The Competitive Implications of Top-of-the-Market and Related Contract-Pricing Clauses

Tian Xia and Richard J. Sexton

This article examines the competitive implications of contract pricing arrangements, which link the contract price to the subsequent cash price. We focus on so-called "top-of-the-market pricing" (TOMP) in cattle procurement. The TOMP clause is shown to have anticompetitive consequences when the same buyers who purchase contract cattle with the TOMP clause also compete to procure cattle in the subsequent spot market. The TOMP clause reduces packers' incentives to compete aggressively in the spot market. Although TOMP pricing is not in producers' collective interest, rational sellers may nonetheless sign these contracts with little or no financial inducement.

Key words: captive supply, cattle, contract, oligopsony, vertical coordination, top-of-the-market.

Vertical coordination between producers and processor/marketers through various types of contracting is an important dimension of modern agriculture (e.g., Tweeten and Flora; Galizzi and Venturini). In many industries, both contract and cash markets co-exist in the sense that some of the market output is procured through contracts, while some is procured through conventional spot exchange.[1] One reason to favor contract marketing is that the contract enables the buyer and seller to specify various attributes of the product to be exchanged and to specify price premiums and discounts associated with those attributes. However, because contracts are normally not settled in an open-market environment, establishing price(s) for contract sales is a pressing issue. Various mechanisms are in practice, including establishing a base price through cooperative bargaining or from a related open-market exchange such as a futures market. When contract production is marketed contemporaneously with production sold through a spot market, a convenient alternative is to specify the contract base price in terms of the yet-to-be-determined cash price (Purcell; Ward, Feuz, and Schroeder; Tweeten and Flora).

In this article, we examine the competitive implications of such pricing arrangements, focusing in particular on so-called "top-of-the-market pricing" (TOMP), used as a tool to establish price in cattle contracts and discussed first by Davis. We show that TOMP contracts are likely to have anticompetitive consequences when the same buyers who purchase contract cattle with the TOMP clause also compete to procure cattle in the subsequent spot market. The intuition behind this conclusion is straightforward—by having committed to purchase cattle at a spot price to be determined later, packers increase their marginal costs of acquisition in the spot market and, thus, attenuate their incentive to compete aggressively in the spot market. Although the TOMP contracts are not in producers' collective interest, we show that, nonetheless, rational sellers may sign TOMP contracts, in some cases with little or no financial inducement, due to externalities and/or coordination problems among themselves.

Although we focus on TOMP contracts in the context of the U.S. cattle industry, the analysis applies broadly to any setting where marketed product in a given period is transacted both through exclusive contracts and a spot market, and contract price terms are tied to the

Tian Xia is Ph.D. candidate and Richard J. Sexton is professor, Department of Agricultural and Resource Economics, University of California–Davis. Sexton is also a member of the Giannini Foundation of Agricultural Economics.

The authors wish to acknowledge helpful comments from Giacomo Bonanno, Michael Caputo, John Crespi, Rachael Goodhue, Rob Innes, Vincent Requillart, Mingxia Zhang, two referees, and seminar participants at the University of Arizona, the University of California, Berkeley, and the fifth INRA and IDEI conference on Industrial Organization and the Food Processing Industry in Toulouse, France. All remaining errors are ours.

[1] A partial list of such industries includes cattle, hogs, wine grapes, corn, and various fresh produce commodities.

Amer. J. Agr. Econ. 86(1) (February 2004): 124–138

subsequent cash price. For example, formula-priced contracts based on cash-market prices are the most common method of hog procurement in the United State, with 32.3% of sales in 1999 (Ward et al.). Similar contract pricing arrangements are in place in other countries as well—for example, Declerck, Fourcadet, and Faucher report that price arrangements for forward-contract cattle in France are based upon the spot-market price.

Cattle Markets and Captive Supplies

Beef packing has become one of the most concentrated industries in the United States (Ward). From 1976 to 1999, the four-firm concentration ratio of U.S. steer and heifer slaughter increased from 25% to 82% (USDA 2002a; Ward). Coincidental with this rise in horizontal concentration, the beef-packing industry has experienced greater vertical coordination between the production and processing sectors. Packers have increasingly used noncash methods to procure cattle, including forward contracts, marketing agreements, and packer-owned cattle. Cattle procured through these "captive supply" methods accounted for 32.3% of total slaughter of the four largest packers in 1999 (USDA 2002b). Forward contracts include fixed-price contracts and basis contracts, which are pegged to a futures market price. Marketing agreements set up an exclusive purchasing and selling relationship between a packer and a producer, usually based upon a pricing formula that establishes a base price for the cattle in reference to either a plant-average price paid by the packer, a market-area price (based usually on government reports), a wholesale price for boxed beef, or a futures market price (Ward, Schroeder, and Feuz). Marketing agreements also often feature a pricing "grid," specifying a set of premiums and discounts from the base price for key dimensions of cattle quality (Ward, Feuz, and Schroeder).[2]

Concerns about the effect of captive supply arrangements on cattle prices have been widespread, culminating in legislation proposed as part of the 2002 U.S. Farm Bill to ban most packer ownership of cattle.[3] Although the empirical evidence on balance suggests a modest inverse relationship between captive supplies and cash market prices, establishing a causal link has been elusive.[4] As Ward, Koontz, and Schroeder noted, by removing a share of cattle from the cash market, captive supplies have the effect of reducing both demand and supply to the cash market. In a competitive market model, the effect on price from these shifts is ambiguous and depends upon the functional forms of demand and supply. However, the competitive markets assumption may not be appropriate for cattle markets in light of rapid increases in seller concentration.[5]

A few studies have analyzed captive supplies in cattle markets using models of imperfect competition. Love and Burton showed that a dominant beef-packing firm has an incentive to use upstream integration to reduce efficiency losses resulting from its monopsony behavior. However, the effect on the cash price from such integration is ambiguous. Azzam developed an equilibrium displacement model of cattle procurement and also found the price effect of captive supplies to be ambiguous. Zhang and Sexton (2000) constructed a spatial model to show that, in certain situations, packers can use exclusive contracts to create geographic buffers, which can reduce competition in the cash market and result in a lower cash price.

Our analysis of contracts with a TOMP clause provides a concrete example of how contracts can be used to affect price in the cash market. The TOMP contract does not have a fixed price. Instead, it specifies that the producer will deliver all of his cattle to the packer, who will pay the producer the highest cash price in the market at the time of delivery. Davis argued that TOMP contracts may have an anticompetitive effect because they resemble both a contemporary most-favored-customer (MFC) clause and a best-price clause. In a more general context, Schroeter and Azzam and also Purcell have expressed concerns about the "typical formula price contract [which] attaches the final price to some observable cash price series or to a price being

[2] Typical grids feature premiums for prime-choice cattle and high yield grades and discounts for select-standard grades, light or heavy carcasses, and low yield grades (Ward, Feuz, and Schroeder).

[3] This legislation passed in the U.S. Senate but was omitted from the Farm Bill that emerged ultimately from the House-Senate conference. See Hayenga for a retrospective look at this policy debate.

[4] Studies finding a negative relationship between captive supplies and fed cattle cash prices include Elam, Schroeder et al., and Schroeter and Azzam. Ward, Koontz, and Schroeder found that the percentage deliveries of forward-contracted and marketing-agreement fed cattle could reduce the cash price but total captive supplies had no significant adverse effects on cash price. Hayenga and O'Brien also found the effect of captive supplies on the cash price to be ambiguous.

[5] The conclusions from empirical research on the issue of processor market power in the U.S. beef sector are rather mixed, as surveys by Azzam and Anderson, and Ward demonstrate.

paid to others by the buyer" (Purcell, p. 18). None, however, have provided rigorous analyses to justify their concerns and to indicate the potential magnitude of the anticompetitive effect emanating from such contracts. Nor has anyone provided an explanation for producers' willingness to sign such contracts if their effect will be to reduce the future cash price and, hence, the price received under the formula contracts.

