

Rent Shifting, Exclusion and Market-Share Contracts*

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October 2008

Abstract

We study rent-shifting in a sequential contracting environment in which two sellers negotiate with a common buyer. We find that the ability of the buyer and the first seller to extract surplus from the second seller depends on each firm's bargaining power and on whether the first seller can offer to sell its product at prices below cost. It also depends, among other things, on whether the buyer and the first seller's contract can depend on the quantities purchased of both sellers' products (market-share contracts) or only on the quantity purchased of the first seller's product. Nevertheless, we show that these differences in the sets of feasible contracts, while affecting the distribution of surplus among firms, do not affect consumer surplus or welfare in the short run. However, in the long run, a ban on below-cost pricing and the offering of market-share contracts may harm consumers and welfare as the buyer may then commit to a single-sourcing strategy.

JEL Classification Codes: D43, L13, L14, L42

*We thank Ray Deneckere, Phil Reny, Sergei Severinov, Ivo Welch, and seminar participants at Duke University, University of Iowa, Ohio State University, University of Pittsburgh, University of Rochester, University of Toronto, Washington University in St. Louis, and the University of Wisconsin for helpful comments on earlier drafts of this paper. We are grateful to the National Science Foundation (Grant SES-0001903) for providing financial support.

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1 Introduction

Settings in which terms of trade are negotiated often occur in intermediate-goods markets, where buyers and sellers jointly participate in creating value for the end user. This creates a tension that does not arise in traditional price theory as individual buyers and sellers are then both partners and adversaries. In the case of a single buyer negotiating a contract with a single seller, the terms of trade play two roles: they determine how much overall value is created, and they determine how that value is divided. But if, as in many intermediate-goods settings, a buyer negotiates contracts with multiple sellers whose payoffs are, or can be made, interrelated, then the terms of trade also play a third role: they affect the outcome of the buyer's future negotiations with all other sellers.

In this paper, we study the economics of rent shifting in a sequential-contracting environment in which two sellers negotiate with a single buyer. As is well known in these environments, the seller that moves first has an advantage (see Aghion and Bolton, 1987). By committing the buyer to pay the first seller a penalty if it purchases from the second seller, the buyer and the first seller can extract all of the second seller's surplus. Surplus can also be extracted via quantity-discount schedules that penalize the buyer if it fails to qualify for the most attractive discounts, and similarly, via discounts that are based on the share of the buyer's total purchases that go to the first seller.¹

Examples of rent shifting abound. A retailer will likely be better able to negotiate more favorable terms of trade from Coca Cola if its rival PepsiCo allows the retailer to purchase additional quantities of Pepsi at discounted prices than if it does not. Pepsi's offer may thus have value to the buyer even if Coca Cola's surplus is not fully extracted. One can also view Phillip Morris' recent Retail Leaders program in this context. Under the program, retailers' discounts were an increasing function of the percentage of shelf space they gave to Philip Morris' products. This almost assuredly had the effect of increasing their opportunity costs of buying from the rival manufacturers, and thus the Retail Leaders' program may have effectively served to transfer surplus from the rival manufacturers to the retailers and Philip Morris according to their respective bargaining powers.²

Antitrust law is generally permissive of quantity-discount schedules and of contracts that feature payments for shelf space or, relatedly, that offer discounts based on market shares, except when a seller's prices are found to be below cost and the seller has substantial market power.³ Antitrust challenges to these types of contracts typically claim that the defendant's intent is exclusionary (i.e.,

¹See Mills (2004) and Abrams (2005) for examples of firms that offer such share-based contracts. The concern in antitrust is that these contracts may be used to foreclose competition. Our approach instead is to look at market-share contracts as a means of shifting rents from rival sellers. Mills also develops a non-foreclosure based model of market-share contracts, but in his model a dominant seller uses them not to shift rents, but to induce retail services.

²See *R.J. Reynolds Tobacco Co. v. Philip Morris, Inc.*, Civ. No. 1:99CV00185 (M.D.N.C. May 1, 2002), in which summary judgment was granted against R.J. Reynolds. The court noted that the Retail Leaders program was successful in that it forced R.J. Reynolds to respond by increasing its own promotional discounts and merchandising payments to retailers. However, it found no evidence that the program caused R.J. Reynolds to lose market share.

³In *Anti-Monopoly, Inc. v. Hasbro*, 958 F. Supp. 895 at 901 (S.D.N.Y., 1997), Anti-Monopoly, Inc. argued that it was disadvantaged by Hasbro's practice of offering quantity discounts because when selling its products to the retailer Toys "R" Us, its sales would "cut into TRU's sales of Hasbro products, which will reduce the percentage of TRU's volume discount." The court ultimately ruled against Anti-Monopoly, Inc., stating that an antitrust plaintiff cannot argue that its competitor's prices are too low unless it can prove that the competitor's prices are below cost.

that the seller with substantial market power wants to drive its smaller rivals out of the market and is offering monetary inducements to obtain the buyer's acquiescence).⁴ Offers to sell at below-cost prices by firms with market power, for example, are considered to be predatory and thus illegal under Section 2 of the Sherman Act (for the US) and Article 82 (for the European Union). And similarly, market-share contracts are subject to a rule-of-reason analysis and may be banned in settings where a seller is found to have significant market power (see Tom, et al., 2000).

A different picture emerges when these contracts are alternatively viewed through the lens of rent shifting. In rent-shifting, the seller with market power wants the rival sellers to be in the market in order to capture the additional surplus created by the sales of their products. In this case, below-cost pricing may be necessary to extract fully a rival seller's surplus. Although exclusion may be induced by mistake (see Aghion and Bolton, 1987, in the case of incomplete information), it is not the intent of the below-cost pricing. Similarly, discounts that are contingent on the buyer's purchases of a rival seller's product may also promote the extraction of surplus, especially when, as we show below, below-cost pricing alone is not sufficient. They are not intended to be exclusionary. Indeed, if the seller were to exclude its rivals from the market, there would be no rents to shift.⁵

A ban on contracts with below-cost pricing and/or share-based discounts when the seller's intent is to shift rents can have adverse welfare consequences. If these contracts are allowed, then we know from Aghion and Bolton (1987) that a buyer and one seller can fully extract a second seller's surplus when there is complete information. In this case, competition is not harmed even though the rent shifting has distributional consequences. But if they are banned, then as we show below, full extraction from the second seller may not be possible even when there is complete information. In this case, firms may be induced to resort to other, less efficient means of shifting rents. We show this in the context of a buyer who can decide which seller moves first. When the full complement of rent-shifting contracts is feasible, the buyer is able to capture all the surplus from sales of the two sellers' products. But when the means of rent-shifting are restricted, the buyer will sometimes find it optimal to adopt a second-best strategy of committing to buy from only one seller, thereby excluding the other. This can be inefficient when the sellers' products are imperfect substitutes.

The use of contracts by sellers who are first-movers in negotiating with a buyer to extract surplus from sellers who are second-movers was first studied by Aghion and Bolton (1987). Following in their tradition, we study the simplest multiple player, sequential contracting environment that captures the key ingredients of rent shifting: there are three players (a buyer and two sellers), two bilateral negotiations, and interdependencies between the sellers' payoffs. We assume an environment of complete information and focus on the distributional consequences and welfare effects of restrictions on market-share contracts and below-cost pricing. We allow for contracts that can depend in a

⁴For example, it was alleged by R.J. Reynolds, Lorillard, and Brown & Williamson that Philip Morris' Retail Leaders program was an attempt by Philip Morris to monopolize cigarette sales through retail outlets. Discriminatory market-share-based discounts are a major issue in both *Masimo v. Tyco Health Care* (2004) and *AMD v. Intel* (2005).

⁵Gans and King (2002) consider a model in which rent-shifting and foreclosure can occur simultaneously. In their model, there are two upstream firms, with decreasing average production costs, and multiple large and small buyers. In equilibrium, one upstream firm offers below-cost pricing to the large buyers. This allows it to extract greater surplus from the small buyers and denies its upstream competitor the ability to achieve its minimum efficient scale.

general way on the buyers' purchases of both sellers' products, and we consider contracts that are restricted to depend only on the buyer's purchases of a seller's own product. We also consider environments in which below-cost pricing is and is not feasible. Unlike in Aghion and Bolton's model with complete information, we allow for continuous quantities, general cost functions, trade with one or both sellers, any interactions (any manner of substitution or complementarity) among the units sold by the sellers, and any distribution of bargaining power among the contracting parties.

Our first main result is that the ability of the buyer and the first seller to shift rents from the second seller depends not only on the set of feasible contracts, but also on the distribution of each firm's bargaining power. We find that surplus extraction is weakly decreasing in the buyer's bargaining power with respect to each seller. We also find that surplus extraction is weakly greater when the contract between the buyer and the first seller can depend on the quantities purchased by the buyer of both sellers' products and when their contract can exhibit below-cost pricing.

Our second main result is that overall joint payoff is maximized, at least in the short run, in all Pareto undominated equilibria for the contracting environments we consider.⁶ Thus, even though full extraction may not always occur, the rent-shifting that arises in our model does not distort the buyer's equilibrium quantity choices; the buyer will choose the same quantities that a fully-integrated monopolist would choose. In the long run, however, firms may be able to undertake investments that affect overall joint payoff. Restrictions on the set of feasible contracts may then have adverse welfare consequences because they may induce firms to adopt second-best strategies.⁷

Our model allows us to consider the effects of different legal environments on the distribution of payoffs and consumer surplus. Consider, for example, Pepsi-Co's recent acquisition of Gatorade, a non-carbonated sports drink. Coca Cola has claimed that it would be harmed by the acquisition. Assuming PepsiCo's acquisition gives it more bargaining power with retailers than it had before the acquisition, then our results suggest that Coca Cola has good reason to worry—PepsiCo will be better off as a result of the merger and Coca Cola will be worse off. However, our result that overall joint payoff is unaffected by rent shifting, at least in the short run, implies that there need not be any effect on the prices consumers pay. Although Coca Cola may lose, the merger need not harm consumers. Our results also suggest that contracts between retailers and PepsiCo that feature market-share discounts or that exhibit below-cost pricing need not raise Coca Cola's costs or drive the company out of business. In the long run, however, antitrust laws that prohibit below-cost pricing or market-share contracts may make matters worse for consumers and welfare because they may induce a retailer to adopt a 'single-sourcing' strategy in which one of the sellers is excluded.

The rest of the paper is organized as follows. We describe the model in Section 2. In Section 3, we offer some preliminary results. In Section 4, we solve the model under different contracting

⁶This contrasts with the results in Marx and Shaffer (1999), who also extend Aghion and Bolton's model of complete information to continuous quantities and products that are imperfect substitutes but find that inefficient quantities are chosen by the buyer in equilibrium. Their result stems from their restriction to two-part tariff contracts.

