensitivity of the expected surplus of the demand side.

A simulation under primitives ($T = 6, \sigma = 1, \gamma = -\log(0.98)$) finds that the group's expected surplus is maximized at an interior commitment $\widehat{\alpha}_1 = 0.274$. As the risk increases, when $\alpha_1 < \widehat{\alpha}_1$, the expected surplus improves but once the risk exceeds $\widehat{\alpha}_1$, it starts to deteriorate (I provide comparative statics of $\widehat{\alpha}_1$ with the σ and γ primitives below).

The central logic of the Coase conjecture lies in self-competition dynamics, where the buyer rationally foresees the monopolist's price discrimination at many future opportunities of price revisions and the monopolist loses his commitment on pricing. In the history of durable goods monopolist literature, the conventional wisdom is that a longer bargaining horizon (or interpretably, less durability) hurts the monopoly power. In fact, the buyers' expected surplus under the hard deadline baseline is characterized by

$$W_0 = \mathbb{E}(v)\Big(1 - (2+\sigma)(1+\sigma)^{-\frac{1+2\sigma}{\sigma}} \exp(-\gamma T)\Big) \tag{11}$$

which is expectedly, strictly increasing in the horizon T.[28] Under the one-shot game ($T \to 0$), the monopolist gains the strongest bargaining power, and the buyer's surplus is minimized at $W_0 = \mathbb{E}(v)(1 - (2+\sigma)(1+\sigma)^{-\frac{1+2\sigma}{\sigma}})$. Essentially, the game is reduced to an ultimatum game under asymmetric information. In the infinite horizon ($T \to \infty$),[29] by contrast, W_0 increases to $\mathbb{E}(v)$, seizing the maximum efficiency as in the Coase conjecture; the marginal-cost trade occurs with no delay. By stochastically mixing a short and long deadline, the model casts new light on the canonical link between the bargaining horizon and the surplus division; as the commitment to exit increases, the bargaining appears shorter in expectation but is favorable for the buyers.[30]

4.2 | Cost-Benefit Analysis Across Buyers' Types

So far, I have characterized the optimal commitment on the soft deadline strategy, but the credibility of the soft deadline is a collective commitment by the group of buyers, and I have assumed that all buyers are forced to join the commitment ex-ante before their types are revealed. Which type of the buyer is better off with an optimal commitment? Are there any buyers getting worse off by the commitment? To examine their ex post incentive to participate in the group, I compute the premium over each type of buyer from the commitment. Figure 3 displays the expected surplus of the each type of buyer (top), and the monopolist's expected revenue when facing each type of buyer (bottom).

Intriguingly with the baseline parameter values ($T = 6, \sigma = 1, \gamma = -\ln(0.98)$), every type of risk-neutral buyer with $v \geq c_T$ ($= 0.26$) is strictly better off even after taking the breakdown cost into consideration. One can see that the following cost–benefit analysis of the commitment holds for each segment of buyers. (For notational convenience, denote a $\widehat{\text{hat}}$ as variables under the buyers' optimal commitment, and 0 as the no-commitment baseline.[31])

- A buyer with $v \in [\widehat{c_{t_1^*}}, 1]$ is better off with earlier agreement on a cheaper price $\widehat{p_t}$ at $t \leq t_1^*$ with probability 1,
- A buyer with $v \in [\widehat{k_T}, \widehat{c_{t_1^*}})$ is better off with earlier agreement on a cheaper price $\widehat{p_t}$ at $t \in (t_1^*, T)$ with probability $1 - \widehat{\alpha}_1$.
- A buyer with $v \in [c_T^0, \widehat{k_T})$ is better off with agreement at $t = T$ on a cheaper price $\widehat{p_T}$ with probability $1 - \widehat{\alpha}_1$.
- A buyer with $v \in [\widehat{c_T}, c_T^0)$ is better off with agreement at $t = T$ with probability $1 - \widehat{\alpha_1}$, compared to breakdown with probability 1.
- A buyer with $v \in [0, \widehat{c_T})$ is indifferent because they cannot trade for both cases with probability 1.