The TOMP clause is similar to MFC and meet-or-release (MOR) pricing clauses, but with some important differences. An MFC clause commits a seller to compensate customers for the difference between their purchase prices and the lowest price offered by the same seller during a specified period following their purchases (Cooper). An MOR clause requires the firm to match the lowest offer by all firms in a market area or release its customers from their contracts (Holt and Scheffman). Cooper demonstrated that, because MFC contracts penalize a firm's own future price cuts, they help the firms collude implicitly to achieve higher profits. Holt and Scheffman showed that the use of both MFC and MOR clauses makes firms' effective strategies similar to quantity-choosing strategies in Cournot competition, in contrast to the harsher competition that prevails in a price-setting (Bertrand) equilibrium. Schnitzer argued that an MOR clause is more powerful than an MFC clause as a tool to reduce competition. In the equilibrium to her finite-period, price-setting model, duopoly firms were able to achieve the monopoly price in all but the last period through the use of contracts with MOR clauses.

Our model with TOMP pricing is quite different from previous studies of MFC and MOR contracts. MFC and MOR contracts specify a fixed price, but offer the possibility that the price may later be adjusted in the consumer's favor. Presumably a rational, price-taking consumer could recognize, for example, that an MFC clause makes future price cuts by the seller less likely, but if the consumer does not intend to make a purchase in the future (as would be true for most consumer durables), this effect is an externality to the consumer's purchase decision. However, TOMP contracts do not have a base price, and a player's acceptance of a contract with a TOMP clause will, as we show, affect adversely the price he does receive or pay. This result raises the question of why rational agents would agree to sign these contracts and makes the acceptance of TOMP contracts a crucial issue to study.

Contract acceptance has not been an issue in the literature on MFC and MOR contracts, perhaps because these studies focus on consumer markets where it may be appropriate to depict passive buyers, whose behavior can be subsumed in a demand curve. However, in markets for the procurement of agricultural raw product inputs and cattle procurement markets in particular, it is important to consider rational agents on both sides of the market and to analyze producers' incentives to accept or reject any TOMP contracts they are offered.

The Basic Model Structure

Consider a duopsony market where two beef packers (A and B) procure cattle from N identical cattle producers. We adopt the convention of using female pronouns when referring to packers and male pronouns when referring to producers. Producers are assumed to be price takers in their production and sales decisions, so N is implicitly considered to be a "large" number, as would be true in the U.S. cattle sector and most agricultural industries. Each cattle producer has a short-run supply function, $q = f(w) = w$, where q is the quantity of cattle offered for sale by a producer, and w is the price the cattle producer receives. The industry supply function is $Q_s = Nq = Nw$.[6] This simple specification of supply facilitates exposition and enables us to obtain analytical solutions. The results are robust to more general specifications of the supply function, as we demonstrate in the Appendix.

Cattle are assumed to be homogeneous. As noted, quality differences are reflected in premiums and discounts relative to a base price. Our focus is on determination of the base price, so quality issues are unimportant in the context of this research. Each packer converts cattle, Q, into a finished product, G (e.g., boxed beef), according to a fixed-proportions production function, $G = \min\{Q/\lambda, h(\mathbf{Z})\}$, where $\mathbf{Z}$ is a vector of processing inputs, and λ is the conversion factor between cattle and boxed beef. Without losing further generality, we can set λ equal to 1 through choice of measurement units, and then $G = Q$.[7]

[6] Omission of an intercept term in the supply function follows Zhang and Sexton (2001) and implies that the price elasticity of supply is unitary for any positive quantities.

[7] See Sexton for a discussion of the fixed-proportions assumption in modeling agricultural markets.

We assume for simplicity that the market for processed output is perfectly competitive, and packers take output price, P, as given.[8] We also assume average and marginal costs associated with the processing inputs, $\mathbf{Z}$, are constant, C, per unit. Thus, packers receive gross profits $R = P - C$, for processing each unit of cattle. The net per-unit profits are $R - w$.

We consider two markets that evolve sequentially in time. First, producers and packers may transact cattle through a contract market, and, later, cattle not committed in the contract market will be offered for cash sale in a spot market. We take as given that producers and packers have various incentives, for example, related to quality assurance, to engage in contract production and do not model those incentives formally. At the time of the cash market, the producers with contracts deliver the cattle under contract to the designated packer. We assume quantity (Cournot–Nash) competition in both the contract and cash markets. Subscripts "1" and "2" are used to represent the contract market and cash market, respectively, and subscripts "s" and "d" to denote supply and demand, respectively.

The Market without TOMP Clauses

To provide a benchmark to evaluate the market equilibrium in the presence of TOMP contracts, we first study the case when contracts do not include the TOMP clause. The contract in the basic model is a fixed price and quantity contract, and it need not be an exclusive contract. The game evolves in two stages. In Stage I, each cattle producer decides whether to sell his cattle in the contract market or in the cash market.[9] Then Packers A and B compete by deciding the quantities of cattle to purchase in the contract market. In Stage II, each packer chooses how many cattle to buy in the cash market, and the producers who did not sell through the contract market sell their cattle in the cash market. The model is solved using backward induction.

Suppose at the time of Stage II that n_1 $(0 \leq n_1 \leq N)$ producers have elected to sell cattle in the contract market. Then $N - n_1$ producers remain to sell in the cash market. The cash-market cattle supply function is

$$Q_{2,s} = (N - n_1) f(w_2) = (N - n_1) w_2.$$

The cash-market demand is $Q_{2,d} = Q_2^{\mathrm{A}} + Q_2^{\mathrm{B}}$. The market clears when $Q_{2,s} = Q_{2,d}$, from which we obtain $w_2 = (Q_2^{\mathrm{A}} + Q_2^{\mathrm{B}})/(N - n_1)$.

Packer j's profit function in the cash market is $\pi_2^j = (R - w_2)Q_2^j$, $j = \mathrm{A}, \mathrm{B}$. Packer j chooses the quantity of cattle to purchase to maximize her profit. The first-order conditions can be solved to yield the following reaction functions:

$$(1) \qquad Q_2^{\mathrm{A}} = (N - n_1)R/2 - Q_2^{\mathrm{B}}/2$$

$$(2) \qquad Q_2^{\mathrm{B}} = (N - n_1)R/2 - Q_2^{\mathrm{A}}/2.$$

By solving equations (1) and (2) simultaneously and substituting the solutions for Q_2^{A} and Q_2^{B} back into the market-clearing condition, we find the equilibrium price and quantity in the cash market as follows: $w_2 = 2R/3$ and $Q_{2,s} = Q_{2,d} = 2R(N - n_1)/3$.

Turning now to Stage I, n_1 producers sell cattle in the contract market, so the total supply function in the contract market is $Q_{1,s} = n_1 f(w_1) = n_1 w_1$. The contract market demand is $Q_{1,d} = Q_1^{\mathrm{A}} + Q_1^{\mathrm{B}}$. The market clears when $Q_{1,s} = Q_{1,d}$, from which we obtain $w_1 = (Q_1^{\mathrm{A}} + Q_1^{\mathrm{B}})/n_1$. Packer j, chooses Q_1^j to maximize her profit, $\pi_1^j = (R - w_1)Q_1^j$, from the contract market. We obtain A's and B's reaction functions from the first-order conditions to their optimization problems, solve them simultaneously, and then substitute the results back into the market-clearing condition to find the equilibrium price and quantity in the contract market as follows: $w_1 = 2R/3$ and $Q_{1,s} = Q_{1,d} = 2Rn_1/3$.

The equilibrium price in the basic model, $2R/3$, is the same as the Cournot equilibrium price when there are two duopsony packers and only one market, either contract or cash. As the equilibrium prices in the two markets are equal, each producer is indifferent between selling through the contract market or the cash market. Therefore, the shares of cattle sold through the contract market and cash market are indeterminate. In equilibrium, each

[8] One justification for this assumption is to note that, relative to live cattle, processed boxed beef is easy to store and transport, so the relevant geographic market for the finished product is broader than markets for the acquisition of live cattle. This greater geographic scope will generally mean greater competition in the output market than in the market for procurement of the raw product (Rogers and Sexton).

