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Abstract

An *all-units discount* is a price reduction applied to all units purchased if the customer's total purchases equal or exceed a given quantity threshold. Since the discount is paid on all units rather than marginal units, the tariff is discontinuous and exhibits a negative marginal price ("cliff") at the threshold that triggers the discount. This paper shows that all-units discounts arise in optimal agency contracts between upstream and downstream firms that face double moral hazard. I present conditions under which all-units discounts dominate two-part tariffs and other continuous tariffs. I also examine these tariffs when the upstream market faces a threat of entry. In the case considered, all-units discounts deter entry by less efficient rivals without distorting price and investment, whereas continuous tariffs either accommodate such entry or deter it by distorting price and investment. These findings begin filling the gap in economists' understanding of the equilibrium effects of all-units discounts in intermediate markets in which contract design affects incentives for pricing, investment, and competitive entry.

Keywords: All-units discounts, retroactive rebates, double marginalization, double moral hazard, principal-agent

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In this paper I offer an explanation for all-units discounts that does not involve exclusionary motives. I consider a vertical relationship in which an upstream and a downstream firm make non-contractible decisions that affect both firms' profits ("double moral hazard"). Prior to these decisions, firms agree to supply terms that may depend on output, but not on investment or pricing upstream investment returns (\uncertain returns"). Under both uncertain prospects and uncertain returns, the upstream firm's incentive to exploit discontinuities in the tariff is limited because the equilibrium quantity generally differs from the quantity at which the tariff is discontinuous. In all three environments, all-units discounts can arise in equilibrium.

Under lumpy upstream investment with deterministic returns, all-units discounts are optimal tariffs. They support the vertically integrated outcome when upstream costs are sufficiently low, and they distort downstream pricing and investment decisions less than two-part tariffs when investment costs are high. In the optimal all-units discount, the wholesale price exceeds marginal cost at all output levels. The tariff works by giving the retailer the incentive to expand output by enough to receive the discount, while giving the manufacturer sufficient margin to support its investment.

When investment returns are deterministic, declining block tariffs (or the un-dominated portion of a menu of piece-wise linear tariffs) are equivalent to all-units discounts, and thus are also optimal. While both price schedules dominate two-part tariffs, the model is not rich enough to distinguish between continuous and discontinuous tariffs when investment returns are deterministic.

However, when investment prospects or returns are uncertain, the tariffs are no longer equivalent. Under these conditions, I identify two cases in which all-units discounts achieve the first best outcome and dominate continuous tariffs: when upstream investment causes an iso-elastic shift in demand, or when the downstream firm's only decision is price. The sufficiency of all-units discounts in these cases does not rely on lumpy upstream investment. The basic logic for the benefits of all-units discounts in these cases is similar to that in the deterministic case: the discounts considered here. On the other hand, all-units discounts deter entry by less efficient competitors without distorting price and investment, whereas continuous volume discounts either accommodate entry by a less efficient competitor or deter it by distorting price and investment.

A related paper is Romano (1994), which examines the role of resale price maintenance under double moral hazard. My focus is on all-units discounts rather than RPM, and I consider the cases of lumpy investment and uncertain investment prospects or returns, whereas Romano examined continuous investment returns that are known with certainty. Under Romano's assumptions, two-part tariffs are optimal contracts. Under the assumptions here, more complex tariffs generally dominate two-part tariffs. Romano also does not address entry, which this paper does.

The literature on moral hazard in teams and partnerships[10] identifies conditions under which sharing rules exist that achieve or approximate the first best outcome in problems with N-sided ($N \geq 2$) moral hazard. Legros & Matthews (1993) study the case of deterministic investment returns and show that a partnership can attain full efficiency with pure strategies if the partners' decision sets are finite or the investment technology is Leontief. In this paper, the upstream firm's decision set is finite (invest or not), but downstream firm's decision set is continuous and smooth, and is not Leontief. Full efficiency is generally not possible in pure strategies, but all-units discounts are optimal, second best contracts in pure strategies.[11] Williams & Radner (1988) and Legros & Matsushima (1991) provide conditions for efficiency under stochastic returns when action spaces are finite. In this paper, I present conditions in which all-units discounts achieve efficiency under stochastic returns when the action space is continuous. Rasmusen (1987) shows that risk aversion also increases the scope for efficiency in the stochastic returns case. In this paper, agents are risk neutral.