⁷This is similar to the finding in Spier and Whinston (1995) that inefficient exclusion can occur in Aghion and Bolton's model with incomplete information because the first seller may overinvest in cost-reduction in order to extract more surplus from the second seller. In contrast, inefficient exclusion occurs here even with complete information since the buyer sometimes has an incentive to adopt a single-sourcing strategy as a means of extracting more surplus.

environments and show that overall joint payoff is maximized in all Pareto undominated equilibria. In Section 5, we show that the buyer might commit to a single-sourcing strategy, thereby excluding one of the sellers, if below-cost pricing and market-share contracts are prohibited. In Section 6, we offer concluding remarks and discuss policy implications. The appendices contain the major proofs.

2 Model

We consider a sequential contracting environment with complete information in which there are two sellers, X and Y , and a single buyer. Sellers X and Y incur costs $c_X(x)$ and $c_Y(y)$, respectively, where x is the quantity purchased from seller X and y is the quantity purchased from seller Y .⁸ We assume that $c_i(\cdot)$ is strictly increasing, continuous, and unbounded, with $c_i(0) = 0$, $i = X, Y$.

The game has three stages. In stage one, the buyer and seller X negotiate a contract T_X for the purchase of seller X 's product. In stage two, the buyer and seller Y negotiate a contract T_Y for the purchase of seller Y 's product. In stage three, the buyer makes its quantity choices and pays the sellers according to contracts T_X and T_Y . We consider cases in which below-cost pricing is and is not feasible. We also consider cases in which contracts can depend on both sellers' quantities and cases in which contracts can depend only on the buyer's purchases of one seller's quantity.

We let $\Omega \in \{\Omega^0, \Omega^M, \Omega^I\}$ denote the set of feasible contracts. Set Ω^0 is our base case with no contract restrictions. In this case, contract T_X specifies a payment from the buyer to seller X as a function of the quantities x and y that are purchased by the buyer from each seller:

$$\Omega^0 \equiv \{T_X : \mathbb{R}_+ \times \mathbb{R}_+ \rightarrow \mathbb{R} \cup \{\infty\}\}.$$

We allow T_x to specify payments in $\mathbb{R} \cup \{\infty\}$, but given later boundedness assumptions, a range that includes large finite values suffices. Contracts in Ω^M allow a seller's contract to depend on both sellers' quantities but do not allow below-cost pricing (the superscript M stands for multi-seller contracts). Contracts in Ω^I do not allow below-cost pricing *and* only allow a seller's contract to depend on the seller's own quantity (the superscript I stands for individual-seller contracts). Thus,

$$\Omega^M \equiv \{T_X \in \Omega^0 \mid T_X(x, y) \geq c_X(x) \quad \forall x, y\}$$

and

$$\Omega^I \equiv \{T_X \in \Omega^M \mid T_X(x, y) = T_X(x, y') \quad \forall y, y' \geq 0\}.$$

We make similar assumptions for T_Y . However, because T_Y is negotiated after T_X , rent-shifting outcomes are unaffected by whether T_Y depends on both x and y or just y (see Lemma 1 below).

If a seller does not have a contract with the buyer, the seller's net payoff is zero. Otherwise, seller X 's net payoff is $\pi_X = T_X(x, y) - c_X(x)$ and seller Y 's net payoff is $\pi_Y = T_Y(x, y) - c_Y(y)$.

⁸We assume in the text that sellers X and Y each sell a single product and that quantities x and y are scalars. Our results hold equally if sellers X and Y each sell multiple products and quantities x and y are vectors.

Let $R(x, y)$ denote the buyer's maximized gross payoff if it purchases quantities (x, y) .⁹ Then the buyer's net payoff if both contracts are in place is $\pi_b = R(x, y) - T_X(x, y) - T_Y(x, y)$. If negotiations with only seller Y fail, the buyer's net payoff is $\pi_b = R(x, 0) - T_X(x, 0)$. If negotiations with only seller X fail, the buyer's net payoff is $\pi_b = R(0, y) - T_Y(0, y)$. If negotiations with both sellers fail, the buyer's net payoff is zero. We assume that $R(\cdot, \cdot)$ is continuous and bounded, with $R(0, 0) = 0$.

Let $\Pi(x, y) \equiv R(x, y) - c_X(x) - c_Y(y)$ denote overall joint payoff, $\Pi_{XY} \equiv \max_{x, y \geq 0} \Pi(x, y)$ denote its maximized value, and $Q_{XY} \equiv \arg \max_{x, y \geq 0} \Pi(x, y)$ denote the set of maximizing quantity pairs. Similarly, let the monopoly value and quantities for the buyer and seller X be denoted by $\Pi_X \equiv \max_{x \geq 0} \Pi(x, 0)$ and $Q_X \equiv \arg \max_{x \geq 0} \Pi(x, 0)$, respectively, and the monopoly value and quantities for the buyer and seller Y be denoted by $\Pi_Y \equiv \max_{y \geq 0} \Pi(0, y)$ and $Q_Y \equiv \arg \max_{y \geq 0} \Pi(0, y)$, respectively. Given our assumptions on $R(\cdot, \cdot)$ and $c_i(\cdot)$, these values and quantities are well defined.

In the negotiation between the buyer and seller i , we assume that the two players choose T_i to maximize their joint payoff, and that each player receives its disagreement payoff plus a share of the incremental gains from trade (the joint payoff of the buyer and seller i if they trade minus their joint payoff if negotiations fail), with proportion $\lambda_i \in [0, 1]$ going to seller i .¹⁰ Our assumption of a fixed division of the gains from trade admits several interpretations. For example, if seller i makes a take-it-or-leave-it offer to the buyer, then $\lambda_i = 1$. If the buyer makes a take-it-or-leave-it offer to seller i , then $\lambda_i = 0$. And if the buyer and seller i split the gains from trade equally, then $\lambda_i = \frac{1}{2}$.

We solve for the equilibrium strategies of the three players by working backwards, taking our assumptions about the outcome of negotiations as given. The equilibrium we identify corresponds to the subgame-perfect equilibrium of the related three-stage game in which the assumed bargaining solution is embedded in the players' payoff functions. For subgame perfection, we must restrict attention to contracts T_X, T_Y such that optimal quantity choices for the buyer in stage three exist.

3 Preliminary Results

To gain some intuition, we start by considering a multiple-units extension of Aghion and Bolton's (1987) model with complete information in which both sellers can make take-it-or-leave-it offers and in which overall joint payoff is maximized when only product Y is sold. That is, we consider an environment in which $\Pi_{XY} = \Pi_Y > \Pi_X$. In this setting, one might think that seller Y will earn at least $\Pi_Y - \Pi_X$ in surplus (that is, the difference between product Y 's monopoly value and product X 's monopoly value). However, this is not the case when contracting is sequential and seller X moves first, as then seller X can offer a contract that penalizes the buyer if it purchases from seller Y . Indeed, by penalizing the buyer by exactly $\Pi_Y - \Pi_X$ if it purchases a positive quantity of product Y , seller X can extract all of the available surplus while still ensuring that overall joint

⁹We do not assume that the buyer must use all that it purchases. Thus, we have $R(x, y) = \max_{x', y'} \tilde{R}(x', y')$, where $0 \leq x' \leq x$ and $0 \leq y' \leq y$ and $\tilde{R}(x', y')$ denotes the buyer's utility (revenue) if it consumes (resells) (x', y') .

¹⁰These assumptions are consistent with bargaining solutions that require players to maximize their bilateral joint payoffs and divide the incremental gains from trade. For example, the bargaining solutions in Nash (1953) and Kalai and Smorodinsky (1975) satisfy these conditions. However, the bargaining solution in Binmore et al. (1989) does not because the additional surplus above the two players' disagreement payoffs is not always divided in fixed proportions.

payoff is maximized. To see this, suppose that seller X offers, and the buyer accepts, the contract:

$$T_X(x, y) = \begin{cases} c_X(x) + \Pi_Y, & \text{if } y > 0 \\ c_X(x) + \Pi_X, & \text{if } y = 0. \end{cases} \quad (1)$$

Then the joint payoff of the buyer and seller Y when $y > 0$ minus the joint payoff of the buyer and seller Y when $y = 0$, after substituting in for (1) and using the definitions of Π_{XY} , Π_X and Π_Y , is

$$\begin{aligned} & \max_{x \geq 0, y > 0} (R(x, y) - c_Y(y) - T_X(x, y)) - \max_{x \geq 0} (R(x, 0) - T_X(x, 0)), \\ &= (\Pi_{XY} - \Pi_Y) - (\Pi_X - \Pi_X) = 0, \end{aligned}$$

which implies that the incremental gains from trade between the buyer and seller Y are zero. It follows that it is optimal for seller Y to offer the buyer the contract $T_Y(x, y) = c_Y(y)$ in stage two (the buyer rejects any offer in which seller Y earns positive payoff), and that, given T_X and T_Y , it is optimal for the buyer to purchase $(x, y) \in Q_{XY}$, giving seller X a payoff of Π_Y . To see that the contract in (1) is an equilibrium contract, note that seller X has no incentive to offer any other contract, since it extracts all the surplus, and the buyer has no incentive to reject seller X 's offer, since then seller Y would offer $T_Y(x, y) = c_Y(y) + \Pi_Y$ and seller Y would extract all the surplus.

In this example, seller X extracts all the surplus in equilibrium, leaving none for seller Y or the buyer. If instead seller Y were to make the first offer, then seller Y would extract all the surplus in equilibrium. In both cases the seller moving first gets Π_Y and the seller moving second gets zero. More generally, surplus may be split between the buyer and first seller according to each player's bargaining power, or among all three players if the second seller retains some surplus. To see how the latter might happen, we now consider the role of market-share contracts and below-cost pricing.

Role of market-share contracts in facilitating rent shifting

Contracts that depend on both sellers' quantities are sometimes referred to as market-share contracts; the buyer's payment to seller X depends not only on how much the buyer purchases from seller X but also on how much the buyer purchases from seller Y .¹¹ These contracts can be instrumental in shifting rents from one seller to another, and thus their feasibility has important rent-shifting implications. When they are infeasible (either because of monitoring difficulties or because they are prohibited), the buyer and the first seller's ability to extract surplus from the second seller may be impaired. For example, in the case described above, there is no way for the buyer and seller X to extract all of seller Y 's surplus without using market-share contracts (see Proposition 3). One might think that seller Y 's surplus can be fully extracted with the contract

$$T_X(x, y) = \begin{cases} c_X(x) + \Pi_Y, & \text{if } x = 0 \\ c_X(x) + \Pi_X, & \text{if } x > 0, \end{cases} \quad (2)$$

¹¹An example of this is the contract in (1), where the buyer must pay $\Pi_Y - \Pi_X$ for any purchase of $y > 0$.

because the penalty in this case from trading with seller Y rather than with seller X is $\Pi_Y - \Pi_X$, which is the same as it was under the contract in (1). However, there is a subtle difference between the two contracts; under the contract in (2), there exists $T_Y(x, y) > c_Y(y)$ such that the buyer can earn non-negative payoff by purchasing positive quantities from both sellers. To see this, note that the gains from trade between the buyer and seller Y when seller X offers the contract in (2) are

$$\begin{aligned} & \max_{x>0, y>0} (R(x, y) - c_Y(y) - T_X(x, y)) - \max_{x>0} (R(x, 0) - T_X(x, 0)), \\ &= \max_{x>0, y>0} (R(x, y) - c_Y(y) - c_X(x) - \Pi_X) - \max_{x>0} (R(x, 0) - c_X(x) - \Pi_X), \\ &= (\Pi_{XY} - \Pi_X) - (\Pi_X - \Pi_X) = \Pi_Y - \Pi_X > 0. \end{aligned}$$

By purchasing a positive quantity from seller X , the buyer ensures that there are gains from trade between itself and seller Y , which implies that seller Y earns strictly positive payoff in equilibrium.