[9] The assumption that producers elect to sell in either the contract or the cash market, but not both, is consistent with practice. For example, data for the Texas Panhandle region reveal that the 220 feedlots that regularly sold cattle to processors in the region during the period from February 1995 through May 1996, sold 90% or more of their cattle through only one market (cash or contract) in 14 of the 16 months. (See Crespi and Sexton, for discussion of this data set.)

producer sells $q = w_1 = w_2 = 2R/3$ cattle, and each packer purchases $Q^A = Q^B = RN/3$ cattle in total from the two markets.

The TOMP Model

Now consider the case when contracts are exclusive and have the TOMP clause. This model evolves in three stages. As the TOMP contracts are exclusive, both packers compete in Stage I in the numbers of producers, n_1^A and n_1^B, to whom they offer the TOMP contracts. Producers who are offered a TOMP contract must decide whether to accept or reject it. In Stage II, but still at the same period of the contract market, each producer who has signed a TOMP contract independently decides how many cattle, q^c, to produce and deliver at the time of the cash market, where superscript "c" denotes quantity in the contract market. In Stage III, at the time of the cash market, each cattle producer with a contract delivers those cattle to his designated packer. Packers also compete in the quantities of cattle to purchase in the cash market, where all supply not previously committed by contracts is offered. Figure 1 illustrates the timing of the game.

The TOMP model is solved using backward induction, beginning with Stage III. Suppose $S = n_1^A + n_1^B$ producers signed the TOMP contract with a packer at the time of the contract market. At the time of the cash market, each producer with a contract delivers q^c cattle to his packer. The cash market supply function is

$$Q_{2,s} = (N - S) f(w_2) = (N - S) w_2.$$

The cash market demand is $Q_{2,d} = Q_2^A + Q_2^B$. The market clears when $Q_{2,s} = Q_{2,d}$, from which we obtain $w_2 = (Q_2^A + Q_2^B)/(N - S)$. Each packer must decide how many cattle to buy through the cash market in order to maximize her total profit over both the contract

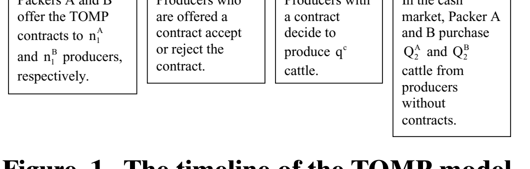

Figure 1. The timeline of the TOMP model

and the cash market. Packer j chooses Q_2^j to maximize

$$\begin{aligned}\pi^j &= \pi_1^j + \pi_2^j \\ &= (R - w_2) q^c n_1^j + (R - w_2) Q_2^j, \\ &\qquad j = \text{A}, \text{B}\end{aligned}$$

where w_2 is the price for both markets due to the TOMP contracts. From the first-order conditions we obtain the following reaction functions:

$$(3) \qquad Q_2^A = (N - S)R/2 - Q_2^B/2 - n_1^A q^c/2.$$

$$(4) \qquad Q_2^B = (N - S)R/2 - Q_2^A/2 - n_1^B q^c/2.$$

Equations (3) and (4) are solved simultaneously, and the results are substituted into the market-clearing condition to obtain the equilibrium quantities and price in the cash market:

$$(3') \quad Q_2^A = (N - S)R/3 + n_1^B q^c/3 - 2n_1^A q^c/3$$

$$(4') \quad Q_2^B = (N - S)R/3 + n_1^A q^c/3 - 2n_1^B q^c/3$$

$$(5) \qquad w_2 = 2R/3 - [Sq^c/3(N - S)].$$

Turning now to Stage II, each producer who has signed a TOMP contract chooses an output level to produce. Individual producers make production decisions as price takers, so the producer with a contract decides his supply based upon the expected cash market price, given the TOMP clause in the contract. Thus, we have

$$(6) \qquad q^c = f(w_2) = w_2.$$

Substitute (5) into (6) and solve for q^c to obtain

$$(6') \qquad q^c(S) = 2(N - S)R/(3N - 2S).$$

Similarly,

$$(5') \qquad w_2(S) = q^c = 2(N - S)R/(3N - 2S).$$

In Stage I, each packer seeks to maximize her total profit from the two markets by choosing an optimal number of producers to offer the TOMP contracts, given the expected cash market price and the expected quantity each producer with a contract will produce. Packer A chooses n_1^A to maximize $\pi^A = (R - w_2)(q^c n_1^A + Q_2^A)$, given q^c, w_2, and Q_2^A as specified in equations (6′), (5′), and (3′), respectively, and also given n_1^B. Making these substitutions into A's total profit function and maximizing it with respect to choice of n_1^A, we obtain the following condition:

$$(7)\quad \partial\pi^A/\partial n_1^A \begin{cases} >0 & \text{if } 0 \le S = n_1^A + n_1^B < N/2 \\ \to =0 & \text{if } S = n_1^A + n_1^B = N/2 \\ <0 & \text{if } N/2 < S = n_1^A + n_1^B \le N. \end{cases}$$

Similarly, the value of $\partial\pi^B/\partial n_1^B$ for Packer B is

$$(8)\quad \partial\pi^B/\partial n_1^B \begin{cases} >0 & \text{if } 0 \le S = n_1^A + n_1^B < N/2 \\ \to =0 & \text{if } S = n_1^A + n_1^B = N/2 \\ <0 & \text{if } N/2 < S = n_1^A + n_1^B \le N. \end{cases}$$

Equations (7) and (8) show that both A's and B's total profits are first increasing and then decreasing in the total number of contracts offered and reach their maximum when $S = n_1^A + n_1^B = N/2$.[10]

Thus, each packer's total profit from the game is maximized if $N/2$ producers agree to sign TOMP contracts. However, $N/2$ producers may not agree to sign the contracts, and we assume that a packer will not offer a contract if she believes the contract will not be signed. In other words, if packers are capable of convincing only $n_1 < N/2$ producers to sign contracts, we assume that they will collectively offer the contracts to at most n_1 producers at the equilibrium.[11]

Each individual producer knows that his signing of the TOMP contract will reduce the future cash market price, which in turn will decrease his own profit. Why then would producers rationally sign the TOMP contracts? Rasmusen, Ramseyer, and Wiley (RRW 1991; RRW 2000) and Segal and Whinston (SW) have discussed a similar question in the context of consumers who sign exclusive contracts with a monopoly seller. These contracts have the effect of deterring entry and, hence, consigning the consumers to future monopoly pricing. They study a market with a minimum efficient scale of production, so that a monopolist can deter potential entry by convincing enough customers to sign exclusive contracts in the period prior to when entry could occur. They show that, by exploiting externalities and/or a lack of coordination among consumers, a monopolist may, at little cost to itself, be able to entice consumers to sign exclusive contracts. As RRW and SW demonstrate, players' decisions to accept or reject contracts they are offered hinge importantly upon the structure of the game, in particular whether contracts are offered and decisions are made sequentially or simultaneously.

We apply a similar logic to analyze cattle producers' decisions regarding acceptance of TOMP contracts, whether they are offered sequentially or simultaneously. However, in this model, each packer's profit increases for each producer who signs a TOMP contract, up to $N/2$ producers. In contrast, the monopoly in the studies of RRW and SW benefits from signing customers to exclusive contracts only if it can achieve the ultimate goal of convincing enough customers to sign contracts so that entry is deterred.

Sequential Offer of the TOMP Contracts

Sequential offers could take various forms. We follow the general structure set forth by RRW (1991, p. 1141). Packers offer the TOMP contracts to producers sequentially. Each producer who is offered a contract publicly makes a permanent decision on whether to sign the contract or not. Packers can discriminate among producers both in the sense of differentiating bonus payments for signing and in offering contracts to some producers but not others. When making his own decision, each producer knows the decisions of all producers who preceded him in the sequence.