Several papers have shown that penalty schemes can be used to approximate or achieve the first best outcome in *one-sided* moral hazard problems.[12] The use of all-units discounts in this paper is related to the role of penalties in those papers, although here the incentive contract must also deal with the manufacturer's moral hazard. In the cases of uncertain investment prospects or returns that I examine, the penalty imposed by the *difference* between the wholesale prices in the upper and lower tiers in a two-price all-units discount aligns the retailer's pricing and investment incentives

[10] Examples include Holmstrom (1982), Rasmusen (1987), Williams & Radner (1988), Legros & Matsushima (1991), and Legros & Matthews (1993).

[11] Legros & Matthews also consider mixed strategies and show that firms can achieve approximate efficiency in mixed strategies in a broad class of cases. This paper does not consider mixed strategies.

[12] See, e.g., Mirrlees (1974, 1975, 1999), Gjesdal (1976), Holmstrom (1979, footnote 7), Lewis (1980), and Singh (1984). For a recent example, see Wang (2009).

with joint incentives. This allows rms to set the wholesale price *level* that the retailer pays the manufacturer to purchase and resell Q units. This tariff depends on the quantity purchased, but it cannot be conditioned on price or investment levels unless otherwise noted.[13] In stage 2, given the contract terms $(S; T(Q))$, the manufacturer chooses I to maximize its profit, and the retailer simultaneously chooses P and x to maximize its profit. The manufacturer's variable profit is $U = T(Q(P;x;I)) - C(Q(P;x;I)) - m(I)$, and the retailer's variable profit is $\pi = PQ(P;x;I) - V(Q(P;x;I)) - T(Q(P;x;I)) - r(x)$. I look for sub-game perfect equilibria.

The joint profits of the manufacturer and retailer are $\Pi = U + \pi = PQ(P;x;I) - C(Q(P;x;I)) - V(Q(P;x;I)) - m(I) - r(x)$. Let $(P^*; x^*; I^*)$ maximize Π. I will refer to $(P^*; I^*; x^*)$ as the "integrated" outcome.

III. Lumpy Investment and Deterministic Returns

If profits are continuous in own investment and demand is known by both firms at the time of contracting, the equilibrium contract must be continuous at the optimal quantity. If it were discontinuous, either the manufacturer or the retailer could adjust its investment slightly up or down and cause a discrete jump in its profit.[14] In this case, a binding all-units discount tariff — one that induces the retailer to purchase the minimum quantity required to receive a discount — cannot arise

In this section, I focus on such lumpy investment:

Assumption 1 (Lumpy Upstream Investment) *The manufacturer chooses investment $I \in \{0; I\}$, i.e., it makes the investment I, or it invests zero.*

To simplify notation under Assumption 1, let $D(P;x) \equiv Q(P;x;I)$ be demand when the upstream firm invests I, and let $D^0(P;x) = Q(P;x;0)$ be demand when it invests zero.

where w, w_1, and w_2 are wholesale prices, F is a fixed fee, and q is a quantity threshold that determines the applicable per-unit price.[16]

The two-part tariff is the standard "continuous" tariff[17] that appears in much of the literature on vertical control. The two-block tariff is a slightly more flexible continuous tariff, charging two different marginal prices depending on whether quantity falls in the first block ($Q < q$) or second block ($Q \geq q$). In most of the literature on vertical control, customer-specific two-block tariffs are equivalent to customer-specific two-part tariffs, because a customer purchasing in the second block will view the extra payment $(w_1 - w_2)q$ for quantities in the first block as part of the fixed fee. The all-units discount tariff is similar to the two-block tariff in that it specifies two prices that depend on whether the quantity purchased is above and below a quantity threshold q. However it differs in two key respects: (1) customers that purchase in the second block ($Q \geq q$) do not pay an implicit fixed fee; and (2) if $w_1 > w_2$, the all-units discount tariff is discontinuous at q. As I have noted, all-units discounts have received little formal attention in the literature on vertical control.[18]

The following preliminary result motivates the potential role for all-units discounts and two-block tariffs in this model.