Role of below-cost pricing in facilitating rent shifting

The ability of firms to engage in rent shifting is also affected by whether or not below-cost pricing is feasible. To see this, suppose as before that overall joint payoff is maximized when only seller Y 's product is sold, i.e., $\Pi_{XY} = \Pi_Y > \Pi_X$, but now assume that market-share contracts are feasible, and that it is the buyer who has all the bargaining power in stage one. Then, if the buyer is to extract all of the available surplus for itself, it must induce seller X to accept a contract offer that eliminates the buyer's gains from trade with seller Y but does not give positive surplus to seller X in equilibrium. For example, the buyer must offer and seller X must accept a contract such as

$$T_X(x, y) = \begin{cases} c_X(x), & \text{if } y > 0 \\ c_X(x) + \Pi_X - \Pi_Y, & \text{if } y = 0. \end{cases} \quad (3)$$

In this case, the buyer's joint payoff with seller Y if it purchases from seller Y is $\Pi_{XY} = \Pi_Y$, which, from (3), is exactly offset by the buyer's opportunity cost of purchasing from seller Y :

$$\max_{x \geq 0} R(x, 0) - c_X(x) - \Pi_X + \Pi_Y = \Pi_Y.$$

Thus, the buyer's gains from trade with seller Y are zero. The buyer extracts all of seller Y 's surplus in this case because seller X earns $\Pi_Y - \Pi_X$ more if the buyer purchases from seller Y than if it does not. However, notice that because $\Pi_Y > \Pi_X$, the rent-shifting mechanism in this case requires the buyer to purchase seller X 's product at below-cost if the buyer does not purchase from seller Y . Although, in principle, an offer to sell at a loss may be feasible, in practice, such contracts may be problematic. For example, if negotiations with seller Y broke down and the buyer purchased from seller X , seller Y could sue and claim that seller X 's below-cost pricing had foreclosed it from the market. Since the facts would show that seller Y was indeed excluded, and that seller X had

sold its product at below-cost prices, it is likely that the courts would find against seller X .¹²

It turns out that the best the buyer can do in this example if below-cost pricing is illegal is to offer seller X the contract $T_X(x, y) = c_X(x)$ (see Section 4.2), thereby earning for itself a payoff of Π_X . Given this T_X , it is optimal for seller Y to offer $T_Y(x, y) = c_Y(y) + \Pi_Y - \Pi_X$, implying that in equilibrium seller X earns zero and seller Y earns $\Pi_Y - \Pi_X$. If the buyer were to negotiate with seller Y first, the equilibrium payoffs would be unchanged. Thus, in this example, the buyer's payoff does not depend on the order of negotiations and neither does the payoff of either seller.

The examples in this section show that rent shifting can take many forms and that the feasibility of certain kinds of contracts can have important effects on the distribution of surplus. In the next section, we extend the model by allowing for any relationship among the sellers' products (i.e., substitutes, complements, or independent) and any distribution of bargaining power among firms.

4 Solving the Model

Stage three—Buyer's quantity choices

We use two stars to denote the buyer's quantity choices when contracts are in place with both sellers. Thus, if the buyer has contracts with both sellers, we denote the buyer's quantity choices by $(x^{**}(T_X, T_Y), y^{**}(T_X, T_Y))$. We use one star to denote the buyer's quantity choice when a contract is in place with only one seller. Thus, for example, if the buyer only has a contract with seller X , we denote the buyer's quantity choice by $x^*(T_X)$ (analogously, $y^*(T_Y)$ for seller Y .) For now, we assume that x^{**} , y^{**} , x^* , and y^* are well defined. Later we verify this for the equilibrium contracts.

Consider first the case in which the buyer has contracts with both sellers at the start of stage three. Then the buyer chooses quantities $(x^{**}(T_X, T_Y), y^{**}(T_X, T_Y))$, where

$$(x^{**}(T_X, T_Y), y^{**}(T_X, T_Y)) \in \arg \max_{x, y \geq 0} R(x, y) - T_X(x, y) - T_Y(x, y). \quad (4)$$

If, instead, the buyer only has a contract with seller X , it chooses $x^*(T_X)$, where

$$x^*(T_X) \in \arg \max_{x \geq 0} R(x, 0) - T_X(x, 0), \quad (5)$$

and if the buyer only has a contract with seller Y , it chooses $y^*(T_Y)$, defined analogously to $x^*(T_X)$.

Stage two—Negotiations with seller Y

Given the buyer's equilibrium behavior in stage three, and assuming the buyer and seller X negotiate contract T_X in stage one, the buyer and seller Y choose contract T_Y in stage two to solve

$$\max_{T_Y \in \Omega} R(x^{**}, y^{**}) - T_X(x^{**}, y^{**}) - c_Y(y^{**}), \quad (6)$$

¹² Antitrust laws prohibit seller X from selling its product at below-cost, and they prohibit the buyer from knowingly inducing seller X to sell its product at below-cost. Predatory pricing is a violation of Section 2 of the Sherman Act and Section 2(a) of the Robinson-Patman Act (for the US), and a violation of Article 82 (for the European Union).

such that seller Y 's payoff is equal to λ_Y times its incremental gains from trade with the buyer:¹³

$$\pi_Y = \lambda_Y (R(x^{**}, y^{**}) - T_X(x^{**}, y^{**}) - c_Y(y^{**}) - (R(x^*, 0) - T_X(x^*, 0))). \quad (7)$$

Given any T_X , it follows from (6) and (7) that the buyer and seller Y have no incentive to negotiate a contract that would distort the buyer's quantity choices in stage three for products X and Y .

Lemma 1 *Given any contract T_X such that $x^*(T_X)$ and $(x^{**}(T_X, c_Y), y^{**}(T_X, c_Y))$ are well defined, if T_Y solves (6) subject to (7), then*

$$(x^{**}(T_X, T_Y), y^{**}(T_X, T_Y)) \in \arg \max_{x, y \geq 0} R(x, y) - T_X(x, y) - c_Y(y).$$

Given any contract T_X , Lemma 1 implies that the buyer and seller Y will choose a contract in stage two such that the buyer is induced to choose their joint payoff-maximizing quantities in stage three. For example, the buyer and seller Y might agree on a contract in which seller Y offers to sell its units to the buyer at cost plus a fixed fee, in which the fixed fee is chosen to satisfy (7).

If negotiations with seller X fail, the buyer and seller Y negotiate T_Y to solve $\max_{T_Y} \Pi(0, y^*)$, subject to seller Y 's earning $\pi_Y = \lambda_Y \Pi(0, y^*)$. It is straightforward to show that for any optimal T_Y in this case, the buyer chooses $y^* \in Q_Y$ in stage three. The buyer's payoff is then $(1 - \lambda_Y)\Pi_Y$.

Stage one—Negotiations with seller X

In stage one, the buyer and seller X negotiate contract T_X to maximize their joint payoff, subject to each player receiving its disagreement payoff plus a share of the gains from trade, with proportion λ_X going to seller X . Thus, in stage one, the buyer and seller X choose contract T_X to solve

$$\max_{T_X \in \Omega} \Pi(x^{**}, y^{**}) - \pi_Y, \quad (8)$$

such that the buyer prefers to negotiate with seller Y in stage two,¹⁴

$$R(x^{**}, y^{**}) - T_X(x^{**}, y^{**}) - c_Y(y^{**}) \geq R(x^*, 0) - T_X(x^*, 0), \quad (9)$$

seller X 's payoff is equal to λ_X times its incremental gains from trade with the buyer,

$$\pi_X = \lambda_X (\Pi(x^{**}, y^{**}) - \pi_Y - (1 - \lambda_Y)\Pi_Y), \quad (10)$$

and, from Lemma 1, that

$$(x^{**}, y^{**}) \in \arg \max_{x, y \geq 0} R(x, y) - T_X(x, y) - c_Y(y). \quad (11)$$

¹³Note that seller Y 's payoff, π_Y , depends on $(x^{**}, y^{**}, x^*, T_X, T_Y)$; we suppress the arguments in the text.

¹⁴Given our assumptions, it is straightforward to show that it is never optimal for the buyer and seller X to negotiate a contract in stage one that precludes negotiations between the buyer and seller Y in stage two.

Note that rent shifting is possible because of the dependency of x^{**} , y^{**} , and π_Y on contract T_x .

4.1 Market-share contracts with below-cost pricing

Suppose there are no restrictions on contracts, so that $\Omega \in \Omega^0$. Then, the buyer and seller X can induce the buyer to choose $(x^{**}, y^{**}) \in Q_{XY}$ in stage three (this maximizes $\Pi(x^{**}, y^{**})$) while ensuring the extraction of all of seller Y 's surplus (this minimizes π_Y) by negotiating the contract¹⁵

$$T_X(x, y) = \begin{cases} c_X(x) + F, & \text{if } y > 0 \\ c_X(x) + F + \Pi_X - \Pi_{XY}, & \text{if } y = 0, \end{cases} \quad (12)$$

With this contract, there are no gains from trade between the buyer and seller Y , and thus seller Y 's payoff is zero. Overall joint payoff is maximized because the combination of (12) and the T_Y that follows from Lemma 1 implies that there will be no distortions in the buyer's quantity choices.

The contract in (12) subsumes as special cases the contracts in (1) and (3). If the buyer makes the offer, it would choose $F = 0$ to ensure that seller X earns zero payoff in equilibrium, as in (3). By contrast, if seller X makes the offer, it would choose $F = \Pi_{XY} - (1 - \lambda_Y)\Pi_Y$ to ensure that the buyer earns no more than its disagreement payoff, $(1 - \lambda_Y)\Pi_Y$, in equilibrium, as in (1).¹⁶ For intermediate levels of bargaining power, seller X and the buyer would split the overall joint payoff by choosing $F = \lambda_X(\Pi_{XY} - (1 - \lambda_Y)\Pi_Y)$. Thus, for $\Omega = \Omega^0$, the following proposition holds.

Proposition 1 *Assume $\Omega = \Omega^0$. Then equilibria exist and overall joint payoff is maximized in all equilibria. Letting π_b^0 , π_X^0 , and π_Y^0 denote respectively the buyer's payoff, seller X 's payoff, and seller Y 's payoff, we find that $\pi_b^0 = \Pi_{XY} - \pi_X^0$, $\pi_X^0 = \lambda_X(\Pi_{XY} - (1 - \lambda_Y)\Pi_Y)$, and $\pi_Y^0 = 0$.*

Proposition 1 establishes that when market-share contracts are feasible and there are no constraints on below-cost pricing, contracting is efficient in the sense that equilibria exist and, in every equilibrium, overall joint payoff is maximized. In this case, seller Y 's surplus is also fully extracted.