We assign producers index numbers $i = 1, \ldots, N$ to coincide with the sequential order in which each is considered for a TOMP contract, recognizing that for some i no contract will be offered. Each producer i who is offered a contract faces the decision s_i to sign $(s_i = 1)$ or not sign $(s_i = 0)$. We assume that if a producer is indifferent between signing or not signing a contract, he will sign. Define $S^t = \sum_{i=1}^{t-1} s_i$ as the number of producers who have signed prior to

---

[10] The results presented here focus on the case when N is an even integer. When N is odd, packers are constrained somewhat from implementing their preferred equilibrium because it is not possible to secure $N/2$ contracts. The results when N is odd are provided in Xia and Sexton. The impact on price of odd versus even N diminishes as N increases, as figure 3 illustrates.

[11] This assumption enables us to establish a unique equilibrium in terms of packer behavior. It can be motivated by appeal to (unmodeled) costs associated with offering contracts. In the absence of this assumption, multiple equilibria would exist for values of $n_1^A + n_1^B$ that cause $n_1 < N/2$ contracts to be signed, based upon producers' rational accept/reject decisions. Any integer offer of contracts, $\hat{n}^A + \hat{n}^B = \hat{n}$, where $n_1 < \hat{n} \le N/2$, is an equilibrium strategy for packers, but price, output, and welfare are identical for these equilibria because results depend only on the number of contracts signed, not the number offered.

the t^{th} producer ($2 \le t \le N$) who is offered a contract, and set $S^1 = 0$. S^t summarizes all relevant information for a player regarding moves in the game preceding his own. From the preceding results, the incremental loss in producer surplus (PS) to each producer from the tth producer signing a TOMP contract, given S^t, is

$$\begin{aligned}\Delta PS(S^t) &= PS(S^t) - PS(S^t+1)\\ &= \tfrac{1}{2}w_2(S^t)q(S^t)\\ &\quad - \tfrac{1}{2}w_2(S^t+1)q(S^t+1).\end{aligned}$$

Substituting from (5′) and (6′) for w_2 and q, respectively, obtains

$$\begin{aligned}(9)\quad \Delta PS(S^t) &= \tfrac{1}{2}((2N-2S^t)R/(3N-2S^t))^2\\ &\quad - \tfrac{1}{2}((2N-2(S^t+1)R)\\ &\quad /(3N-2(S^t+1))^2\\ &= 2NR^2(6N^2-10NS^t-5N\\ &\quad +4(S^t)^2+4S^t)/((3N-2S^t)^2\\ &\quad \times(3N-2S^t-2)^2).\end{aligned}$$

The loss in producer's surplus, ΔPS, is increasing in S^t.

On the other hand, the signing of an additional contract by the tth producer, given S^t, yields the following incremental profit to each packer:

$$\begin{aligned}\Delta\pi(S^t) &= \pi(S^t+1) - \pi(S^t)\\ &= (R-(2N-2S^t-2)R\\ &\quad /(3N-2S^t-2))(N(N-S^t-1)R\\ &\quad /(3N-2S^t-2))\\ &\quad -(R-(2N-2S^t)R\\ &\quad /(3N-2S^t))(N(N-S^t)R\\ &\quad /(3N-2S^t))\\ &= R^2N^2\big(3N^2-8NS^t-4N\\ &\quad +4(S^t)^2+4S^t\big)/\big((3N-2S^t)^2\\ &\quad \times(3N-2S^t-2)^2\big).\end{aligned}$$

$\Delta\pi(S^t)$ is positive when $0 \le S^t \le (N/2)-1$, and is decreasing in S^t.

Define $D(S^t) = \Delta\pi(S^t) - \Delta PS(S^t)$. $D(S^t)$ is decreasing in S^t and is illustrated in figure 2 for alternative N. If $D(S^t) > 0$, each packer has incentive to offer a large enough signing bonus to reimburse the tth producer's loss from signing, given the number, S^t, of producers that have signed before him, and thereby insure the signing of the contract. If $N \ge 8$, it is straightforward to show that $D > 0$ for $0 \le S^t \le (N/2)-2$ and $D < 0$ for $S^t \ge (N/2)-1$. Thus, if the total number of producers is sufficiently large, namely eight or more, duopsony packers have incentive to jointly convince $[(N/2)-2]+1 = (N/2)-1$ producers to sign the contracts.

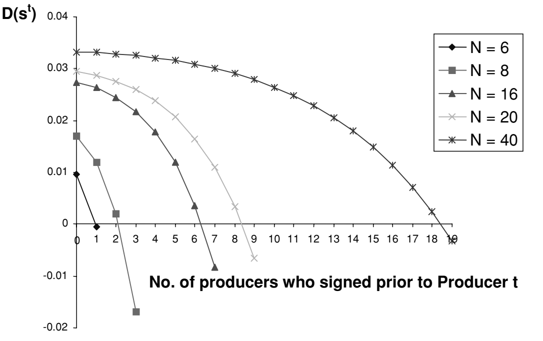

Figure 2. The difference (D) between $\Delta\pi(S^t)$ and $\Delta PS(S^t)$ (unit: R^2)

Assume $N \ge 8$, and consider then the decision of producer $(N/2) - 1$ who has been offered a TOMP contract. Regardless of the decisions preceding him, as summarized by $S^{(N/2)-1}$, this producer knows that $(N/2) + 1$ producers have not yet been offered contracts and that each packer unilaterally has an incentive to offer signing bonuses sufficient to compensate enough of those producers for the loss in producer surplus each can associate with his signing to achieve the ultimate objective of securing $(N/2) - 1$ TOMP contracts. Therefore, regardless of the number, $S^{(N/2)-1}$, of producers who have signed preceding him, producer $(N/2) - 1$ in the sequence of offers knows that his action will have no effect on packers eliciting $(N/2) - 1$ contract acceptances and, thus, ultimately enforcing price $w(S^{(N/2)-1})$ in both the contract and the cash markets. This producer's surplus from cattle sales will be unaffected by whether he sells through the contract or cash markets, and, thus, he will sign the TOMP contract for any nonnegative signing bonus.

A similar logic applies to all producers preceding producer $(N/2) - 1$ in the sequence of TOMP contract offers. Regardless of the number, S^t, of contracts signed by producers preceding him in the sequence, each producer t knows that packers will be able to elicit

$(N/2) - 1$ signatures. Thus, rejection of the contract gains the player nothing, and each will sign for any nonnegative signing bonus.

Packers can infer this behavior by producers, and, thus, they can, when $N \geq 8$, collectively offer TOMP contracts with zero signing bonuses to $(N/2)-1$ producers.[12] By substituting $n_1^A + n_1^B = (N/2) - 1$ in (5′) for S, we obtain the equilibrium price, $w_2 = w_1 = (R/2) + R/(2N+2)$. The results are summarized in the following proposition:

PROPOSITION 1. *When the TOMP contracts are offered sequentially and the total number of cattle producers, N, is a sufficiently large* $(N \geq 8)$ *even integer, all pure-strategy, subgame-perfect Nash equilibria (SPNE) are characterized by packers collectively offering the contracts with a zero bonus to* $(N/2) - 1$ *producers, and all producers who are offered the contracts signing them. The equilibrium cash price is* $(R/2) + R/(2N+2)$, *which approaches the monopsony price,* $w^m = R/2$, *as N becomes large.*

Because the contracts are offered with zero signing bonus, and the contract and cash price are identical, packers are indifferent as to which of them offers the contracts, so long as the total number offered is $(N/2)-1$. Thus, all combinations of integers n_1^A and n_1^B, such that $n_1^A + n_1^B = (N/2) - 1$, constitute Nash equilibria in Stage I.

The results when N is odd and when $N < 8$ are provided in Xia and Sexton. When N is odd, the packers are unable to offer contracts to $(N/2) - 1$ producers because this number is not an integer. Instead, the packers will offer contracts to $[(N-1)/2]-1$ producers (the largest integer less than $(N/2) - 1$) to maximize their profits. The equilibrium cash price still converges to the monopsony price as N becomes large.