Proposition 1 *Two-part tariffs support the integrated outcome if and only if the manufacturer's incremental quasi-rents from investment at wholesale price* $w^* = c(D(P^*;x^*))$ *are sufficiently large.*

Proof: Under a two-part tariff, the retailer will choose the fully integrated price and investment only if it faces the same marginal incentives as an integrated firm. This requires the wholesale price $w^* = c(D(P^*;x^*))$. The upstream firm's incremental profit from investing is then

$$\Delta = \int_{D^0(P^*;x^*)}^{D(P^*;x^*)} [w^* - c(q)]dq - m(I^*) \tag{3}$$

The integral represents the manufacturer's incremental quasi-rents from investment at the wholesale price w^*. The integrated outcome is supported if and only if $\Delta \geq 0$, which requires sufficiently large quasi-rents. **Q.E.D.**

Proposition 1 is the lumpy investment analog of Proposition 1 in Romano (2004), which established that two-part tariffs cannot support the integrated outcome when the manufacturer chooses investment from a continuous set.[19] In the remainder of this paper, I assume that the manufac-

[16] Of course, T^{TB} and T^{TA} only exhibit marginal price "discounts" if $w_2 < w_1$.

[17] It is continuous except at zero.

[18] Kolay et al. (2004) is the primary exception.

[19] Although he assumed constant marginal cost, a two-part tariff would not support the integrated outcome in his model even with high quasi-rents because the manufacturer would distort its continuous investment choice at the margin.

turer produces at constant marginal cost c (no quasi-rents). This rules out the possible efficiency of two-part tariffs due to high manufacturer quasi-rents, focusing attention on cases in which more complex contracts might do better.

A. Optimal All-Units Discounts

Next I characterize the optimal all-units discount tariff. Define an *effective* all-units discount as one in which $w_1 > w_2$, and the retailer elects to sell enough to reach the discount threshold q and pay the lower price w_2. (An ineffective all-units discount would have the same incentive effects as a two-part tariff with wholesale price w_1.) Under an effective all-units discount that induces upstream investment, there are three constraints on the firms' investment and pricing decisions. First, the retailer will choose P and x to maximize its profit given the all-units discount quantity threshold:

$$(4) \qquad (P; x) = \arg\max_{(P^0; x^0)} (P^0 - w_2)D(P^0; x^0) - V(D(P^0; x^0)) - r(x^0) \ \text{ s:t: } D(P^0; x^0) \geq q:$$

Second, the retailer must earn more by selling at least q units at price w_2 than by "defecting" from the all-units discount and optimizing against the higher wholesale price w_1:

$$(5) \quad (P - w_2)D(P; x) - V(D(P; x)) - r(x) \geq \hat{\ }(w_1) \quad \max_{(P^0; x^0)} (P^0 - w_1)D(P^0; x^0) - V(D(P^0; x^0)) - r(x^0):$$

Given Assumption 2, an effective all-units discount that induces upstream investment will solve

$$\text{(AUDT)} \quad \max_{(P;x;w_1;w_2;q;\lambda)} (P - c)D(P;x) - V(D(P;x)) - r(x) - m(I) \quad s.t.$$

$$(7) \qquad (P - w_2)D(P;x) - V(D(P;x)) - r(x) \geq \hat{\pi}(w_1);$$

$$(8) \qquad (w_2 - c)D(P;x) - m(I) \geq \hat{U};$$

$$(9) \qquad D(P;x) + (P - v(D(P;x)) - w_2)D_P(P;x) + \lambda D_P(P;x) = 0;$$

$$(10) \qquad (P - v(D(P;x)) - w_2)D_x(P;x) - r_x(x) + \lambda D_x(P;x) = 0;$$

$$(11) \qquad D(P;x) \geq q;$$

$$(12) \qquad \lambda(D(P;x) - q) = 0$$

where conditions (9) through (12) are the first order conditions for $(P;x)$ to maximize the retailer's profit, and λ is the Lagrangian multiplier in the retailer's maximization problem (4). The Lagrangian for (AUDT) is [20]

$$\begin{aligned} L = {} & (P - c)D - V - r - m + \mu[(P - w_2)D - V - r - \hat{\pi}] + \gamma[(w_2 - c)D - m - \hat{U}] \\ & + \mu_1[D + (P - v - w_2 + \lambda)D_P] + \mu_2[(P - v - w_2 + \lambda)D_x - r_x] + \mu_3[D - q] + \mu_4 \lambda[D - q]. \end{aligned}$$

The following lemmas characterize the role of the quantity constraint in the all-units discount.

Lemma 1 In any effective all-units discount that improves upon a two-part tariff, $q \geq D^0(P;x)$, and thus $\hat{U} = (w_1 - c)D^0(P;x)$.