4.2 Market-share contracts without below-cost pricing

Now suppose that market-share contracts are feasible but below-cost pricing is not, i.e., $\Omega \in \Omega^M$. Then although the buyer might like to offer the contract in (12), with $F = 0$, this would involve below-cost pricing if the buyer's negotiations with seller Y were to fail and $\Pi_{XY} > \Pi_X$. Similarly, although seller X might like to offer the contract in (12) with $F = \Pi_{XY} - (1 - \lambda_Y)\Pi_Y$, this would involve below-cost pricing if the buyer's negotiations with seller Y were to fail and $\Pi_X < (1 - \lambda_Y)\Pi_Y$.

¹⁵This contract is by no means unique, as other contracts can achieve the same outcome. For example, suppose the buyer and seller X negotiate $T_X(x, y) = R(x, y) - c_Y(y) - G$ for all $y \geq 0$, where $G > 0$. Then, it is easy to show that overall joint payoff is maximized in any equilibrium, and that there are no gains from trade between the buyer and seller Y (the latter follows because their joint payoff is constant for all $y \geq 0$, i.e., $\max_{x, y \geq 0} R(x, y) - T_X(x, y) - c_Y(y) = G$).

¹⁶If seller X attempted to extract more surplus from the buyer by asking for a payment of more than $F = \Pi_{XY} - (1 - \lambda_Y)\Pi_Y$, the buyer would reject seller X 's offer and earn $(1 - \lambda_Y)\Pi_Y$ from trading only with seller Y .

More generally, for $\lambda_Y > 0$, it must be that $F = \lambda_X(\Pi_{XY} - (1 - \lambda_Y)\Pi_Y)$ if overall joint payoff is to be maximized, seller Y 's surplus is to be fully extracted, and seller X is to earn its bargaining share of the surplus in equilibrium.¹⁷ It follows that pricing is above cost only if $\Delta_Y \leq 0$, where

$$\Delta_Y \equiv \Pi_{XY} - \Pi_X - \lambda_X (\Pi_{XY} - (1 - \lambda_Y)\Pi_Y).$$

This says that seller Y 's contribution to overall joint payoff, which is represented by the difference $\Pi_{XY} - \Pi_X$, must be less than the profit that seller X earns in an equilibrium with full-extraction, so that seller X can credibly offer to cut its profit by an amount equal to seller Y 's contribution if the buyer were to drop seller Y and only buy from seller X . In other words, all the incremental gains from trading with seller Y must accrue to seller X if seller Y 's surplus is to be fully extracted.¹⁸

To gain further insight, note that the optimal contract between the buyer and seller X depends on the buyer's bargaining power with each seller, and recall from (7) that seller Y 's payoff is

$$\lambda_Y (R(x^{**}, y^{**}) - T_X(x^{**}, y^{**}) - c_Y(y^{**}) - (R(x^*, 0) - T_X(x^*, 0))),$$

which is decreasing in $T_X(x^{**}, y^{**})$ and increasing in $T_X(x^*, 0)$. The more bargaining power sellers X and Y have, the more the burden of surplus extraction is on the former term (seller X commits the buyer to paying it a large amount on the equilibrium path), whereas the more bargaining power the buyer has, the more the burden of surplus extraction is on the latter term (where seller X offers a good deal to the buyer if the buyer does *not* purchase from seller Y). The problem is that $T_X(x^{**}, y^{**})$ is determined by what seller X makes in equilibrium while $T_X(x^*, 0)$ is constrained by the feasibility of below-cost pricing. Depending on each firm's bargaining power, full extraction from seller Y may not be possible. If $\Pi_{XY} > \Pi_X$, then this happens when the buyer's bargaining power with respect to each seller is sufficiently large (i.e., when λ_X and λ_Y are sufficiently small).¹⁹

If $\Delta_Y \leq 0$, then the contract in (12) eliminates the buyer's gains from trade with seller Y and, together with the optimal T_Y from Lemma 1, induces the buyer to choose $(x^{**}, y^{**}) \in Q_{xy}$ in stage three. By contrast, if $\Delta_Y > 0$, then full extraction from seller Y is not possible when T_X is chosen to maximize overall joint payoff. In this case, the question is whether T_X will be chosen to maximize overall joint payoff, or whether the buyer and seller X will want to distort quantities.

To reduce the dimensionality of the problem, we begin by proving the following lemma.

Lemma 2 *Assume $\Omega = \Omega^M$. Then T_X is an equilibrium contract if and only if $(x_2, y_2, x_1, t_2, t_1) =$*

¹⁷If $\lambda_Y = 0$, then seller Y earns zero payoff in any equilibrium and full extraction is trivially achieved.

¹⁸Alternatively, the buyer and seller X might negotiate a contract T_X that specifies a payment from seller X to the buyer at the time the contract is signed and another payment from the buyer to seller X of $R(x, y) - c_Y(y)$ if the buyer purchases quantities x and y , thereby yielding $T_X(x, y) = R(x, y) - c_Y(y) - G$ for all $x, y \geq 0$, where $G > 0$. In this case, however, it must be that $G = \Pi_{XY} - \lambda_X (\Pi_{XY} - (1 - \lambda_Y)\Pi_Y)$ if the buyer and seller X are to earn their bargaining shares of the surplus in equilibrium, which again implies that pricing will be above-cost only if $\Delta_Y \leq 0$.

¹⁹In Aghion and Bolton (1987)'s model with complete information, $\Delta_Y \leq 0$ (the condition for full extraction to occur in equilibrium) is always satisfied. Since $\lambda_X = \lambda_Y = 1$, in their model, it follows that $\Delta_Y = -\Pi_X < 0$.

$(x^{**}(T_X), y^{**}(T_X), x^*(T_X), T_X(x^{**}, y^{**}), T_X(x^*, 0))$ solves

$$\max_{x_2 \geq 0, y_2 \geq 0, x_1 \geq 0, t_2, t_1} \Pi(x_2, y_2) - \tilde{\pi}_Y \quad (13)$$

subject to

$$R(x_2, y_2) - t_2 - c_Y(y_2) \geq R(x_1, 0) - t_1, \quad (14)$$

$$t_1 \geq c_X(x_1) \text{ and } t_2 \geq c_X(x_2), \quad (15)$$

$$\tilde{\pi}_Y = \lambda_Y (R(x_2, y_2) - t_2 - c_Y(y_2) - (R(x_1, 0) - t_1)), \quad (16)$$

$$t_2 - c_X(x_2) = \lambda_X (\Pi(x_2, y_2) - \tilde{\pi}_Y - (1 - \lambda_Y)\Pi_Y). \quad (17)$$

Lemma 2 simplifies the task of choosing contract T_X to the easier task of choosing quantities x^{**} , y^{**} , and x^* , and payment terms $T_X(x^{**}, y^{**})$ and $T_X(x^*, 0)$ to maximize the buyer and seller X 's joint payoff in (13) subject to the buyer and seller Y 's having non-negative gains from trade, (14), seller X 's earning non-negative payoff on and off the equilibrium path, (15), and each seller's earning its bargaining share of the buyer's gains from trade with it, (16) and (17), respectively.

The constraint on below-cost pricing implies that the buyer and seller X cannot always choose $(x^*, T_X(x^*, 0))$ to eliminate seller Y 's surplus. Note from (15) and (16) that for $\tilde{\pi}_Y > 0$, the buyer and seller X can extract surplus from seller Y by decreasing $T_X(x^*, 0)$ as long as $T_X(x^*, 0) \geq c_X(x^*)$ is satisfied. However, if this constraint binds before surplus extraction is complete, then the best the buyer and seller X can do is to choose $(x^*, T_X(x^*, 0))$ such that the buyer earns payoff Π_X if negotiations with seller Y fail. Thus, in any such equilibrium, seller Y 's payoff, $\tilde{\pi}_Y$, is given by

$$\begin{aligned} & \lambda_Y (R(x^{**}, y^{**}) - T_X(x^{**}, y^{**}) - c_Y(y^{**}) - \Pi_X), \\ = & \lambda_Y (\Pi(x^{**}, y^{**}) - (T_X(x^{**}, y^{**}) - c_X(x^{**})) - \Pi_X), \\ = & \lambda_Y ((1 - \lambda_X)\Pi(x^{**}, y^{**}) + \lambda_X \tilde{\pi}_Y + \lambda_X(1 - \lambda_Y)\Pi_Y - \Pi_X), \\ = & \frac{\lambda_Y}{1 - \lambda_X \lambda_Y} ((1 - \lambda_X)\Pi(x^{**}, y^{**}) + \lambda_X(1 - \lambda_Y)\Pi_Y - \Pi_X), \end{aligned}$$

where the second line is obtained from the first line by adding and subtracting $c_X(x^{**})$, the third line is obtained by substituting in (10) for seller X 's equilibrium payoff, and the last line is obtained by rearranging the expression to get $\tilde{\pi}_Y$ by itself (alternatively, it can be written as $\frac{\lambda_Y}{1 - \lambda_X \lambda_Y} \Delta_Y$). Because the coefficient in front of $\Pi(x^{**}, y^{**})$ in seller Y 's payoff above is less than one for all $\lambda_Y < 1$, and because the buyer and seller X 's joint payoff is $\Pi(x^{**}, y^{**}) - \tilde{\pi}_Y$, it follows that the buyer and seller X have no incentive to choose quantities x^{**} and y^{**} to reduce overall joint payoff.

To summarize, seller Y 's surplus is given by its bargaining share of the difference between the stage-two coalitional values of the buyer with and without seller Y given the contract the buyer already has with seller X . This surplus is reduced by reducing the coalitional value of the buyer with seller Y and/or by raising the coalitional value of the buyer without seller Y . A ban on pricing below-cost prevents the buyer and seller X from raising the latter above a certain level, and the fact

that their joint payoff is increasing in the overall joint payoff whether or not seller Y has positive surplus implies that they will not want to introduce distortions in order to reduce the former.

Proposition 2 *Assume $\Omega = \Omega^M$. If $\lambda_Y = 1$, then equilibria exist and overall joint payoff is maximized in all Pareto undominated equilibria. For all other λ_Y , equilibria exist and overall joint payoff is maximized in all equilibria. Letting π_b^M , π_X^M , and π_Y^M denote respectively the buyer's payoff, seller X 's payoff, and seller Y 's payoff in any Pareto undominated equilibrium with $\Omega = \Omega^M$, then*

$$\begin{aligned}\pi_b^M &= \Pi_{XY} - \pi_X^M - \pi_Y^M, \\ \pi_X^M &= \lambda_X (\Pi_{XY} - \pi_Y^M - (1 - \lambda_Y)\Pi_Y), \\ \pi_Y^M &= \max \left\{ 0, \frac{\lambda_Y}{1 - \lambda_X \lambda_Y} \Delta_Y \right\}.\end{aligned}$$

Proposition 2 says that overall joint payoff is maximized in all Pareto undominated equilibria, and that in these equilibria, the buyer earns the difference between the overall joint payoff and the sum of the sellers' payoffs, seller X earns its share of the buyer's gains from trade with it, which in equilibrium are given by the overall joint payoff minus the sum of seller Y 's payoff and the buyer's disagreement payoff, and seller Y earns $\frac{\lambda_Y}{(1 - \lambda_X \lambda_Y)} \Delta_Y$ if the constraint on below-cost pricing binds.