Regarding cases where $N < 8$, recall that we have assumed producers are price takers in making their output decisions. This assumption is most appropriate for large N. When N is small, the market has a bilateral oligopoly structure, and producers may not act as price takers, in which case equilibrium outcomes will depend on the relative bargaining power of packers and producers. Xia and Sexton characterize the market equilibria for cases where $N < 8$, given price-taking behavior by producers, but those results should be interpreted cautiously for the reason noted. Figure 3 summarizes the relationship between the equilibrium cash price and the number of cattle producers for the case of sequential contract offers, given producer price-taking behavior.[13]

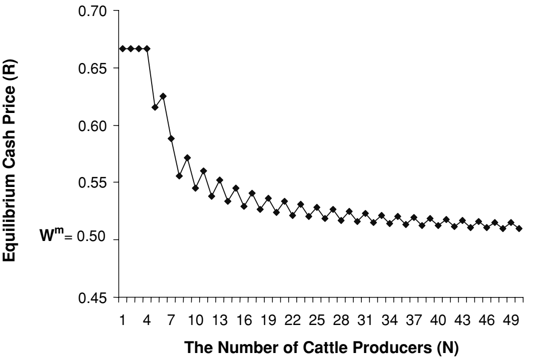

Figure 3. The equilibrium cash price when the contracts are offered sequentially

Simultaneous Offer of the TOMP Contracts

The simultaneous offer of the TOMP contracts means that both packers offer the TOMP contracts to some cattle producers simultaneously and each producer decides whether to accept or reject the contract independently and simultaneously without knowing other producers' decisions. After producers make their decisions, packers cannot revise their offers to those who rejected the contracts or offer additional contracts to producers who had not previously received an offer; otherwise the situation reverts to the case of sequential offers. This structure of play works to the packers' detriment because, unlike the sequential offer case, the prospect of offering additional contracts cannot be used as a threat to reduce the signing bonus each producer can demand.

Suppose packers offer the TOMP contracts to $S = n_1^A + n_1^B$ producers. Each producer who is offered a contract knows that his signing will reduce his surplus. The specific loss that each producer associates with his own signing depends upon the number of producers that he anticipates will sign. Suppose a producer refuses to sign and anticipates that S^o producers will sign. Under the structure of this game, packers will not be able to make additional offers to elicit more than S^o contract signings.

[12] Recall that producers who are indifferent between signing and not signing a contract are assumed to sign it. This assumption is standard (e.g., it is made by RRW and SW) and has no meaningful effect on results; it merely enables us to dispense with the $\varepsilon > 0$ payment to producers that would be required in its absence.

[13] The "sawtooth" pattern for the $R(N)$ function in figure 3 is due to packers being constrained somewhat from implementing their preferred equilibrium when N is an odd integer. See footnote 10 and Xia and Sexton for more details.

This producer will sign the contract only if a packer provides a signing bonus equal to or greater than the loss in surplus the producer can associate with his signing. Each packer, in turn, can infer that she must offer a sufficient signing bonus to insure a producer's signing of the contract.

In stage I, each packer decides how many contracts to offer and how much signing bonus to offer with each contract. These decisions are related, as described in the following lemma.

LEMMA 1. *When the TOMP contracts are offered simultaneously, for any possible pure-strategy SPNE, there is a fixed relation between the number of contracts that a packer can convince producers to sign and the signing bonus,* X, *offered with each contract. For Packer* A, *the relation is* $X^{\mathrm{A}} = \Delta PS(S^o)$, *where* $S^o = n_1^{\mathrm{A}} + n_1^{\mathrm{B}} - 1$, *and* n_1^{A} *is the number of contracts Packer* A *offers, given* n_1^{B}. *Similarly, for Packer* B, *the relation is* $X^{\mathrm{B}} = \Delta PS(S^o)$, *where* n_1^{B} *is the number of contracts Packer* B *offers, given* n_1^{A}, *and* $\Delta PS(\cdot)$ *is defined in* (9).

Proof: Suppose there is an SPNE equilibrium where $X^{\mathrm{A}} < \Delta PS(S^o)$. Then each of the n_1^{A} producers who sign the contracts with Packer A under the proposed equilibrium has an incentive to deviate from his proposed equilibrium strategy because each of them can gain $\Delta PS(S^o) - X^{\mathrm{A}} > 0$ by refusing to sign the contract. Thus, no SPNE equilibrium can include bonus payments $X^{\mathrm{A}} < \Delta PS(S^o)$. On the other hand, suppose there is an SPNE equilibrium when $X^{\mathrm{A}} > \Delta PS(S^o)$. Then Packer A has an incentive to reduce the signing bonus to $\Delta PS(S^o)$ without eliciting contract rejections, because no producer can unilaterally anticipate gaining more than $\Delta PS(S^o)$ by rejecting his contract offer. Thus, no SPNE equilibrium can include bonus payments $X^{\mathrm{A}} > \Delta PS(S^o)$. The same logic applies to Packer B. Thus, only when $X^j = \Delta PS(S^o)$, does none of the producers who signed the contracts have an incentive to change his decision given other players' decisions. Also, given n_1^{A} and n_1^{B}, no packer has an incentive to increase or reduce her signing bonus from the amount $\Delta PS(S^o)$, given the producers' decision rule. Therefore, only the offers $X^{\mathrm{A}} = X^{\mathrm{B}} = \Delta PS(S^o)$ are consistent with any SPNE equilibrium.[14] ■

[14] Based upon Lemma 1, the contracts that emerge in equilibrium are nondiscriminatory (among the subset of producers who receive contract offers).

Given the signing bonus $X^{\mathrm{A}} = \Delta PS(S^o) > 0$ needed to convince producers to sign the contract, packer A's total profit function in the simultaneous offer game becomes

$$\begin{aligned}\pi^{\mathrm{A}} &= (R - w_2)\big(q^c n_1^{\mathrm{A}} + Q_2^{\mathrm{A}}\big) - n_1^{\mathrm{A}} X^{\mathrm{A}} \\ &= (R - w_2)\big(q^c n_1^{\mathrm{A}} + Q_2^{\mathrm{A}}\big) \\ &\quad - n_1^{\mathrm{A}} \Delta PS\big(n_1^{\mathrm{A}} + n_1^{\mathrm{B}} - 1\big).\end{aligned}$$

Given n_1^{B}, Packer A chooses n_1^{A} and, consequently, $X^{\mathrm{A}}(n_1^{\mathrm{A}})$ to maximize her total profit. When $N \geq 10$, the following condition holds:

$$(10)\quad \partial\pi^{\mathrm{A}}/\partial n_1^{\mathrm{A}} \to \begin{cases} >0 & \text{if } 0 \leq n_1^{\mathrm{A}} + n_1^{\mathrm{B}} \leq (N/2) - 2 \\ <0 & \text{if } (N/2) - 1 \leq n_1^{\mathrm{A}} + n_1^{\mathrm{B}} \leq N. \end{cases}$$

The analogous condition for Packer B is

$$(11)\quad \partial\pi^{\mathrm{B}}/\partial n_1^{\mathrm{B}} \to \begin{cases} >0 & \text{if } 0 \leq n_1^{\mathrm{A}} + n_1^{\mathrm{B}} \leq (N/2) - 2 \\ <0 & \text{if } (N/2) - 1 \leq n_1^{\mathrm{A}} + n_1^{\mathrm{B}} \leq N. \end{cases}$$

Equations (10) and (11) show that the packers must collectively choose either $(N/2) - 2$ or $(N/2) - 1$ producers to offer the contracts. Direct calculation reveals that offering $(N/2) - 1$ contracts generates higher packer profits, thereby yielding the following proposition:

PROPOSITION 2. *When the TOMP contracts are offered simultaneously and N is sufficiently large even integer* $(N \geq 10)$, *all pure-strategy, SPNE are characterized by packers collectively offering the contracts with the positive bonus,* $X^{\mathrm{A}} = X^{\mathrm{B}} = \Delta PS((N/2) - 1 - 1) = (2N^3 + 9N^2 + 8N)R^2/(8(N+2)^2(N+1)^2)$, *to* $(N/2) - 1$ *producers, and all producers who are offered the contracts signing them. The equilibrium cash price is* $w_1 = w_2 = (R/2) + R/(2N + 2)$ *and approaches the monopsony level,* $w^m = R/2$, *as N becomes large.*

Xia and Sexton discuss results when $N < 10$ and when N is odd. The intuition for these results is very similar to the intuition for results when $N < 8$ and when N is odd in the case of sequential offers. Figure 4 summarizes the relationship between the equilibrium cash price and the number of cattle producers for the game with simultaneous offers.