Proof: Suppose $q < D^0(P;x)$. Then $\lambda = 0$, and the quantity constraint does not affect the manufacturer's investment decision. It is then optimal to set w_1 arbitrarily high to relax (7) as much as possible, which sets $\hat{\pi}(w_1) = 0$. The contracting problem is then equivalent to choosing a two-part tariff with fixed fee S and wholesale price w_2. Q.E.D.

Lemma 2 In characterizing the optimal retail price and investment levels under an all-units discount that improves upon two-part tariffs, it is sufficient to consider only cases in which (11) is binding (i.e., $D(P;x) = q$).

[20] Arguments of functions are omitted for brevity except when this could cause confusion.

Proof: Suppose constraint (11) does not bind. Then $_3 = 0$, and since the constraint in the retailer's optimization problem is slack, $= 0$. The derivative of the Lagrangian with respect to q is then $L_q = \quad _3 \quad _4 = 0$, and the other derivatives of the Lagrangian do not depend on q. Therefore increasing q until $q = D(P;x)$ does not a ect the maximized joint pro ts or the optimal investment levels. Q.E.D.

Using $D(P;x) = q$ and $\hat{U} = (w_1 \quad c)D^0(P;x)$ from Lemmas 1 and 2, the rst order conditions for w_1, w_2, and are

$$L_{w_1} = \quad \hat{}_{w_1} \quad D^0(P;x$$

Let $w_2^R(w_1)$ be the value of w_2 that solves the retailer's participation constraint (7) with equality. That is, $w_2^R(w_1)$ is the retailer's iso-pro t contour representing the set of wholesale prices over which it is just indi erent between pricing and investing to reach the discount threshold q and defecting by optimizing against w_1. Similarly let $w_2^M(w_1)$ solve the manufacturer's participation constraint (8) with equality; $w_2^M(w_1)$ is the manufacturer's iso-pro t contour along which it is just indi erent between investing I and investing zero. Using these de nitions, the participation constraints (7) and (8) evaluated at (

Figure 1: Equilibrium wholesale prices under all-units discounts.

between the iso profit contours. Analytically, m^A is the right hand side of (17) evaluated at $(P^*; x^*)$. Using condition (16), m^A can be written

$$m^A = \{(P^* - c)D(P^*; x^*) - V(D(P^*; x^*)) - r(x^*)\} - \left\{(\hat{P} - c)D^0(P^*; x^*) - V(D^0(P^*; x^*)) - r(\hat{x})\right\}:$$

Let m^* be the maximum upstream investment a fully integrated firm would make. This is

$$m^* = \{(P^* - c)D(P^*; x^*) - V(D(P^*; x^*)) - r(x^*)\} - \max_{P;x}\left((P - c)D^0(P; x) - V(D^0(P; x)) - r(x)\right):$$

Subtracting m^A from m^* gives

$$m^* - m^A = \left\{(\hat{P} - c)D^0(P^*; x^*) - V(D^0(P^*; x^*)) - r(\hat{x})\right\} - \max_{P;x}\left((P - c)D^0(P; x) - V(D^0(P; x)) - r(x)\right):$$

If $m^* - m^A > 0$, an integrated firm would make investments that cannot be supported by all-units discounts.

A simple example shows that $m^* - m^A$ may be positive, which means that all-units discounts may not support the integrated outcome. Suppose demand is unaffected by downstream investment (x fixed at zero), assume $V_Q = v$ is constant, and let $D^0(P; 0) = \alpha D(P; 0)$ for some $\alpha < 1$. Then the integrated price P^* also maximizes joint profit when there is no upstream investment. The

Proof: The equilibrium contract $T^e(\cdot)$ is chosen from the set of all feasible contracts, $\mathcal{T}$. Let $\mathcal{F} \subset \mathcal{T}$ be the set of all two-point forcing contacts of the form

$$T^F(Q) = \begin{cases} T_1 & \text{if } Q = D'(P', x') \\ T_2 & \text{if } Q = D(P', x') \\ \infty & \text{otherwise.} \end{cases}$$

The method of proof is to show that (GCP) can be solved by restricting attention to contracts from the set $\mathcal{F}$, and that the solution to (AUDT) yields the same price and investment levels as when contracts from the set $\mathcal{F}$ are employed.