This has implications for efficiency, consumer surplus, and welfare. With respect to efficiency, Proposition 2 implies that joint-profit maximization considerations can be separated from surplus extraction considerations in all Pareto undominated equilibria, even if full extraction from seller Y is not achieved. If $\lambda_Y < 1$, the buyer's and seller X 's payoff is increasing in $\Pi(x^{**}, y^{**})$, whether or not full extraction is achieved, and thus the buyer and seller X have an incentive to choose T_X to induce $(x^{**}, y^{**}) \in Q_{XY}$ (choosing $(x^{**}, T_X(x^{**}, y^{**}))$ to distort the buyer's quantity choices in equilibrium would lower overall joint payoff with no offsetting gain to either player). If $\lambda_Y = 1$, seller Y captures any gains from inducing the buyer to choose $(x^{**}, y^{**}) \in Q_{XY}$, and so the buyer and seller X are then indifferent to choosing T_X in stage one to induce $(x^{**}, y^{**}) \in Q_{XY}$ or not.

With respect to consumer surplus and welfare, one can infer immediately from Propositions 1 and 2 what the consequences would be of a law that prohibits sellers from engaging in below-cost pricing. If $\Delta_Y \leq 0$, then a law prohibiting below-cost pricing has no distributional effect and the contract in (12) can be used by the buyer and seller X to extract all of seller Y 's surplus. Otherwise, if $\Delta_Y > 0$, then seller Y gains from the law, and if $\lambda_X \in (0, 1)$, seller X and the buyer lose. Surprisingly, there is no short-run effect on the quantities purchased in equilibrium or on overall joint payoff, and hence no effect on the prices that end-users pay. Although the constraint affects the players engaged in rent-shifting, it neither helps nor harms consumers in the short run.

4.3 No market-share contracts and no below-cost pricing

Market-share contracts are infeasible if a seller cannot observe how much the buyer purchases from its rival, or if they are banned by law. In this section, we extend the analysis to consider rent shifting in an environment in which both market-share contracts and below-cost pricing are

infeasible, i.e., contracts must be chosen from $\Omega = \Omega^I$. We refer to contracts in Ω^I as individual-seller contracts.²⁰

The new contract restrictions imply that the buyer and seller X will no longer be able to penalize the buyer for choosing positive quantities of seller Y 's product in stage three. This is important because, as we showed in the section on preliminary results, the inability to penalize the buyer for choosing $y > 0$ may limit the ability of the buyer and seller X to extract surplus from seller Y .

As before, we begin by simplifying the buyer and seller X 's task of choosing contract T_X to the easier task of choosing quantities x^{**} , y^{**} , and x^* , and payment terms $T_X(x^{**}, y^{**})$ and $T_X(x^*, 0)$.

Lemma 3 *Assume $\Omega = \Omega^I$. Then T_X is an equilibrium contract if and only if $(x_2, y_2, x_1, t_2, t_1) = (x^{**}(T_X), y^{**}(T_X), x^*(T_X), T_X(x^{**}, y^{**}), T_X(x^*, 0))$ solves (13) subject to (14)–(17) and*

$$y_2 \in \arg \max_{y \geq 0} R(x_2, y) - c_Y(y), \quad (18)$$

$$R(x_1, 0) - t_1 \geq R(x_2, 0) - t_2, \quad (19)$$

$$R(x_2, y_2) - t_2 - c_Y(y_2) \geq \max_{y \geq 0} R(x_1, y) - t_1 - c_Y(y). \quad (20)$$

Conditions (18)–(20) are incentive-compatibility constraints: y^{**} must maximize $R(x^{**}, y) - c_Y(y)$, the buyer must choose $(x^*, 0)$ over $(x^{**}, 0)$ when it only has a contract with seller X , and the buyer must choose (x^{**}, y^{**}) over (x^*, y) for any y when it has contracts with both sellers.

The first requirement, which corresponds to the constraint in (18), has no effect on surplus extraction, and the second requirement, which corresponds to the constraint in (19), does not bind in equilibrium since the incentive of the buyer and seller X is to decrease payments for x^* . But the requirement that the buyer must choose (x^{**}, y^{**}) over (x^*, y) for any y when it has contracts with both sellers, which corresponds to the constraint in (20), while never binding for $\Omega = \Omega^M$,²¹ may be binding with individual-seller contracts. Thus, for $\Omega = \Omega^I$, the following constraint can bind:

$$R(x^{**}, y^{**}) - T_X(x^{**}, y^{**}) - c_Y(y^{**}) \geq \max_{y \geq 0} R(x^*, y) - T_X(x^*, 0) - c_Y(y). \quad (21)$$

If (21) does bind, then the definition of π_Y in (7) implies that seller Y 's payoff satisfies²²

$$\pi_Y = \lambda_Y \left(\max_{y \geq 0} \Pi(x^*, y) - \Pi(x^*, 0) \right).$$

Thus, the joint payoff of the buyer and seller X , $\Pi(x^{**}, y^{**}) - \pi_Y$, is maximized by choosing contract T_X such that $(x^{**}, y^{**}) \in Q_{XY}$ and $x^* \in \arg \min_{x \geq 0} \lambda_Y (\max_{y \geq 0} \Pi(x, y) - \Pi(x, 0))$. It follows that

²⁰If we restrict attention to individual-seller contracts but allow below-cost pricing, then as in Proposition 3 below, it can be shown that overall joint payoff is maximized in all equilibria, and as discussed in Section 3, the contract given in (2) shows that it is not always possible for the buyer and seller X to extract all the surplus from seller Y .

²¹Contracts in Ω^M can penalize the buyer for choosing x^* together with any positive y .

²²From condition (7), $\pi_Y = \lambda_Y (R(x^{**}, y^{**}) - T_X(x^{**}, y^{**}) - c_Y(y^{**}) - (R(x^*, 0) - T_X(x^*, 0)))$. It follows that if the constraint in (21) binds, then $\pi_Y = \lambda_Y (\max_{y \geq 0} R(x^*, y) - T_X(x^*, 0) - c_Y(y) - (R(x^*, 0) - T_X(x^*, 0)))$. The displayed expression in the text can then be obtained by judiciously adding and subtracting $c_X(x^*)$, and simplifying.

even with individual-seller contracts, the buyer and seller X will still want to maximize overall joint payoff. This gives a result for individual-seller contracts that is analogous to that in Proposition 2.

Proposition 3 *Assume $\Omega = \Omega^I$. If $\lambda_Y = 1$, then equilibria exist and overall joint payoff is maximized in all Pareto undominated equilibria. For all other λ_Y , equilibria exist and overall joint payoff is maximized in all equilibria. Letting π_b^I , π_X^I , and π_Y^I denote respectively the buyer's payoff, seller X 's payoff, and seller Y 's payoff in any Pareto undominated equilibrium with $\Omega = \Omega^I$, then*

$$\begin{aligned}\pi_b^I &= \Pi_{XY} - \pi_X^I - \pi_Y^I, \\ \pi_X^I &= \lambda_X (\Pi_{XY} - \pi_Y^I - (1 - \lambda_Y)\Pi_Y), \\ \pi_Y^I &= \max \left\{ \pi_Y^M, \lambda_Y \min_{x \geq 0} \max_{y \geq 0} (\Pi(x, y) - \Pi(x, 0)) \right\}.\end{aligned}$$

One might have thought from previous literature on sequential contracting in intermediate-goods markets (see, for example, McAfee and Schwartz, 1994; and Marx and Shaffer, 1999) that the buyer's quantity choices would be distorted when only individual-seller contracts are feasible. However, this literature restricts attention to two-part tariff contracts. For example, Marx and Shaffer find that the first seller will offer the buyer a wholesale price that is below its marginal cost in order to increase the buyer's disagreement payoff with the second seller. The distortion occurs both on and off the equilibrium path because only two instruments, the wholesale price and fixed fee, are being used to control three objectives (maximization of overall joint payoff, division of surplus between the first seller and the buyer, and extraction of surplus from the second seller).

The class of contracts we consider here, although more restrictive than the class of market-share contracts, is sufficiently less restrictive than the class of two-part tariff contracts that the buyer and seller X can separate the maximization of overall joint payoff from how much surplus is extracted and how it is divided. What may be surprising is that this holds even when full extraction is not achieved (either because the constraint on below-cost pricing binds, or because the constraint that the buyer must choose (x^{**}, y^{**}) over (x^*, y) when it has contracts in place with both sellers binds).

If $\lambda_Y = 1$ or the constraint in (21) does not bind, then the problem of choosing T_X to maximize the joint payoff of the buyer and seller X is the same for individual-seller contracts as it is for multi-seller contracts. (This is readily apparent from the proof of Proposition 3.) However, if $\lambda_Y < 1$ and the constraint in (21) binds, then seller Y 's payoff is $\lambda_Y \min_{x \geq 0} \max_{y \geq 0} (\Pi(x, y) - \Pi(x, 0))$.

Comparing the equilibrium payoffs in Propositions 2 and 3, it follows that, because

$$\pi_Y^M = \max \left\{ 0, \frac{\lambda_Y}{1 - \lambda_X \lambda_Y} (\Pi_{XY} - \Pi_X - \lambda_X (\Pi_{XY} - (1 - \lambda_Y)\Pi_Y)) \right\},$$

a ban on market-share contracts and below-cost pricing has distributional consequences only if

$$\begin{aligned}& \lambda_Y \min_{x \geq 0} \max_{y \geq 0} (\Pi(x, y) - \Pi(x, 0)) \\ > \max \left\{ 0, \frac{\lambda_Y}{1 - \lambda_X \lambda_Y} (\Pi_{XY} - \Pi_X - \lambda_X (\Pi_{XY} - (1 - \lambda_Y)\Pi_Y)) \right\}.\end{aligned}\tag{22}$$

This inequality is satisfied in some environments but not others. For example, if products are independent (i.e., $R(x, y) = R(x, 0) + R(0, y)$), then (22) is satisfied as long as $\lambda_X, \lambda_Y, \Pi_X$, and Π_Y are positive.²³ In these cases, a restriction to individual-seller contracts reduces the amount of surplus the buyer and seller X can extract from seller Y . However, if products are perfect complements (i.e., $R(x, y) \geq 0, R(x, 0) = R(0, y) = 0$), then the left-hand side of (22) is zero, which implies that seller Y 's payoff is the same as it is with multi-seller contracts. And if products are perfect substitutes (i.e., $R(x, y) = R(x + y, 0) = R(0, x + y)$) and costs are zero, then both sides of (22) are zero, which implies that full extraction from seller Y is achieved in all equilibria. In this case, a ban on market-share contracts and below-cost pricing has no distributional consequences.