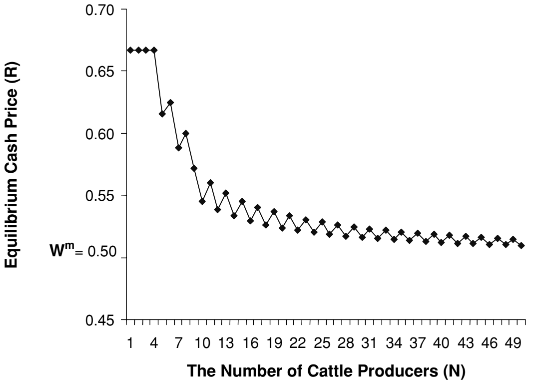

Figure 4. The equilibrium cash price with simultaneous contract offers

Perfectly Coalition-Proof Nash Equilibria

Subgame perfect Nash equilibrium is the widely accepted solution concept for dynamic games with symmetric information, such as those discussed here. However, it is worth considering briefly a refinement of SPNE that may have particular relevance in agricultural contexts. Bernheim, Peleg, and Whinston (BPW) introduced the concept of perfectly coalition-proof Nash equilibria (PCPNE) to apply in settings where decision makers can freely discuss their strategies but cannot make binding agreements.

Although agricultural producers' inability to coordinate for their mutual betterment is well known, the United States and many other countries have laws that allow and facilitate coordination among agricultural producers.[15] Thus, it is worth asking whether the TOMP contracts summarized in Propositions 1 and 2, in addition to representing SPNE, also meet the generally more stringent requirements of PCPNE. PCPNE are SPNE that are efficient within the class and which meet the additional test that they are immune to perfectly self-enforcing deviations by any coalition of players. A deviation is perfectly self-enforcing if it is immune to deviations by subcoalitions formed among the deviating players.

Although the formal definition of PCPNE is rather complex (see BPW for details), the main issue in our context is to ask whether, through nonbinding pre-play communication, a coalition of cattle producers might be able to prevent the TOMP contracts described in Propositions 1 and 2 from being implemented. We have two propositions to offer on this point.

PROPOSITION 3. *When the TOMP contracts are offered sequentially and the total number of cattle producers, N, is sufficiently large* ($N \geq 8$), *all pure-strategy SPNE are not perfectly coalition-proof. Moreover, there is no PCPNE for the game with sequential contract offers.*

Proof: All producers who are offered a contract sign it with zero bonus in any SPNE to this game. These producers can form a coalition and deviate from any of these equilibria by agreeing to reject the TOMP contracts. Through this deviation, all of these producers are better off because they receive a higher cash price, $w(0)$, that is, the Cournot price, rather than the TOMP price $w(S^{(N/2)-1})$. Furthermore, no subcoalition can benefit by deviating from this coalition. If a subcoalition deviates by signing the contract with zero bonus, any producer in this coalition is worse off because he will receive a cash price, $w(S) < w(0)$, given $S > 0$. Thus, the nonsigning coalition of all producers who are offered a contract is perfectly self-enforcing. Because this coalition can benefit all its members in a perfectly self-enforcing way, any SPNE in the game is not perfectly self-enforcing. Perfect self-enforcement is a necessary condition for a strategy vector to constitute a PCPNE. Thus, all SPNE for this game are not PCPNE because they are not perfectly self-enforcing. Finally, because a PCPNE is also an SPNE, the fact that none of the SPNE for the game are perfectly coalition-proof, implies that there is no perfectly coalition-proof Nash equilibrium for the game with sequential contract offers.[16] ■

PROPOSITION 4. *When the TOMP contracts are offered simultaneously and N is sufficiently large* ($N \geq 10$), *all pure-strategy, SPNE are perfectly coalition proof*.

The formal proof to Proposition 4 is quite lengthy because we must consider the incentives of all possible coalitions to deviate from

[15] The most prominent such law in the United States is the Capper-Volstead Act, which grants partial exemption from the U.S. antitrust laws to agricultural marketing cooperatives that meet certain requirements.

[16] In particular, the self-enforcing deviation of no producer signing a TOMP contract with zero signing bonus is not an SPNE because packers would have incentive to offer positive signing bonuses in response to producers' decision to not sign for zero bonuses. The practical implication of failure of PCPNE to exist is that market settings where producers can easily form coalitions may be characterized by contractual instability. Packers' incentives to implement these contracts are unabated. The uncertainty is regarding the bonus levels contained in the contract offers.

the SPNE, including coalitions involving one or more packers and producers both with and without TOMP contract offers. We relegate the full proof to our working paper (Xia and Sexton), and provide only a sketch of it here, focusing on the behavior of producers. Consider first coalitions involving only producers who sign the contracts in the SPNE. Such coalitions cannot deviate from the SPNE in a perfectly self-enforcing way. In the component game induced on producers by packers' strategy of offering $N/2 - 1$ contracts with the bonus, $X = \Delta PS((N/2) - 2)$, any producer who is offered a contract has two choices, sign or reject. Sign is the dominant strategy for each producer given any strategy choices of other producers because $\Delta PS((N/2) - 2)$ equals the highest producer surplus loss that his signing will impose on himself. Consider, for example, the coalition of all $(N/2) - 1$ producers who are offered contracts. These producers can increase their welfare relative to what they attain in the SPNE by each agreeing to reject his contract offer, that is, they can achieve $w(0)$, the Cournot equilibrium. However, because "sign" is the dominant strategy, any producer in the coalition has an incentive to further deviate from the "nonsigning" coalition and sign his contract. Thus, the coalition is not perfectly self-enforcing.

Adding producers who were not offered contracts to any potential producer coalition does not affect this conclusion. Producers who are not offered the contracts do not have a choice to sign or reject. That is, they have nothing to deviate from in terms of the contract strategies in Stage I. Their only choice is their production level in Stage III, which they decide based on the expected cash price. Any deviation from the optimal production choice based on $q = f(w_2) = w_2$ will reduce the surplus for a producer without a contract. Thus, no producers without contracts will join a coalition and deviate from the SPNE described in Proposition 2.[17]

Discussion of the TOMP Contracts

To better understand how contracts with the TOMP clause can depress the cash price, consider the quantity choices by packers in the cash market. Each finds her optimal quantity to purchase and sell where the marginal revenue from the last unit purchased and sold is equal to that unit's perceived marginal cost.[18] For the case when contracts do not include the TOMP clause (denoted by subscript NT), each packer chooses her cash market quantity to maximize profit from the cash market only, because there is no connection to the contract market. For example, for Packer A, marginal revenue (MR) net of per-unit processing and perceived marginal cost (MC) are, respectively:

$$(12) \quad MR_{NT}^{A} = \partial\left(RQ_2^{A}\right)/\partial Q_2^{A} = R$$

$$(13) \quad MC_{NT}^{A} = \partial\left(w_2 Q_2^{A}\right)/\partial Q_2^{A} = \left(2Q_2^{A} + Q_2^{B}\right)/\left(N - n_1^{A} - n_1^{B}\right).$$