Consider the specific two-point forcing contract

$$T^{Fe}(Q) = \begin{cases} T^e(D'(P^e, x^e)) & \text{if } Q = D'(P^e, x^e) \\ T^e(D(P^e, x^e)) & \text{if } Q = D(P^e, x^e) \\ \infty & \text{otherwise.} \end{cases}$$

Under this contract, the retailer will choose either (P^e, x^e), or some (P', x') such that $D(P', x') = D'(P^e, x^e)$. Any other choice would be unprofitable. Since (P^e, x^e, T^e) solves (GCP), it follows that for all (P', x'),

$$\begin{aligned} & P^e D(P^e, x^e) - V(D(P^e, x^e)) - T^{Fe}(D(P^e, x^e)) - r(x^e) \\ = \; & P^e D(P^e, x^e) - V(D(P^e, x^e)) - T^e(D(P^e, x^e)) - r(x^e) \\ \geq \; & P' D(P', x') - V(D(P', x')) - T^e(D(P', x')) - r(x'). \end{aligned} \tag{20}$$

Since (20) is true for all (P', x'), it is also true for any (P', x') such that $D(P', x') = D'(P^e, x^e)$. Therefore, for all (P', x') such that $D(P', x') = D'(P^e, x^e)$,

$$\begin{aligned} & P^e D(P^e, x^e) - V(D(P^e, x^e)) - T^{Fe}(D(P^e, x^e)) - r(x^e) \\ \geq \; & P' D'(P^e, x^e) - V(D'(P^e, x^e)) - T^e(D'(P^e, x^e)) - r(x') \\ = \; & P' D \end{aligned}$$

Next I argue that the solution to (AUDT) yields the same retail price, investment levels, and transfers as an optimal two-point forcing contract and therefore solves (GCP). For any candidate solution $(P^0; x^0; w_1^0; w_2^0; q^0)$ to (AUDT), $D(\hat{P}(w_1^0); \hat{x}(w_1^0)) = D^0(P^0; x^0)$ by (16). Therefore, the retailer's decision whether to price and invest as expected under the all-units discount or optimize against w_1^0 is e ectively a decision whether to produce $D(P^0; x^0)$ or $D^0(P^0; x^0)$. The manufacturer is e ectively choosing between the same two points. Thus, there is no loss of generality in restricting attention to two-point forcing contracts of the form

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tari , might accomplish the same objective with a wholesale price in the low-price block equal to w_2^A and an inframarginal price in the high-price block that compensates the manufacturer for investing. I now show that this conjecture is correct when investment returns are deterministic.

De ne an *e ective* two-block tari as one in which the retailer purchases in the low-price block and pays the marginal price $w_2 < w_1$. A two-block tari that supports upstream investment I will solve

$$(TBT) \qquad \max_{(P;x;w_1;w_2;q)} (P \quad c)D(P;x) \quad V(D(P;x)) \quad r(x) \quad m(I \ ) \text{ s:t:}$$

(22) $$(P \quad w_2)D(P;x) \quad V(D(P;x)) \quad (w_1 \quad w_2)q \quad r(x) \quad \hat{\ }(w_1);$$

(23) $$(w_2 \quad c)D(P;x) + (w_1 \quad w_2)q \quad m(I \ ) \quad \hat{U}^T;$$

(24) $$D(P;x) + (P \quad v(D(P;x)) \quad w_2)D_P(P;x) = 0;$$

(25) $$(P \quad v(D(P;x)) \quad w_2)D_x(P;x) \quad r_x(x) = 0;$$

(26) $$D(P;q) \quad q$$

where

$$\hat{U}^T$$

Proposition 5 *Under lumpy upstream investment and deterministic returns, two-block tariffs and all-units discounts are equivalent tariffs. Both are optimal contracts.*

Proof: Let $(P^A; x^A; w_1^A; w_2^A; q^A; \ ^A)$ solve (AUDT). I will show that there exists a vector $(w_1; w_2; q)$ such that constraints (22) through (26) are satisfied when evaluated at $(P^A; x^A)$. This means that $(P^A; x^A)$ is feasible under two-block tariffs, and since two-block tariffs cannot do better than all-units discount tariffs (by Proposition 3), two block tariffs will yield the same outcome as all-units discounts.

Let $w_2 = w_2^A \quad ^A$ and w_1

marginal price can replicate a one-point forcing contract for the case in which only retail incentives matter, a two-block tariff with two marginal prices can replicate a two-point forcing contract for the case in which both retail and manufacturer incentives matter.