5 The effect of restrictions in the long run

5.1 Order of negotiations

We have thus far assumed that the order of negotiations in which each seller contracts with the buyer is exogenous, which may be justified in the short run if one seller has a natural first-mover advantage (e.g., if seller X is an incumbent and seller Y is an entrant). In the long run, however, the buyer may be able to influence the order of negotiations by selling the right to move first to the highest bidder (it follows from the propositions above that both sellers strictly prefer to move first if both have bargaining power and their products are not perfect complements or independent). In this way, the buyer may be able to capture an additional amount equal to the difference between what the first seller earns by negotiating first and what it would have earned by negotiating second, resulting in a payoff to the buyer of Π_{XY} minus what each seller would earn if it negotiated second.²⁴

Formally, let $\Delta_X \equiv \Pi_{XY} - \Pi_Y - \lambda_Y (\Pi_{XY} - (1 - \lambda_X)\Pi_X)$ denote the difference between seller X 's contribution to overall joint payoff and the payoff that seller Y would earn under full extraction if seller X negotiates second (note that Δ_X is defined analogously to Δ_Y). Then, the buyer's overall payoff if it can capture the value to each seller of moving first is given in the following corollary.

²³If products are independent, then the left-hand side of (22) simplifies to $\lambda_Y \Pi_Y$ and the right-hand side of (22) simplifies to $\max\{0, \lambda_Y \Pi_Y - \frac{\lambda_Y \lambda_X}{1 - \lambda_Y \lambda_X} \Pi_X\}$. Since the left side exceeds the right side, it follows that when the products are independent, a ban on market-share contracts and below-cost pricing will have distributional consequences. On the other hand, if products are perfect complements, then the left-hand side of (22) is zero (since $\max_{y \geq 0} (\Pi(0, y) - \Pi(0, 0)) = 0$). In this case, a ban on market-share contracts and below-cost pricing has no effect.

²⁴For example, consider the following game. At stage zero, seller $i, i = X, Y$, offers $F_i \geq 0$ to the buyer for the right to move first. Let π_i^1 denote seller i 's payoff in the continuation game if it negotiates first, and let π_i^2 denote seller i 's payoff in the continuation game if it negotiates second. Then, it must be that $F_x + \Pi_{XY} - \pi_x^1 - \pi_y^2 \geq F_y + \Pi_{XY} - \pi_x^2 - \pi_y^1$ in any equilibrium in which the buyer accepts seller X 's offer. Since it must also be that seller Y offers $F_y = \pi_y^1 - \pi_y^2$ in this equilibrium, it follows that seller X will offer $F_x = \pi_x^1 - \pi_x^2$, giving the buyer a payoff of $\Pi_{XY} - \pi_x^2 - \pi_y^2$.

Corollary 1 *The buyer's payoff if it can capture the value to each seller of moving first is*

$$\pi_b = \begin{cases} \Pi_{XY}, & \text{if } \Omega = \Omega^0 \\ \Pi_{XY} - \max \left\{ 0, \frac{\lambda_X}{1-\lambda_X\lambda_Y} \Delta_X \right\} - \max \left\{ 0, \frac{\lambda_Y}{1-\lambda_X\lambda_Y} \Delta_Y \right\}, & \text{if } \Omega = \Omega^M \\ \Pi_{XY} - \max \left\{ 0, \frac{\lambda_X}{1-\lambda_X\lambda_Y} \Delta_X, \lambda_X \Gamma_X \right\} - \max \left\{ 0, \frac{\lambda_Y}{1-\lambda_Y\lambda_X} \Delta_Y, \lambda_Y \Gamma_Y \right\}, & \text{if } \Omega = \Omega^I. \end{cases}$$

where $\Gamma_X \equiv \min_{y \geq 0} \max_{x \geq 0} (\Pi(x, y) - \Pi(0, y))$ and $\Gamma_Y \equiv \min_{x \geq 0} \max_{y \geq 0} (\Pi(x, y) - \Pi(x, 0))$.

Corollary 1 follows from Propositions 1, 2, and 3, where each seller's payoff is what it would earn if it negotiated second, and the buyer's payoff is Π_{XY} minus the sum of the two sellers' payoffs.

5.2 Buying from at most one seller

Unless it has all the bargaining power with respect to each seller, it is clear from Propositions 1, 2, and 3 that the buyer does not capture all of the available surplus. Unless contracts are unrestricted, it is clear from Corollary 1 that the buyer does not always extract all of the surplus even when it can capture the value to each seller of moving first. In these cases, the buyer may be able to shift additional rent in its favor by committing to a single-sourcing strategy in which it buys from at most one seller (see O'Brien and Shaffer, 1997; Dana, 2006; Inderst and Shaffer, 2007; and Inderst, 2008, for models of single sourcing in environments with simultaneous contracting).²⁵ However, this may involve a tradeoff for the buyer in that the greater surplus extraction may come at the expense of a decrease in overall joint payoff (necessarily a decrease if $\Pi_{XY} > \max\{\Pi_X, \Pi_Y\}$), of which it receives a positive share. Thus, whether the buyer can profit by committing to single sourcing depends on whether its payoff increases with a larger share of a smaller overall profit pie.

We now consider how the buyer's incentive to commit to single sourcing depends on the set of feasible contracts. For simplicity, we assume the buyer can commit to a single sourcing (if it wants to do so) at no cost. This allows us to modify the game with a minimal change in notation. As before, contracting is sequential, with seller X moving first (except, perhaps, when the buyer can choose the order of negotiations,²⁶ in which case seller Y may move first). Also, as before, if the buyer does not commit to single sourcing, then $\Pi_{XY} = \max_{x, y \geq 0} \Pi(x, y)$. However, if the buyer does commit to a single-sourcing strategy, then $R(x, y) = \max\{R(x, 0), R(0, y)\}$ and $\Pi_{XY} = \max\{\Pi_X, \Pi_Y\}$.

Market-share contracts are feasible

We begin by supposing that market-share contracts are feasible. We have two main results. Our first result is that if $\Omega = \Omega^0$, or if $\Omega = \Omega^M$ and the constraint on below-cost pricing does not bind, then single sourcing is unprofitable. It follows from Corollary 1 and Propositions 1 and 2 that, in both cases, the buyer earns Π_{XY} if it can capture the value to each seller from moving first

²⁵For example, a buyer might be able to effectively commit to a single-sourcing strategy by limiting its shelf space.

²⁶For a complete characterization of the determinants of the order of negotiations when the buyer can choose which seller to negotiate with first, but may or may not be able to fully extract the value to each seller of moving first, see Marx and Shaffer (2007). For a contrasting perspective using a different setup, see the article by Raskovich (2007).

and

$$\begin{aligned} & \Pi_{XY} - \pi_X^o \\ &= (1 - \lambda_X)\Pi_{XY} + \lambda_X(1 - \lambda_Y)\Pi_Y, \end{aligned} \quad (23)$$

if it cannot. In contrast, the buyer's payoffs, respectively, under single sourcing are $\max\{\Pi_X, \Pi_Y\}$ and $(1 - \lambda_X)\max\{\Pi_X, \Pi_Y\} + \lambda_X(1 - \lambda_Y)\Pi_Y$, where we have used the fact that $\Pi_{XY} = \max\{\Pi_X, \Pi_Y\}$. The buyer's payoff is lower under single sourcing because seller Y 's surplus is already fully extracted.

Our second result is that if $\Omega = \Omega^M$ and the constraint on below-cost pricing binds then single sourcing allows the buyer to extract more surplus from seller Y but the decrease in overall joint payoff that accompanies it is only partially offset by the gain from greater surplus extraction (receiving a larger share of a smaller pie in this case is unprofitable). To establish that the buyer is once again worse off from single sourcing, it suffices to show that its payoff is increasing in Π_{XY} . Consider first the case covered in Corollary 1. If the constraint on below-cost pricing binds, then²⁷

$$\pi_b = \Pi_{XY} - \frac{\lambda_X}{1 - \lambda_X\lambda_Y}\Delta_X - \frac{\lambda_Y}{1 - \lambda_X\lambda_Y}\Delta_Y. \quad (24)$$

Differentiating this expression with respect to Π_{XY} yields

$$\begin{aligned} \frac{d\pi_b}{d\Pi_{XY}} &= 1 - \frac{\lambda_X}{1 - \lambda_X\lambda_Y}(1 - \lambda_Y) - \frac{\lambda_Y}{1 - \lambda_X\lambda_Y}(1 - \lambda_X), \\ &= \frac{1}{1 - \lambda_X\lambda_Y}(1 - \lambda_X)(1 - \lambda_Y) > 0, \end{aligned} \quad (25)$$

where we have used the fact that the constraint on below-cost pricing does not bind if both sellers can make take-it-or-leave-it offers. This suggests that the buyer gains from an increase in overall joint payoff, and thus that destroying surplus by committing to a single-sourcing strategy makes it worse off. We leave it to the reader to verify that the buyer also gains from an increase in Π_{XY} even if it cannot capture the value to each seller of moving first. Thus, in both cases, when the constraint on below-cost pricing binds, the buyer will always prefer to purchase from both sellers.

Market-share contracts are infeasible

The tradeoff may be resolved differently, however, if market-share contracts are infeasible and the constraint in (21) binds. Suppose the buyer is able to capture the value to each seller of moving first. Then, from Corollary 1, the buyer's payoff if it does not adopt a single-sourcing strategy is

$$\Pi_{XY} - \lambda_X \left(\min_{y \geq 0} \max_{x \geq 0} (\Pi(x, y) - \Pi(0, y)) \right) - \lambda_Y \left(\min_{x \geq 0} \max_{y \geq 0} (\Pi(x, y) - \Pi(x, 0)) \right), \quad (26)$$

²⁷The buyer's payoff in (24) is derived assuming that the constraint on below-cost pricing binds irrespective of which seller negotiates second. The gain to the buyer from an increase in Π_{XY} would be even greater otherwise.

whereas its payoff if it can commit to purchasing at most one product (assuming $\Pi_Y \geq \Pi_X$) is²⁸

$$\Pi_Y - \lambda_Y \left(\max\{0, \Pi_Y - \max_{x \geq 0} R(x, 0)\} \right). \quad (27)$$

If the payoff is larger in (27) than it is in (26), the buyer will find single sourcing profitable. The buyer clearly suffers a loss when overall joint payoff decreases from Π_{XY} to Π_Y , but this may be more than offset by the increase in surplus that can be extracted from sellers X and Y . The simplest way to show that either effect can dominate is to consider the case of independent products, which implies that $R(x, y) = R(x, 0) + R(0, y)$ when both products can be sold. In this case, (26) simplifies to $(1 - \lambda_X)\Pi_X + (1 - \lambda_Y)\Pi_Y$, which is strictly less than (27) if seller Y earns positive surplus and

$$(1 - \lambda_X)\Pi_X < \lambda_Y \max_{x \geq 0} R(x, 0). \quad (28)$$

Since $\max_{x \geq 0} R(x, 0) > \Pi_X$, a sufficient condition for (28) to hold is $\lambda_X + \lambda_Y > 1$. This follows because the larger is $\lambda_X + \lambda_Y$, the more weight the buyer will place on extracting surplus from the sellers, and therefore the more likely the buyer will commit to a single-sourcing strategy. On the other hand, for sufficiently small λ_X and λ_Y , the buyer's payoff in (26) exceeds its payoff in (27).