Overall, this simulation example demonstrates that the soft deadline strategy may be Pareto-improving for every risk-neutral buyer in the demand pool, assuring the ex post participation constraint of each buyer to form a group. In a stark contrast in Figure 3 (bottom), one can see that a gain for the monopolist (red area) is smaller than the loss (area surrounded by two lines), suggesting the soft deadline serves as a countermeasure to the monopoly power.

4.3 | Comparative Statics of Optimal Commitment

In Proposition 3, I pin down the optimal commitment to the soft deadline. Next, I assess how does the commitment policy varies

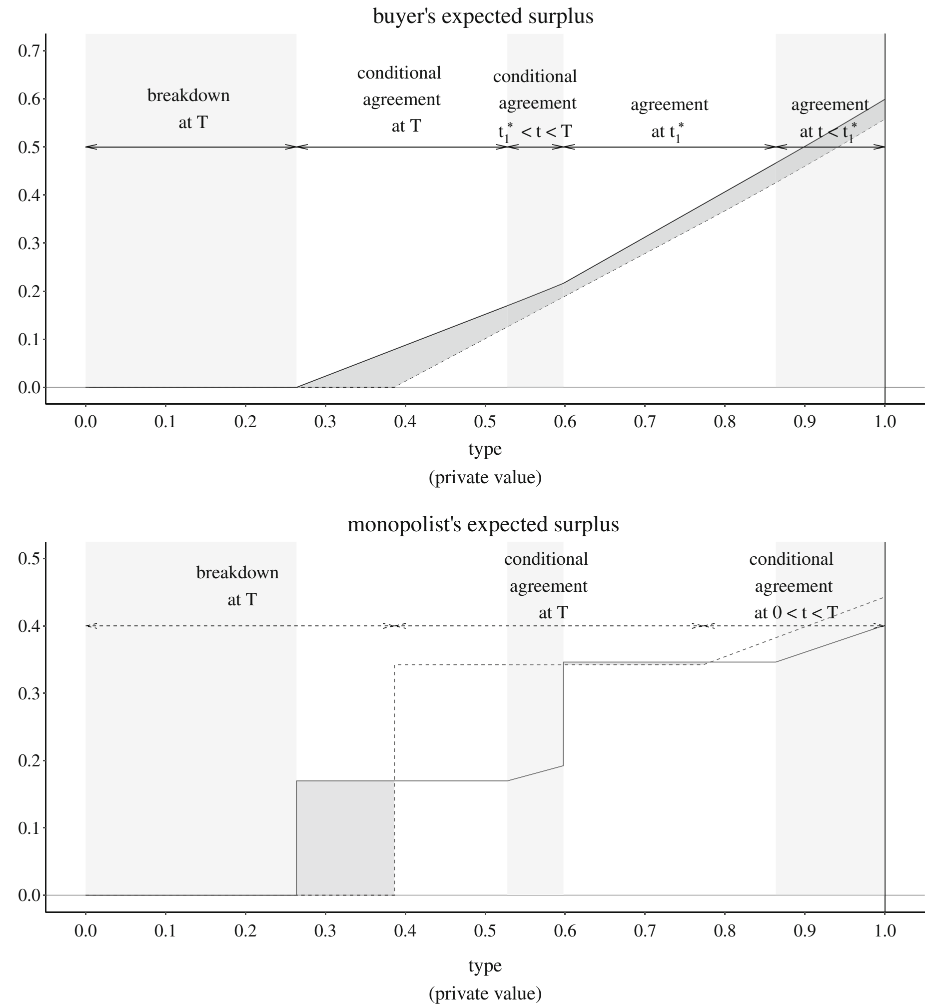

FIGURE 3 | Expected surplus across types (optimal commitment (solid line) vs. baseline (dashed line)). A model is simulated with $T = 6$, $\sigma = 1$, $\gamma = -\ln(0.98)$, and a single soft deadline is set at $t_1^* = 3$. A shaded blue or red area is an expected gain from the soft deadline for buyers or the monopolist, respectively. *Notes:* [Colour figure can be viewed at wileyonlinelibrary.com]

with other primitives, namely, bargaining friction (discount rate) and the market distribution of private values. To see this, given a parameterized model ($T = 6, \sigma = 1, \gamma = -\ln(0.98)$) with a single soft deadline at $t_1^* = 3$, I simulate the sensitivity of $\widehat{\alpha}_1$ with respect to σ and $\exp(-\gamma)$, as depicted in Figure 4.