IV. Uncertain Investment Prospects and Returns

The previous section established the equivalence of two-price all-units discounts and two-block tariffs when upstream investment is lumpy and investment returns are certain. In this section, I introduce two notions of uncertainty and show that all-units discounts and declining block tariffs are no longer equivalent. The two cases are described as follows:

Definition 1 (Uncertain Prospects)*. At the time of contracting, firms are uncertain whether a productive upstream investment project exists. The prospects for investment are revealed to the manufacturer before its investment decision, but after contracts have been signed.*

Definition 2 (Uncertain Returns)

x. Uncertain prospects and returns di er according to whether the manufacturer knows whether a productive investment opportunity exists before making its investment decision.

In either case, the best rms can hope to achieve is to maximize joint pro ts conditional on P and x being chosen before the resolution of uncertainty. Let (P ; x ; I) be this \ rst best" outcome.[22] In both cases I assume that investing I is jointly optimal. The optimal retail price and investment solve

(30) $$\max_{P;x} (P \quad c)\overline{D}(P;x) \quad V(D(P;x)) \quad (1 \quad)V(D^{0}(P;x)) \quad m(I \ ) \quad r(x)$$

where $\overline{D}(P;x) = D(P;x$

The retailer can \defect" from choosing (P ; x) by choosing a quantity of zero (e.g., by setting P very high and x = 0) and earning a pro t of K , or by choosing some price and investment levels that yield positive quantities in some states under the recognition that it will pay the higher price w_1 and potentially a penalty K when its sales are below D^0(P ; x). The expression for the retailer's defection pro t is somewhat tedious to write. What is important is that w_1 and K can be set high enough that the retailer's best defection is to sell zero and earn K . Thus, the contract T will support the rst best outcome for su ciently high w_1 if E[ ] K . If the retailer's expected quasi-rents, $\int_0^{D^0}$[a v(q)]dq, equal or exceed the retailer's investment cost r (x), then the inequality is satis ed when K = 0, and no penalty (and no minimum commitment) is required. This is always true in Case 1, and it will be true in Case 2 if the retailer's expected quasi-rents exceed r (x). If the retailer's expected quasi-rents are less than r (x), then a minimum commitment and associated penalty is required to ensure that the retailer chooses (P ; x). This establishes Parts 1 and 2 of the Proposition.

Part 3. I now establish the general insu ciency of two-block tari s. To simplify notation, assume V = 0, r = 0, and D^0 = D (iso-elastic upstream investment). This case su ces to establish the insu ciency of two-block tari s. Let w_1^T and w_2^T be the prices in the high-price and low-price blocks of a two-block tari , and let q be the quantity that divides the blocks. In any rst best two-block tari , D^0 q D ; otherwise the tari would be equivalent to a two-part tari , which cannot yield the rst best outcome. Given (w_1^T; w_2^T; q), the retailer solves

(41) $$\max_{(P;x)} \; P\overline{D}(P;x) \quad [w_1^T q + w_2^T (D(P;x) \quad q)]$$

Using (45), we have

(46) $$w_1^T \quad c = \frac{(w_1^T \quad w_2^T)}{+ (1 \quad)};$$

(47) $$w_2^T \quad c = \frac{(1 \quad) \; (w_1^T \quad w_2^T)}{+ (1 \quad)}:$$

The highest investment an integrated rm would make under uncertain prospects is $(P \quad c)[D \quad D^0]$

The manufacturer will make the same investment only if

(48) $$(w_2^T \quad c)D + (w_1^T \quad w_2^T)q \quad (w_1^T \quad c)D^0 \quad (P \quad c)[D$$

both uncertain prospects and returns, the retailer weighs the risk of failing to reach the quantity threshold against the potential gains from raising price and reducing its investment. If the penalty for failing to reach the threshold is high enough, then the retailer will price and invest to ensure that it reaches the discount threshold *even if successful investment by the manufacturer does not occur.* If price is the retailer's only decision, the penalty can be set high enough with an all-units discount in all cases. If the retailer also makes a demand-enhancing investment, a minimum commitment and penalty for breach may also be required if the investment cost is large relative to the retailer's quasi-rents.

Given the alignment of the retailer's incentives with joint incentives via the discontinuous tariff, the manufacturer becomes the residual claimant to the joint profits from its investment. Therefore, the manufacturer chooses the joint profit-maximizing level of upstream investment.

Two-block tariffs are generally not sufficient to support the first best outcome. An optimal two-block tariff must set a measure of the *average* wholesale price equal to the manufacturer's marginal cost c to make the retailer the residual claimant to joint profits. If upstream investment costs are sufficiently high relative to the expected returns from upstream investment, then no such tariff exists that can also support upstream investment.