These results on the profitability of single-sourcing can be summarized as follows.

Proposition 4 *Single-sourcing is not profitable for the buyer when market-share contracts are feasible and contracting between the buyer and sellers is sequential. Single sourcing is profitable, however, when market-share contracts are banned and sellers have sufficiently high bargaining power.*

Proposition 4 yields some counterintuitive policy implications. A common view in antitrust circles is that market-share contracts should be presumed to be exclusionary when they are used by dominant firms. Under this view, the appropriate antitrust policy is to ban dominant firms from using them. However, if one takes the view that these contracts facilitate rent-shifting, then banning them may have unforeseen adverse consequences. In the short run, a ban on market-share contracts causes surplus to be redistributed but does not harm welfare. However, in the long run, a ban on market-share contracts may harm welfare because it may induce the buyer to commit to single-sourcing, resulting in the exclusion of one of the sellers.²⁹ Moreover, as Proposition 4 implies, the more dominant are the sellers in the sense of having more bargaining power, the more likely this buyer-induced exclusion will occur if market-share contracts are banned. Thus, although the intended purpose of the ban may be to preserve the number of competitors in the market, the actual effect may be just the opposite; there may be fewer sellers and consumers may lose from the reduced variety of products. On the other hand, a law that aims to protect smaller sellers by

²⁸The assumption that $\Pi_Y \geq \Pi_X$ implies that seller X earns zero payoff in any equilibrium in which the buyer is committed to purchasing at most one product. Thus, it follows that $\lambda_X (\min_{y \geq 0} \max_{x \geq 0} (\Pi(x, y) - \Pi(0, y))) = 0$.

²⁹The idea that banning 'exclusionary' clauses may result in long-run adjustments with adverse efficiency effects can also be found in the seminal work of Bernheim and Whinston (1998) on exclusive dealing. In that paper, the adjustment is in higher quantities, while in this paper it is in the buyer's decision to commit to carry only one product.

banning only below-cost pricing does not by itself facilitate buyer-induced exclusion, and in that sense its effect may be more in line with the goals of antitrust, or at least not opposed to them.

6 Conclusion

In this paper, we analyze the use of contracts to shift rents between buyers and sellers. In particular, we focus on a sequential contracting environment in which two sellers negotiate terms of trade with a common buyer. We find that the ability of the buyer and the first seller to extract surplus from the second seller depends on each firm’s bargaining power and, among other things, on whether the first seller’s contract can depend on sales of both sellers’ products (market-share contracts) or only on sales of its own product, and on whether the first seller can offer to sell its own product at prices below cost. Nevertheless, we show that these differences among feasible contracts, while affecting the distribution of surplus among firms, do not affect consumer surplus or welfare in the short run, as overall joint payoff is maximized in every Pareto-undominated equilibrium.

Business practices such as exclusive dealing, market-share contracts, and below-cost pricing are often viewed in antitrust as a potential means by which a dominant firm can raise rivals’ costs and induce exclusion. In contrast, our model offers a different perspective for why a dominant firm might use them. As in O’Brien and Shaffer (1997) and Bernheim and Whinston (1998), we find that it is not optimal for one seller to exclude another when this would lower overall joint payoff because this prevents the seller from extracting rents from the excluded firm. Similarly, tactics by a seller that are designed to raise its rival’s costs are also not optimal because they destroy surplus.

Sellers in our model prefer to use contractual provisions to maximize overall joint payoff and extract as much surplus as possible rather than to obtain a larger share of a smaller overall payoff. This perspective yields some surprising implications. In the short run, when things like product design, shelf space, and production and distribution costs are fixed, the use of market-share discounts and below-cost pricing in rent-shifting contracts between buyers and sellers has no effect on consumer surplus or welfare. For example, in the case of market-share contracts, offering discounts that are contingent on how much the buyer purchases from another seller always affects the distribution of surplus, but has no effect on the prices consumers pay, product variety, or welfare.

In the long run, however, the feasibility of such contracts may matter. We considered the incentive of the buyer to commit to a single-sourcing strategy, and found that when market-share contracts were feasible, the buyer had no incentive to do so. However, we also found that single sourcing could be profitable if market-share contracts were not feasible. Surprisingly, when this holds, our results suggest that antitrust laws that are aimed at reducing exclusionary behavior may do more harm than good. For example, a policy in which the use of market-share contracts by dominant firms is banned may have the effect of *increasing* the incidence of exclusion, as industry participants seek to maximize their payoffs subject to the prevailing legal constraints.

Determining the intent of an ‘exclusionary’ clause in any given case may be difficult, especially since the distinction between foreclosure and rent shifting is sometimes blurred (e.g., in Aghion

and Bolton's (1987) model with incomplete information, it is impossible to extract surplus without reducing the probability of entry). Nevertheless, we believe that viewing the behavior of firms through the lens of rent-shifting presents a useful alternative to the foreclosure claims of some and the efficiency claims of others. The literature on exclusive dealing provides a case in point. Some would argue that exclusive dealing has efficiency motives and is thus procompetitive, while others would argue that exclusive dealing forecloses rivals and thus is anticompetitive. Typically antitrust authorities must balance competing claims, recognizing that no one motive applies in every instance, which is why antitrust law on exclusive dealing claims are evaluated on a case-by-case basis. In any given case, if authorities decide to ban exclusive dealing, it is because they think that the possibility of foreclosure in the case is more plausible than some alleged efficiency. Authorities try to stop the foreclosure and take their chances that there may be an efficiency loss if indeed the exclusive dealing was serving some other purpose. In contrast, in our model, if authorities decide to ban the 'exclusionary' clause, they do not even have the comfort of knowing that they will be preventing foreclosure. Instead, as we have shown, they may in some cases be making foreclosure more likely.

A Appendix

Proof of Lemma 1. Let T_X be such that $x^*(T_X)$ and $(x'', y'') \equiv (x^{**}(T_X, c_Y), y^{**}(T_X, c_Y))$ are well defined. Let T_Y solve (6) subject to (7). Then $(x^{**}(T_X, T_Y), y^{**}(T_X, T_Y))$ solves (4). Suppose that

$$(x^{**}(T_X, T_Y), y^{**}(T_X, T_Y)) \notin \arg \max_{x, y \geq 0} R(x, y) - T_X(x, y) - c_Y(y). \quad (\text{A1})$$

Then

$$\begin{aligned} & R(x^{**}(T_X, T_Y), y^{**}(T_X, T_Y)) - T_X(x^{**}(T_X, T_Y), y^{**}(T_X, T_Y)) - c_Y(y^{**}(T_X, T_Y)) \\ < & R(x'', y'') - T_X(x'', y'') - c_Y(y''). \end{aligned} \quad (\text{A2})$$

Define $T_Y^e(x, y) \equiv c_Y(y) + \tilde{F}$, where

$$\tilde{F} \equiv \lambda_Y \max\{0, R(x'', y'') - T_X(x'', y'') - c_Y(y'') - (R(x^*(T_X), 0) - T_X(x^*(T_X), 0))\}.$$

Note that $(x^{**}(T_X, T_Y^e), y^{**}(T_X, T_Y^e))$ is well defined, $T_Y^e(x'', y'') - c_Y(y'') \geq 0$, and

$$\begin{aligned} & R(x'', y'') - T_X(x'', y'') - c_Y(y'') \\ = & R(x^{**}(T_X, T_Y^e), y^{**}(T_X, T_Y^e)) - T_X(x^{**}(T_X, T_Y^e), y^{**}(T_X, T_Y^e)) - c_Y(y^{**}(T_X, T_Y^e)). \end{aligned} \quad (\text{A3})$$

Then, using the definition of \tilde{F} , T_Y^e satisfies (7). Expressions (A2) and (A3) imply

$$\begin{aligned} & R(x^{**}(T_X, T_Y), y^{**}(T_X, T_Y)) - T_X(x^{**}(T_X, T_Y), y^{**}(T_X, T_Y)) - c_Y(y^{**}(T_X, T_Y)) \\ < & R(x^{**}(T_X, T_Y^e), y^{**}(T_X, T_Y^e)) - T_X(x^{**}(T_X, T_Y^e), y^{**}(T_X, T_Y^e)) - c_Y(y^{**}(T_X, T_Y^e)), \end{aligned}$$

which contradicts our assumption that T_Y solves (6) subject to (7). Q.E.D.

Proof of Lemma 2. Suppose contract $T_X \in \Omega^M$ is an equilibrium contract. Then T_X solves (8) subject to (9), (10), and (11), where π_Y is given by (7). Consider $(x_2, y_2, x_1, t_2, t_1) \equiv (x^{**}(T_X), y^{**}(T_X), x^*(T_X), T_X(x^{**}, y^{**}), T_X(x^*, 0))$. Constraint (9) implies that (14) is satisfied. Constraint (10) implies that (17) is satisfied, where $\tilde{\pi}_Y$ and π_Y are defined analogously. Since $T_X \in \Omega^M$, the definitions of x^{**} and x^* imply that (15) is satisfied. Thus, $(x_2, y_2, x_1, t_2, t_1)$ is a feasible solution. Suppose $(x_2, y_2, x_1, t_2, t_1)$ does not solve the program in (13)–(17). Then there exists $(x'_2, y'_2, x'_1, t'_2, t'_1)$ satisfying the constraints in (14)–(17) such that (13) is greater at $(x'_2, y'_2, x'_1, t'_2, t'_1)$ than at $(x_2, y_2, x_1, t_2, t_1)$. Consider contract T'_X defined by:

$$T'_X(x, y) \equiv \begin{cases} t'_2, & \text{if } (x, y) = (x'_2, y'_2) \\ t'_1, & \text{if } (x, y) = (x'_1, 0) \\ \infty, & \text{otherwise.} \end{cases}$$

Because $(x'_2, y'_2, x'_1, t'_2, t'_1)$ satisfies the constraints in (14)–(17) and $(x^{**}(T'_X), y^{**}(T'_X)) = (x'_2, y'_2)$ and $x^*(T'_X) = x'_1$, it follows that $T'_X \in \Omega^M$ and that T'_X satisfies (9), (10), and (11). Thus, T'_X is a feasible contract and gives the buyer and seller X higher joint payoff than T_X , a contradiction.