One can see that σ and $\exp(-\gamma)$ is positively linked with a lower $\widehat{\alpha}_1$ (left) and a higher $\widehat{\alpha}_1$ (right), respectively. To understand the intuition, recall that two competing forces shaping the response of monopoly power a_0 from an incremental shift of commitment α_1 (or $da_0/d\alpha_1$) are at work. As α_1 increases, the exploitive price hike from strategic interaction surpasses price discounting from self-competition (see Figure 2, Recall the decomposition of change in monopoly power after Proposition 3). Therefore, the higher $\widehat{\alpha}_1$ indicates that in the bargaining protocol of interest, self-competition is likely to serve stronger at the soft deadline relative to strategic interaction.

I begin with a straightforward case. As a value distribution parameter $\sigma > 0$ increases,[32] the demand pool has on average higher willingness to pay. As the typical buyers have less incentive to wait, and the monopolist enjoys larger strategic interaction benefits, as suggested by the lower $\widehat{\alpha}_1$ (i.e., $\frac{d(da_0/d\alpha_1)}{d\sigma} > 0$). In contrast, as a discount rate $\gamma > 0$ decreases (or equivalently, a periodic discount factor $\exp(-\gamma)$ increases), the bargaining is less frictional and the monopolist suffers from heavier self-competition as indicated by the higher $\widehat{\alpha}_1$ (i.e., $\frac{d(da_0/d\alpha_1)}{d\gamma} < 0$). The pair of sensitivity tests on optimal commitment is insightful regarding the policy design of soft deadlines.

5 | Efficiency

In the previous section, I discussed the sensitivity of consumer surplus with the credibility of a soft deadline. In the durable goods monopolist model, the consumer surplus is often associated with the overall market efficiency. I close my analysis by briefly exploring how the bargaining efficiency responds to commitment intensity. I define the bargaining efficiency $U \equiv V_0 + W_0$ as the sum of the players' ex-ante expected payoffs at $t = 0$. An immediate corollary of Proposition 3 is given as follows.

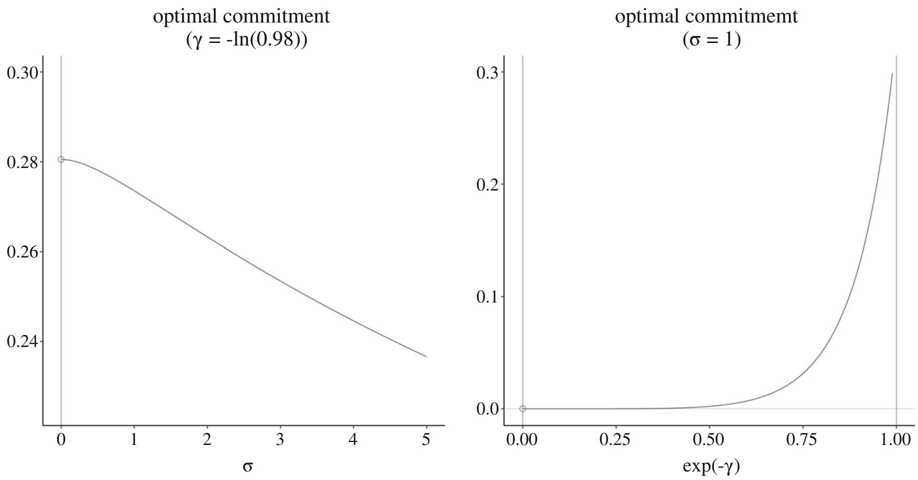

FIGURE 4 | Optimal commitment under various primitives. A baseline model is simulated with $T = 6$, $\sigma = 1$, $\gamma = -\ln(0.98)$, and a single soft deadline is set at $t_1^* = 3$. Then, following (9), consider the sensitivity of the optimal commitment $\widehat{\alpha}_1$ with $\sigma > 0$ or $\exp(-\gamma) > 0$, respectively, all else equal. *Notes:* [Colour figure can be viewed at wileyonlinelibrary.com]

Corollary 3 (Efficiency impact of Soft-deadline). *In the limit as* $\Delta \to 0, \widehat{\alpha_d} \in (0,1)$ *uniquely maximizes* U.