On the other hand, if the contracts include the TOMP clause, each packer chooses her cash-market purchases to maximize her total profit from both the contract and cash markets, given that the two are now interconnected through the TOMP contracts. Net marginal revenue is the same as in (12) but the perceived marginal cost, MC_T^{A}, is higher because the cash price determines the price to be paid for cattle procured through the contract market:

$$(14) \quad MC_{T}^{A} = \partial\left\{w_2\left(Q_2^{A} + n_1^{A}q^{c}\right)\right\}/\partial Q_2^{A} = \left(2Q_2^{A} + Q_2^{B}\right)/\left(N - n_1^{A} - n_1^{B}\right) + n_1^{A}q^{c}/\left(N - n_1^{A} - n_1^{B}\right).$$

The TOMP clause increases the packer's perceived marginal cost of procuring cattle in the cash market and, thus, causes the packer to compete less aggressively in this market. Packer B's situation is analogous. Therefore, for any number of suppliers, $N - n_1^{A} - n_1^{B}$, in the cash market, the equilibrium price will be reduced due to the presence of the TOMP contracts. In both the cases of sequential and simultaneous offers, for sufficiently large N, the equilibrium cash price of the TOMP model approaches $R/2$, the monopsony price. Depending upon the timing of contract offers, those who are offered contracts may be able to recapture some of the surplus lost from TOMP

[17] A referee has noted correctly that, if allowed to do so by the structure of the game, producers who were not offered contracts would have an incentive to offer side payments or bribes to those with contract offers to induce those producers to reject their offers. Such a game is dramatically different from what we model. Nor do we tend to observe this type of payment in reality.

[18] We use the term "perceived marginal cost" because under Cournot competition, each packer takes her rival's action as given, that is, "perceives" that the rival's quantity is unaffected by a change in her own quantity. In equilibrium, perceived marginal cost and actual marginal cost are identical.

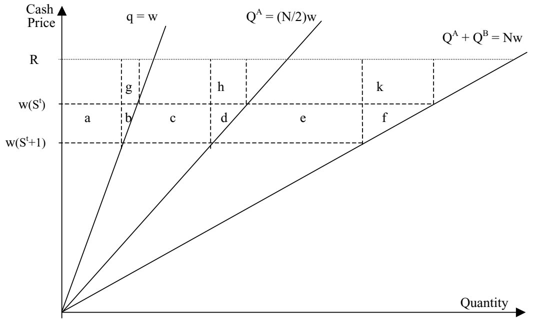

Figure 5. Welfare effects from imposition of TOMP contracts

contracts through signing bonuses. However, at least half of the producers are not offered a contract in equilibrium, and they bear the full brunt of the diminished market competition caused by TOMP contracts.

Figure 5 illustrates the benefits and costs of TOMP contracts from packers' and producers' perspectives. For large N, packers are able to elicit signing of TOMP contracts because each producer's signing, up to $N/2$ producers, depresses the future cash price and allows a packer to increase profit not only from the signing producer but also from all other producers who sell cattle to the packer. Although a packer's gain from any one producer (area $a - g$) is smaller than this producer's loss (area $a + b$) due to the deadweight loss (area $b + g$), a packer's gain from all $N/2$ of her suppliers (areas $a + b + c - h$) is greater than the loss of this single producer, when N is large. The losses in surplus to the other producers are an externality from the signing producer's perspective.

Finally, to gain a perspective on the relative importance of possible benefits and losses from imposition of a regime of TOMP contracts, consider the simulation results reported in table 1. In all cases R, the wholesale price net of per-unit processing costs is set to 1.0. Equilibria were derived for duopsony packers and alternative numbers of producers for the sequential-offer case (no signing bonuses) and the simultaneous-offer case. In both scenarios, packers' gain in profits from TOMP contracts is increasing in N, For $N \geq 20$, packers' profits increase with TOMP contracts by 10% or more under both the sequential-offer and simultaneous-offer cases relative to the base Cournot equilibrium.

Packers' gains are less than producer losses, due to the deadweight loss from reduced purchases and sales caused by the lower price—areas f and k in figure 5. Table 1 identifies the loss in producer surplus for both those who sign contracts and those who are not offered a contract. In the simultaneous-offer case, those with contracts lose less than those without them, but the bonus payments are rather inconsequential as N becomes large (because each producer can unilaterally command a bonus only equal to the marginal surplus loss caused by his signing). Producers' surplus loss is increasing in N because the contract and cash price is declining in N, and converges to the monopsony price as N becomes very large. For large N producer surplus losses can exceed 40% of the surplus attainable in the no-contract, duopsony equilibrium.

Conclusions

Agricultural economists have been active in documenting the increasing vertical coordination between producers and food marketers and in identifying the economic incentives for such coordination. Little attention, however, has been paid to the competitive implications of the various mechanisms used to implement vertical coordination. This article has focused

Table 1. Simulation Results

	Scenario	Increase in Packer Profits (%)	Reduction in Producer Surplus	
			Signers (%)	Nonsigners (%)
$N = 8$	Sequential offer	11.1	30.6	30.6
	Simultaneous offer	6.8	19.0	30.6
$N = 16$	Sequential offer	12.1	36.9	36.9
	Simultaneous offer	9.3	30.6	36.9
$N = 20$	Sequential offer	12.2	38.3	38.3
	Simultaneous offer	9.9	33.1	38.3
$N = 40$	Sequential offer	12.4	41.0	41.0
	Simultaneous offer	11.2	38.3	41.0

on market settings when contracts and spot exchanges coexist. The common practice of linking contract payments to the subsequent cash price was shown to have anticompetitive implications in concentrated markets when these contracts are exclusive and the same set of buyers operates in both the contract and the cash market.

Although we focused on a particular type of contract, the so-called top-of-the-market-pricing (TOMP) contract, and a parsimonious analytical model with duopsony buyers, the economic forces at work are general and apply broadly. By committing to contracts that link acquisition cost to a subsequent spot price, buyers credibly increase their marginal costs of acquisition in the spot market, which, in turn, diminishes the intensity of spot-market competition relative to what would prevail otherwise. Notably, in the case of the TOMP contract, we showed that duopsony buyers can achieve cash and contract prices that converge to the simple monopsony price as the number of sellers becomes large.

Rational and informed sellers are not necessarily a remedy to the implementation of such contracts. The straightforward logic that "contracts involve two consenting parties, so contracts could be expected to involve mutual benefits" (Ward et al., p. 633) misses the key point that contracts can be individually rational for producers to sign but mutually damaging for producers as a group.

Given producers' limited ability to deter the implementation of these contracts, a clear case exists for their proscription through policy. The beneficial aspects of vertical coordination can be achieved through contracts that lack this anticompetitive feature. For example, the arguments raised in this article do not apply when contract prices are pegged to prices in markets where the contract purchaser lacks market power. Futures markets may satisfy this criterion, although allegations of manipulation of cattle futures have proliferated in recent years, making this question a subject worthy of future research.

[Received May 2002; accepted March 2003.]

References

Azzam, A. "Captive Supplies, Market Conduct, and the Open-Market Price." *American Journal of Agricultural Economics* 80(1998):76–83.

Azzam, A., and D. Anderson. *Assessing Competition in Meatpacking: Economic History, Theory and Evidence*. Washington DC: U.S. Department of Agriculture, GIPSA-RR 96-6, May 1996.

Bernheim, B.D., B. Peleg, and M.D. Whinston. "Coalition-Proof Nash Equilibria: Concepts." *Journal of Economic Theory* 42(1987):1–12.

Cooper, T.E. "Most-Favored-Customer Pricing and Tacit Collusion." *Rand Journal of Economics* 17(1986):377–88.

Crespi, J.M., and R.J. Sexton. "Bidding for Cattle in the Texas Panhandle." Working Paper, Department of Agricultural Economics, Kansas State University, 2003.

Davis, D.E. *Does Top of the Market Pricing Facilitate Oligopsony Coordination?* Washington DC: U.S. Department of Agriculture, Grain Inspection, Packers & Stockyards Administration, Discussion Paper, August 2000.