The role of the iso-elastic upstream investment assumption is not transparent from the proof of Proposition 6. Under the all-units discount contract T, the retailer can choose any ratio of P and x to achieve $D^0(P;x) = D^0(P\ ;x\ )$. The first best outcome requires a particular ratio that weighs the marginal effects of P and x on both D^0 and D. The assumption that $D^0 = D$ is sufficient to ensure that the retailer chooses the optimal ratio.

The lumpy upstream investment assumption is not required for all-units discounts to achieve the first best outcome. The key is that an all-units discount exists that imposes a sufficiently high the manufacturer believes the retailer will choose $(P; x)$, then the manufacturer is the residual claimant and will invest to maximize the fully integrated expected profit. If $F'(0) > 0$, then a small price increase by the retailer induces a discrete increase in the probability that it will sell less than q and incur an all-units discount penalty. As in the case of lumpy upstream investment, a sufficiently large all-units discount, possibly combined with a minimum quantity commitment and penalty for breach, will induce the retailer to price and invest to reach the threshold. If $F'(0) = 0$, then the first best can be approached arbitrarily closely by imposing a sufficiently high penalty.

Several papers in the early agency literature identified conditions under which penalty schemes can be used to approximate or achieve the first best outcome in various one-sided moral hazard problems.[24] The finding here is that it is possible to find an all-units discount (with a breach penalty, if needed) that provides the retailer with the right incentives *and* makes the manufacturer the residual claimant to the joint benefits of its investment.

V. Upstream Entry

The policy debate surrounding all-units discounts centers on their potential role as a device to exclude competitors. A complete analysis of this question is beyond the scope of this paper. However, I make a few observations about how the potential for upstream entry affects my results when investment returns are deterministic.

Consider the following modification of the game under deterministic returns. In stage one, the incumbent manufacturer and retailer agree to a contract, as before. In stage two, in addition to making investment and pricing decisions, the retailer considers whether to purchase at most $q_E \quad D'(\hat{P}(w_1^A); \hat{x}(w_1^A))$ units from an alternative source of supply at a unit price of w_E. Entry at quantity q_E

A. Accommodating Entry

Suppose first that firms employ an effective all-units discount intended to accommodate upstream entry. The following intuitive result establishes that firms always accommodate small scale entry by a more efficient competitor.

Proposition 7 *Suppose upstream investment is lumpy and investment returns are deterministic. Under either all-units discounts or two-block tariffs, the incumbent manufacturer and retailer will accommodate small scale entry by a more efficient competitor.*

Proof: Since the analysis is similar to that for the case without entry, I will simply sketch the argument for all-units discounts. The argument for two-block tariffs parallels the argument in Proposition 5.

The retailer must earn at least as much by accommodating entry and pricing and investing as expected under the all-units discount as it would earn by choosing not to accommodate entry and pricing and investing the same way. That is,

$$(P - w_2)D(P;x) + (w_2 - w_E)q_E - r(x) \ge (P - w_2)D(P;x) - r(x): \tag{53}$$

This requires $w_E \le w_2$. In addition, the retailer must earn at least as much by accommodating entry and pricing and investing as expected as it would earn by accommodating entry but optimizing against w_1. That is,

$$(P - w_2)D(P;x) + (w_2 - w_E)q_E - r(x) \ge \max_{(P^0;x^0)} [(P^0 - w_1)D(P^0;x^0) - r(x^0)] + (w_1 - w_E)q_E$$

$$\Longrightarrow (P - w_2)D(P;x) - r(x) - (w_1 - w_2)q_E \ge \hat{\pi}(w_1): \tag{54}$$

The retailer must also prefer accommodation over non-accommodation and optimizing against w_1. It is easy to show that this will be true when (54) is satisfied and $w_E < w_2$. The manufacturer must earn more by investing I^* than by choosing not to invest:[26]

$$(w_2 - c)D(P;x) - m(I^*) + (w_1 - w_2)q_E \ge (w_1 - c)D^0(P;x): \tag{55}$$

Finally, the analog of the incentive constraints (9) through (12) must also hold to ensure profit maximization by the retailer.