Proof. From Corollary 1, $V_0 = \frac{\sigma}{\sigma+1} a_0$ and $W_0 = \frac{\sigma}{\sigma+1}(1 - \frac{\sigma+2}{\sigma+1} a_0)$ holds, as $\Delta \to 0$. Therefore,

$$U \equiv V_0 + W_0 = \frac{\sigma}{\sigma+2}\left(1 + \frac{W_0}{\sigma}\right) \quad (12)$$

holds. Because U is strictly decreasing with a_0, the rest follows the proof of Proposition 3. □

As (12) shows, the model links the consumer surplus to the overall efficiency in the monopolistic market. Therefore, an inverted-U sensitivity of the buyer's expected surplus at Proposition 3 is smoothly inherited to the sensitivity of efficiency as well. Mirrored by the discussion on consumer surplus, this result is also intriguing from the perspective of market design of durable good transactions. Under the classical durable goods monopolist model, recall that a longer trade horizon (or durability) implies larger efficiency. Consider the two extreme cases again as in section 4.1. Under the one-shot game ($T \to 0$),[33] the ultimatum bargaining undergoes the largest distortion from the strongest monopoly power; the bargaining closes instantaneously, but a significant share of buyers cannot buy the goods in the face of the monopoly pricing. In the infinite horizon ($T \to \infty$), however, the bargaining achieves Pareto efficiency, consistent with the Coase conjecture; all the buyers enjoy a competitive pricing with no delay. One may observe that the soft deadline enhances the market efficiency through the resurgence of the self-competition dynamics previously constrained by the hard deadline.

6 | Concluding Remarks

The monopolist often employs a hard deadline as a commitment device to create his brinkmanship. This paper explores a new commitment technology by a consortium of buyers—a soft deadline—to counter the monopoly. Using a simple model of a durable goods monopolist under a deadline, I show that the buyers' imperfect commitment to exit early potentially increases their expected surplus by creating a new motive for the monopolist to engage in price discrimination. One may observe that the soft deadline partially revives the self-competition dynamics that were dormant under the hard deadline; when the price discounting from the self-competition dominates the price raising from the strategic interaction under the soft deadline, the imperfect commitment to a soft deadline serves as a countermeasure to monopoly power. This finding revisits the conventional wisdom regarding the durable goods monopolist model to relate durability to monopoly power, which lies at the heart of Coasian logic.

Three caveats are worth noting. First, to adopt a soft deadline strategy, one might consider the strategic use of the soft deadlines with varying timing and number of soft deadlines, which is not addressed in this article.[34] Second, while the model assumes common outside options for both a monopolist and buyers, monopolists are plausibly armed with richer outside options than the buyers. Third, although my model imposes risk neutrality for both parties, in the real world either party may be risk-averse or risk-loving, which is potentially associated with their outside options. The distributional implications may depend on the relative strength of the outside options and risk preferences. These issues are left for future work.

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Endnotes

[1] Purchasing consortia are often formed by independent firms to reduce costs and increase bargaining power by sharing supply-side information (see, e.g., Eija and Virolainen [2]). In the public sector, municipalities engage in similar collaborative purchasing (see Walker et al. [3]).

[2] In 2002, the Pacific Maritime Association led a lockout of West Coast dockworkers that paralyzed nationwide logistics. In professional sports, owners have locked out players in the past (e.g., NHL (2004), NFL (2011) and MLB (2021)).

[3] Simsek and Yildiz [4] analyzed the shift in bargaining power in the face of political elections. In the context of international sovereign debt renegotiations, an election was once used as a commitment device. In 2015, Greece scheduled a national referendum to accept the creditors' bailout proposal before the default deadline. Analysts predicted that the rejection of the plan could unleash financial terror. (*The Telegraph*, July 6, 2015).