Suppose T_X is not an equilibrium contract. If $x^{**}(T_X)$, $y^{**}(T_X)$, or $x^*(T_X)$ is not well defined, then there does not exist x_2 , y_2 , or x_1 satisfying (15) when $(t_2, t_1) = (T_X(x^{**}, y^{**}), T_X(x^*, 0))$. Because T_X is not an equilibrium contract, the contract T_X'' , where

$$T_X''(x, y) \equiv \begin{cases} T_X(x^{**}(T_X), y^{**}(T_X)), & \text{if } (x, y) = (x^{**}(T_X), y^{**}(T_X)) \\ T_X(x^*(T_X), 0), & \text{if } (x, y) = (x^*(T_X), 0) \\ \infty, & \text{otherwise,} \end{cases}$$

is also not an equilibrium contract. Since $T_X \in \Omega^M$, it follows that $T_X'' \in \Omega^M$, so if T_X'' is not feasible, then either (9), (10), or (11) is violated. Consider

$$(x_2, y_2, x_1, t_2, t_1) \equiv (x^{**}(T_X), y^{**}(T_X), x^*(T_X), T_X(x^{**}, y^{**}), T_X(x^*, 0)).$$

If T_X'' violates (9), then $(x_2, y_2, x_1, t_2, t_1)$ violates (14). If T_X'' violates (10), then $(x_2, y_2, x_1, t_2, t_1)$ violates (17). If T_X'' violates (11), then $(x_2, y_2, x_1, t_2, t_1)$ violates (14). If T_X'' is feasible, then there exists $T_X''' \in \Omega^M$ also feasible but giving higher payoff to the buyer and seller X . Then $(x_2, y_2, x_1, t_2, t_1)$ and $(x_2''', y_2''', x_1''', t_2''', t_1''') \equiv (x^{**}(T_X'''), y^{**}(T_X'''), x^*(T_X'''), T_X'''(x^{**}, y^{**}), T_X'''(x^*, 0))$ satisfy the constraints in (14)–(17), but $(x_2''', y_2''', x_1''', t_2''', t_1''')$ results in a higher value of the maximand in (13) than $(x_2, y_2, x_1, t_2, t_1)$. Thus, $(x^{**}(T_X), y^{**}(T_X), x^*(T_X), T_X(x^{**}, y^{**}), T_X(x^*, 0))$ does not solve the program in (13)–(17). Q.E.D.

Proof of Proposition 2. Assume $\Omega = \Omega^M$. Suppose $\lambda_Y < 1$. Using Lemma 2, we consider $(x_2, y_2, x_1, t_2, t_1)$ solving the program in (13)–(17). Note that (16) and (17) imply

$$t_2 = c_X(x_2) + \frac{\lambda_X}{1 - \lambda_X \lambda_Y} ((1 - \lambda_Y)\Pi(x_2, y_2) - (1 - \lambda_Y)\Pi_Y + \lambda_Y (R(x_1, 0) - t_1)) \quad (\text{A4})$$

and

$$\tilde{\pi}_Y = \lambda_Y \left(\frac{1 - \lambda_X}{1 - \lambda_X \lambda_Y} \Pi(x_2, y_2) + \frac{\lambda_X(1 - \lambda_Y)}{1 - \lambda_X \lambda_Y} \Pi_Y - \frac{1}{1 - \lambda_X \lambda_Y} (R(x_1, 0) - t_1) \right). \quad (\text{A5})$$

Substituting in for t_2 and $\tilde{\pi}_Y$, the program in (13)–(17) is

$$\max_{x_2, y_2, x_1, t_1} \frac{1 - \lambda_Y}{1 - \lambda_X \lambda_Y} \Pi(x_2, y_2) + \frac{\lambda_Y}{1 - \lambda_X \lambda_Y} (R(x_1, 0) - t_1) - \frac{\lambda_X \lambda_Y (1 - \lambda_Y)}{1 - \lambda_X \lambda_Y} \Pi_Y \quad (\text{A6})$$

subject to

$$R(x_1, 0) - t_1 \leq (1 - \lambda_X)\Pi(x_2, y_2) + \lambda_X(1 - \lambda_Y)\Pi_Y, \quad (\text{A7})$$

$$\lambda_X \lambda_Y (R(x_1, 0) - t_1) \geq \lambda_X(1 - \lambda_Y)\Pi_Y - \lambda_X(1 - \lambda_Y)\Pi(x_2, y_2), \quad (\text{A8})$$

$$t_1 \geq c_X(x_1). \quad (\text{A9})$$

Because choosing $(x_2, y_2) \in Q_{XY}$ maximizes the first term in the maximand and maximally relaxes the constraints, and because a feasible solution exists with $(x_2, y_2) \in Q_{XY}$, choosing $(x_2, y_2) \in Q_{XY}$

is optimal. This completes the proof that all equilibria are efficient when $\lambda_Y < 1$. If $\lambda_Y = 1$, then the joint payoff of the buyer and seller X does not depend on (x_2, y_2) , so there exists an equilibrium in which $(x_2, y_2) \in Q_{XY}$.

One can calculate the equilibrium payoffs to the players by using (7), (10), the above efficiency result, the result that full extraction is achieved if and only if $\lambda_Y = 0$ or $\Delta_Y \leq 0$, and the fact that the buyer's disagreement payoff with seller Y is Π_X when full extraction is not achieved. Q.E.D.

Proof of Lemma 3. Define Program I to be $\max_{T_X \in \Omega^I} \Pi(x^{**}, y^{**}) - \pi_Y$ subject to (9)–(11), and define Program II to be (13) subject to (14)–(20). Suppose $\hat{T}_X \in \Omega^I$ is an equilibrium individual-seller contract. Then \hat{T}_X solves Program I. Letting

$$(x_2, y_2, x_1, t_2, t_1) \equiv (x^{**}(\hat{T}_X), y^{**}(\hat{T}_X), x^*(\hat{T}_X), \hat{T}_X(x^{**}), \hat{T}_X(x^*)),$$

constraint (9) implies that (14) is satisfied, constraint (10) implies (17) is satisfied, constraint (11) implies that (18) is satisfied. Since $\hat{T}_X \in \Omega^I$, the definitions of x^{**} and x^* imply that (15), (19), and (20) are satisfied. Thus, $(x_2, y_2, x_1, t_2, t_1)$ is a feasible solution to Program II. Suppose $(x_2, y_2, x_1, t_2, t_1)$ does not solve Program II. Then there exists $(x'_2, y'_2, x'_1, t'_2, t'_1)$ satisfying (14)–(20) such that the maximand in (13) is greater at $(x'_2, y'_2, x'_1, t'_2, t'_1)$ than at $(x_2, y_2, x_1, t_2, t_1)$. Consider contract T'_X defined by:

$$T'_X(x) \equiv \begin{cases} t'_2, & \text{if } x = x'_2 \\ t'_1, & \text{if } x = x'_1 \\ \infty, & \text{otherwise.} \end{cases}$$

Because $(x'_2, y'_2, x'_1, t'_2, t'_1)$ satisfies (14)–(20) it follows that $T'_X \in \Omega^I$ and that $(x^{**}(T'_X), y^{**}(T'_X)) = (x'_2, y'_2)$ and $x^*(T'_X) = x'_1$, and so T'_X satisfies (9)–(11). Thus, T'_X is a feasible contract in Program I and gives the buyer and seller X higher joint payoff than \hat{T}_X , a contradiction. Thus, \hat{T}_X solves Program II.

Now suppose \hat{T}_X is not an equilibrium contract. Then \hat{T}_X does not solve Program I. If $x^{**}(\hat{T}_X)$, $y^{**}(\hat{T}_X)$, or $x^*(\hat{T}_X)$ is not well defined, then there does not exist x_2, y_2 , or x_1 satisfying (15) when $(t_2, t_1) = (T_X(x^{**}), T_X(x^*))$. So suppose they are well defined. Because \hat{T}_X is not an equilibrium contract, the contract T''_X , where

$$T''_X(x) \equiv \begin{cases} \hat{T}_X(x^{**}(\hat{T}_X)), & \text{if } x = x^{**}(\hat{T}_X) \\ \hat{T}_X(x^*(\hat{T}_X)), & \text{if } x = x^*(\hat{T}_X) \\ \infty, & \text{otherwise,} \end{cases}$$

is also not an equilibrium contract. Since $\hat{T}_X \in \Omega^I$, it follows that $T''_X \in \Omega^I$, and so if T''_X is not a feasible solution to Program I, then at least one of (9)–(11) is violated. Consider $(x_2, y_2, x_1, t_2, t_1) \equiv (x^{**}(\hat{T}_X), y^{**}(\hat{T}_X), x^*(\hat{T}_X), \hat{T}_X(x^{**}), \hat{T}_X(x^*))$. If T''_X violates (9), then $(x_2, y_2, x_1, t_2, t_1)$ violates (14). If T''_X violates (10), then $(x_2, y_2, x_1, t_2, t_1)$ violates (17). If T''_X violates (11), then $(x_2, y_2, x_1, t_2, t_1)$ violates at least one of (14)–(20). If T''_X is a feasible solution to Program I, then there exists

$T_X''' \in \Omega^I$ also feasible but giving a higher value of the maximand. Then $(x_2, y_2, x_1, t_2, t_1)$ and

$$(x_2''', y_2''', x_1''', t_2''', t_1''') \equiv (x^{**}(T_X'''), y^{**}(T_X'''), x^*(T_X'''), T_X'''(x^{**}), T_X'''(x^*))$$

both satisfy the constraints of Program II, but $(x_2''', y_2''', x_1''', t_2''', t_1''')$ results in a higher value of the maximand in (13) than $(x_2, y_2, x_1, t_2, t_1)$. Thus, $(x^{**}(\hat{T}_X), y^{**}(\hat{T}_X), x^*(\hat{T}_X), \hat{T}_X(x^{**}), \hat{T}_X(x^*))$ does not solve Program II. Q.E.D.

Proof of Proposition 3. Assume $\lambda_Y < 1$. Using Lemma 3, we consider $(x_2, y_2, x_1, t_2, t_1)$ solving (13) subject to (14)–(20), which we refer to as Program II. As in the proof of Proposition 2, (16) and (17) imply (A4) and (A5). Using (A4) and (A5) to substitute in for t_2 and $\tilde{\pi}_Y$, Program II can be rewritten as (A6) subject to (A7)–(A9), (18),

$$\lambda_X \lambda_Y (R(x_1, 0) - t_1) \leq (1 - \lambda_X) \Pi(x_2, y_2) + \lambda_X (1 - \lambda_Y) \Pi_Y - (1 - \lambda_X \lambda_Y) \left(\max_{y \geq 0} R(x_1, y) - t_1 - c_Y(y) \right),$$

and

$$R(x_1, 0) - t_1 \geq (1 - \lambda_X \lambda_Y) \Pi(x_2, 0) - \lambda_X ((1 - \lambda_Y) \Pi(x_2, y_2) - (1 - \lambda_Y) \Pi_Y). \quad (\text{A10})$$

A feasible solution exists with $(x_2, y_2) \in Q_{XY}$, and choosing $(x_2, y_2) \in Q_{XY}$ maximizes the first term in (A6) and maximally relaxes all the constraints except (A10). One can easily confirm that (A10) does not bind because it specifies a lower bound for $R(x_1, 0) - t_1$ and the objective function requires that (x_1, t_1) be chosen to maximize $R(x_1, 0) - t_1$. This completes the proof that all equilibria are efficient when $\lambda_Y < 1$. If $\lambda_Y = 1$, then the joint payoff of the buyer and seller X does not depend on (x_2, y_2) , so there exists an equilibrium in which $(x_2, y_2) \in Q_{XY}$. Q.E.D.

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