[26] By an argument similar to that in Lemma 1, we can restrict attention to the case when $D(P;x)$)

I now explain that $(P^A; x^A)$ will be chosen if entry is accommodated. Fix $(P; x) = (P^A; x^A)$. Conditions (54) and (55) are the same as the participation constraints (7) and (8) in (AUDT) except for the terms involving $(w_1 \quad w_2)q_E$. Note that reducing w_2 raises the left hand side of (54) and lowers the left hand side of (55) by the same amount. Thus, for any value of w_1, there exists a value of w_2 such that (54) and (55) are satis ed at $(P^A; x^A)$. In particular, they can be satis ed by setting $w_1 = w_1^A$ and setting $w_2 > c$ such that (54) and (55) hold. The incentive constraints on retail pricing and investment can be satis ed by choosing the appropriate shadow price of output expansion, as in (AUDT). Thus, $(P^A; x^A)$ is feasible unde3(setting)]TJ/F3(setting)o.g two-block tari , the wholesale price in the rst block must be lowered to w_E to prevent entry. It is not immediately clear which tari is more pro table.

The reason entry changes the defection constraint under a two-price all-units discounts is that the retailer can pro tably purchase a quantity other than $D^0(P^A; x^A)$ from the incumbent. Thinking back to the general contracting problem (GCP) and modifying it to allow for entry, it is still true that a two-point contract is optimal. That is, the rms could easily deter entry by charging very high prices for any quantities other than $D(P^A; x^A)$ and $D^0(P^A; x^A)$. The problem is that a *two-price* all units discount does not replicate the two-point contract because it allows the retailer to lower its purchases by q_E without a penalty when it defects and optimizes against the high price block. However, a *three-price* all-units discount will replicate a two-point contract in this case. In particular, consider a contract that charges a very ecause conconstraint8ery a veur a0a $(P^A; x^A)$ and allows4r37--6-34eur (0e 049 a0f167(x)] TJ7F20 7.970159. Td [(A)]Tw7F19 10.9091 Tf 6.841103.95

Summarizing the results in this section, all-units discounts are a stronger entry deterrent than continuous tariffs, but they are used only to deter less efficient entrants, and they do so without distorting price and investment relative to the case when the entry threat is absent. If firms are restricted to continuous tariffs, they may accommodate entry by a less efficient competitor, or they may deter entry by distorting price and investment.

VI. Implications and Conclusion

The antitrust policy debate over all-units discounts has largely lacked an economic foundation explaining why firms use these tariffs. This paper, along with that of Kolay et al. (2004), takes steps toward providing this foundation.

While Kolay et al. examined the role of all-units discounts by a firm offering a menu of discounts to multiple buyers, this paper takes a step back to examine the simpler environment of bilateral monopoly, but with the additional complication of double moral hazard. I explored three cases in which all-units discounts arise in equilibrium: (1) lumpy upstream investment with deterministic returns; (2) uncertain upstream investment prospects that may become available to the upstream firm after contracts are signed; and (3) uncertain investment returns. All-units discounts and continuous two-block tariffs are optimal contracts in the first case. I provided sufficient conditions for all-units discounts to support a first best outcome and dominate two-block tariffs in the second and third cases. In all cases, all-units discounts work by giving the retailer an incentive to expand output to reach the discount threshold while keeping upstream margins high enough to encourage upstream investment.

Since all-units discounts arise in efficient vertical contracts between bilateral monopolists that face no threat of entry, it would be inappropriate to presume without evidence that the practice is anticompetitive simply because the firms employing such tariffs have market power. In fact, the benefits of all-units discounts may actually increase with the degree of market power, as this is precisely when sophisticated contracts have the largest effect on incentives.

The antitrust concern raised by all-units discounts is that they may raise barriers to entry and harm competition. To begin addressing this issue, I extended the model to allow for the possibility of small scale entry into the upstream market, focusing on the case of lumpy investment and deterministic returns. In this environment, I showed that the incumbent supplier and retailer will always accommodate entry by an equally- or more-efficient upstream competitor. Contrary to the conventional view, all-units discounts are not used in this model to deter such entrants. I also find that all-units discounts deter entry by less efficient competitors, whereas continuous tariffs either accommodate such entry or deter it by distorting price and investment.

The analysis of entry in this paper is limited to a special case — entry into a single market served by a downstream monopolist, with no potential for dynamic entry effects. Nonetheless, the analysis casts doubt on the presumption of some European Courts that all-units discounts are anticompetitive simply because they have low (or negative) marginal prices around quantity thresholds. The model suggests that in the presence of double moral hazard, entry-deterring all-

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