[4] In another intriguing example outside the structured industrial world, terrorist groups or pirates (monopolists) often demand the payment of a ransom within a deadline in negotiations for the release of captured hostages (see Ambrus et al. [5]; Mickolus et al. [6] document the ransoms demanded and deadlines imposed in the history of terrorist incidents). The buyer side (e.g., the police, government) often imposes an earlier deadline with a warning of repression, but with room for renegotiation.

[5] See, for example, Güth and Ritzberger [12].

[6] The durable goods monopolist model is widely applied to outside the seller-buyer trades; labor group disputes (Hart [15]), medical malpractice disputes (Sieg [16]), sovereign debt renegotiation (Bai and Zhang [17]), and hostage-taking negotiation with pirates (Ambrus et al. [5]).

[7] Güth [18] called the dynamics as the intrapersonal price competition of the monopolist.

[8] Ostatnickỳ [25] emphasizes that a hard deadline fails the Coase conjecture. The avoidance of the zero-profit trap in the finite horizon framework is already contained by Stokey [26] and Fudenberg and Tirole [27], although the role of a deadline is not explicitly mentioned Gneezy, Haruvy and Roth [28]. consider an infinite-horizon version of ultimatum game where the proposer completely loses the bargaining power, and call it a "reverse" ultimatum game. However, the simple imposition of the deadline completely recovers the power, making the game resemble a canonical ultimatum game.

[9] In the variant of the wisdom, the infinite horizon model Stokey [7], shows that a longer time between offers (or less frequent offer revision, or low discount factors) leads to a monopolist's gain Bond and Samuelson [21]. show that the monopolistic power is also sustained if discount factors are low (or good depreciates faster) without a hard deadline Güth and Ritzberger [12]. show that sufficiently high patience is a requisite the Coase conjecture.

[10] Fanning [32] uses the reputation model of Abreu and Gul [33] to provide a foundation of deadline effects from reputation across a wide range of protocols. In his model, however, one-sided incomplete information in the durable goods monopoly generates no delay. See the "Related Literature" section in Fanning [32] for a comparison with one-sided, incomplete information models (e.g., Spier [29]; Fuchs and Skrzypacz [34]).

[11] In the similar vein Guth and Ritzberger [35], explore that the relative patience of monopolists vs. consumers shapes the surplus division in a durable goods context.

[12] While this distributional assumption may be restrictive, it ensures stationarity of the monopolist's problem in every period in the finite-horizon model because its truncated distribution is isomorphic to the original distribution. In addition, it provides concavity of the monopolist's problem and unique pricing (e.g., Fuchs and Skrzypacz [34]. Sobel and Takahashi [9]).

[13] This corresponds to the "no-gap" case, where a marginal cost is no lower than the lower bound of the buyer's private value. If there is a "gap" (buyer's lowest value is higher than marginal cost), a periodic stationarity of the problem is violated and the problem is analytically intractable.

[14] This is different from the revenue management literature (e.g., Horner and Samuelson [39]), where firms have limit of the stocks of durable goods, and the goods are perishable at the deadline.

[15] Although an optimal choice for a monopolist is $T = 0$ to make an ultimatum, one may view this assumption as institutional, because real-world bargaining requires a positive interval of days or at least, hours for decision making. Moreover, monopolists would maintain a stronger reputational concern than buyers by imposing a perfectly committed hard deadline.

[16] Ausubel and Deneckere [19] provides a justification for the rule in which only the uninformed party is permitted to make offers. They showed that under alternating-offer games with one-sided incomplete information, the informed party endogenously never makes any serious offers when Δ is sufficiently short (the Silence Theorem).

[17] They are allowed to use mixed strategies, but this does not change the argument because the seller's equilibrium pricing turns out to be uniquely and deterministically specified and the buyer's mixed strategy is rationalizable in the tie-breaking cases (i.e., the private value is equal to the cutoff).

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

[19] This is different from cheap talk (see Farrell and Rabin [40] for a survey) in that the group commits to the realization of breakdown. The setting is in line with bargaining with breakdown (e.g., Rubinstein and Wolinsky [38]; Binmore et al. [36]) as discussed in the literature review.

[20] Much of the commitment literature (initially proposed by Crawford [41], and later, investigated by Ellingsen and Miettinen [42]) similarly frames the intensity of commitment on the proposer's offer with some probability (α_d in my model). Their participation constraint for the group is discussed in Section 4 below.

[21] See for eample, Lemma 9.3 in Muthoo [43].

[22] Note that C_n is a function of P_n, not of v. One can check that the difference between payoffs of agreement today and tomorrow is strictly increasing in C_n.

[23] One can see this protocol adopts a more general dynamically-varying patience (e.g., hyperbolic discounting; non-geometric discounting).

[24] For a behavior of opening price p_0, Corollary 2 is extended under multiple soft deadline cases ($D > 1$). See the Supporting Information for a discussion of the extension.

[25] In contrast to the Coase conjecture, the Packman conjecture (see, e.g., Bagnoli et al. [22]) claims that price discrimination is a source of monopoly power. Although this theory holds true for other bargaining protocols (e.g., complete information. See, for example, von der Fehr and Kühn [45]), this paper adopts Coase's view that price discrimination undermines ex-ante monopoly power by violating the commitment to price as self-competition.

[26] When $D = 1$, recursive notations are simplified to $\lim_{t \downarrow t^*} a_t = e^{-\gamma(T-t^*)} a_T = e^{-\gamma(T-t^*)}(1+\sigma)^{\frac{-1}{\sigma}}$.

[27] Even at multiple soft deadline case ($D > 1$), there exists an optimal $\widehat{\alpha_d}$ at each dth soft deadline. Note that $\widehat{\alpha_d}$ is recursively defined as a function of $\lim_{t \downarrow t_d} a_t$, which absorbs the effect from future commitments $\widehat{\alpha_{d+1}}, \ldots, \widehat{\alpha_D}$, and is independent from previous commitments $\widehat{\alpha}_1, \cdots, \widehat{\alpha_{d-1}}$.

[28] $W_0 = \frac{1}{\sigma+1}(1 - \frac{\sigma+2}{\sigma+1}a_0)$. See the Supporting Information for a derivation.

[29] A pair of exercises of taking limits ($T \to 0$ and $T \to \infty$) comes based on (11) after I take $\Delta \to 0$ and derive a continuous time limit W_t from the discrete period game.

[30] Although my continuous-time results (Propositions 2 and 3, Corollaries 2 and 3) are based on the distributional assumption $F(v) = v^\sigma$, the derived differential equations do not depend on a distributional parameter σ. Moreover, σ only affects the terminal or intermediate conditions in static problems at hard and soft deadlines (see the Supporting Information). I conjecture, thereby, that the results could potentially be extended to any well-behaved atomless full-support $F(v)$. My conjecture would hold if the equilibrium in the limit case has a Markov property (i.e., value functions depend exclusively on k_t and $T-t$) and no atoms of trades occur except at hard and soft deadlines. The extension to a general distribution remains an open question.

[31] Under the simulation with $\gamma = -\ln(0.98), T = 6, t_1^* = 3$ at Figure 3, $\widehat{c_{t_1^*}} = 0.60, \widehat{k_T} = 0.53, c_T^0 = 0.38, \hat{c}_T = 0.26$ holds.

[32] Recall that σ captures the first-order stochastic dominance of the cumulative distribution function of private value, $F(v) = v^\sigma$.

[33] As in Footnote 30, an order of taking limits ($T \to 0$ and $T \to \infty$) comes after I take $\Delta \to 0$ and derive a continuous time limit U at (12).

[34] I am grateful to an anonymous referee for suggesting this avenue. In another bargaining protocol for games with alternating offers under complete information Mauleon and Vannetelbosch [46], consider a strategic choice of deadlines to derive a possibility of inefficiency. They remain silent on the allocation of surplus. Using the reputation approach with the war of attrition protocol of Kambe [47], Özyurt [48] jointly analyzes the commitment to the offer of the proposer and the endogenous timing of the deadline and shows that the deadline setter is better off in the efficient unique equilibrium.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Data S1.** Supporting Information.