Declerck, F., O. Fourcadet, and H. Faucher. "Forward Contract Versus Spot Market: The Case of the French Beef Chain." In G. Galizzi and L. Venturini, eds. *Vertical Relationships and Coordination in the Food System*. Heidelberg, Germany: Physica-Verlag, 1999.

Elam E. "Cash Forward Contracting Versus Hedging of Fed Cattle, and the Impact of Cash Contracting on Cash Prices." *Journal of Agricultural and Resource Economics* 17(1992): 205–17.

Galizzi, G., and L. Venturini, eds. *Vertical Relationships and Coordination in the Food System*. Heidelberg, Germany: Physica-Verlag, 1999.

Hayenga, M.L. "Cutting Verticals Down to Size: Congress, the Farm Bill, and Packer Control." *Choices* 17(2002):36–39.

Hayenga, M.L., and D. O'Brien. "Packer Competition, Forward Contracting Price Impacts, and the Relevant Market for Fed Cattle." In W.D. Purcell, ed. *Pricing and Coordination in Consolidated Livestock Markets: Captive Supplies, Market Power, and IRS Hedging Policy*. Blacksburg, VA: Research Institute on Livestock Pricing, 1992.

Holt, C.A., and D.T. Scheffman. "Facilitating Practices: The Effects of Advance Notice and Best-Price Policies." *Rand Journal of Economics* 18(1987):187–97.

Love, H.A., and D.M. Burton. "A Strategic Rationale for Captive Supplies." *Journal of Agricultural and Resource Economics* 24(1999):1–18.

Purcell, W.D. "White Paper on Status, Conflicts, Issues, Opportunities, and Needs in the U.S. Beef

Industry." Virginia: Research Institute on Livestock Pricing, Virginia Tech University, May 1999.
Rasmusen, E.B., J.M. Ramseyer, and J.S. Wiley, Jr. "Naked Exclusion." *American Economic Review* 81(1991):1137–45.
——. "Naked Exclusion: Reply." *American Economic Review* 90(2000):310–11.
Rogers, R.T., and R.J. Sexton. "Assessing the Importance of Oligopsony Power in Agricultural Markets." *American Journal of Agricultural Economics* 76(1994):1143–50.
Schnitzer, M. "Dynamic Duopoly with Best-price Clauses." *Rand Journal of Economics* 25(1994):186–96.
Schroeder, T.C., R. Jones, J. Mintert, and A.P. Barkley. "The Impact of Forward Contracting on Fed Cattle Transaction Prices." *Review of Agricultural Economics* 15(1993):325–37.
Schroeter, J.R., and A. Azzam. "Econometric Analysis of Fed Cattle Procurement in the Texas Panhandle," Washington DC: U.S. Department of Agriculture, Grain Inspection, Packers & Stockyards Administration, Report submitted, November 1999.
Segal, I.R., and M.D. Whinston. "Naked Exclusion: Comment." *American Economic Review* 90(2000):296–309.
Sexton, R.J. "Industrialization and Consolidation in the U.S. Food Sector: Implications for Competition and Welfare." *American Journal of Agricultural Economics* 82(2000):1087–104.
Tweeten, L.G., and C.B. Flora. "Vertical Coordination of Agriculture in Farming-Dependent Areas." Council for Agricultural Science and Technology, Task Force Report No. 137, March 2001.
U.S. Department of Agriculture. *Packers and Stockyards Statistical Report: 1999 Reporting Year*. Grain Inspection, Packers, and Stockyards Administration, Washington, DC, SR-02-1, 2002a.
——. *Captive Supply of Cattle and GIPSA's Reporting of Captive Supply*. Grain Inspection, Packers, and Stockyards Administration, Washington, DC, 2002b.
Ward, C.E. "A Review of Causes for and Consequences of Economic Concentration in the U.S. Meatpacking Industry." *Current Agriculture, Food & Resource Issues* 3(2002):1–28.
Ward, C.E., D. Feuz, and T.C. Schroeder. *Fed Cattle Pricing: Formulas and Grids*. Oklahoma State University, Oklahoma Cooperative Extension Service, OSU Extension Facts WF-557, June 1998.
Ward, C., M. Hayenga, T. Schroeder, J. Lawrence, and W. Purcell. "Contracting in the U.S. Pork and Beef Industries: Extent, Motives, and Issues." *Canadian Journal of Agricultural Economics* 48(2000):629–39.
Ward, C.E., S.R. Koontz, and T.C. Schroeder. "Impacts from Captive Supplies on Fed Cattle Transaction Prices." *Journal of Agricultural and Resource Economics* 23(1998):494–514.
Ward, C.E., T.C. Schroeder, and D. Feuz. *Grid Pricing of Fed Cattle: Base Prices and Premium-Discount Grids*. Oklahoma State University, Oklahoma Cooperative Extension Service, OSU Extension Facts WF-560, August 1999.
Xia, T., and R.J. Sexton. "Top-of-the-Market Pricing Clauses in Fed Cattle Procurement." Working paper, Dept. of Agricultural and Resource Economics, University of California, Davis, 2002.
Zhang, M., and R.J. Sexton. "Captive Supplies and the Cash Market Price: A Spatial Markets Approach." *Journal of Agricultural and Resource Economics* 25(2000):88–108.
——. "FOB or Uniform Delivered Prices: Strategic Choice and Welfare Effects." *Journal of Industrial Economics* 49(2001):197–221.

Appendix

A General Formulation of Producer Supply

Results are unaffected when producers have a general convex supply function. The intuition is the same; packers use the TOMP contracts to impose self-restraint and thus reduce competition in the cash market. Producers accept the contracts due to lack of coordination and/or negative externalities among themselves.

Consider a convex short-run supply curve for each producer represented by a general functional form, $q = f(w)$, where $f' > 0$, $f'' \leq 0$, and $f(0) = 0$. All other aspects of the model are as before. To provide a reference for comparison, first consider a monopsony packer and N cattle producers. The market-clearing condition is $Q_s = Nf(w_2) = Q_d$. The monopsony's profit function is $\pi = (R - w_2)Q$. From the first-order condition to maximize π with respect to choice of Q, the equilibrium monopsony price, w^m, is obtained as the solution to the equation,

$$\text{(A.1)} \quad F1(w_2) = w_2 + f(w_2)/f'(w_2) = R.$$

$F1$ is a strictly monotonic increasing function of w_2, and, thus, the monopsony price is unique and between 0 and R.

Next consider the duopsony model without TOMP clauses. In the cash market, each packer chooses her cash quantity to maximize her profit from the cash market. The market supply is $Q_{2,s} = (N - S)f(w_2)$, where S is the number of producers selling in the contract market. The cash-market demand is $Q_{2,d} = Q_2^A + Q_2^B$. The market clears when $(N - S)f(w_2) = Q_2^A + Q_2^B$. First-order conditions are $R - w_2 - Q_2^j(\partial w_2/\partial Q_2^j) = 0$, for packers j = A, B. Solving these two equations simultaneously obtains the equilibrium cash price as the solution to the following equation:

$$\text{(A.2)} \quad F2(w_2) = w_2 + f(w_2)/(2f'(w_2)) = R$$

where $F2$ is a strictly monotonic increasing function of w_2. Since $F2(0) = 0$ and $F2(R) > R$, there must be a unique value of w_2 between 0 and R, which is the root of equation (A.2). Using the same approach, we can show that the equilibrium price in the contract market is the same as the equilibrium cash price. Since $F1(w_2) > F2(w_2)$ for any given w_2, the monopsony price, is lower than the equilibrium price of the duopsony model without TOMP contracts.

Finally, consider the market in the presence of TOMP contracts. In the cash market, the supply is $Q_{2,s} = (N - S)f(w_2)$, where $S = n_1^A + n_1^B$. Both packers choose their cash quantities to maximize their total profits from two markets. The first-order conditions are:

$$R - w_2 - \left(Q_2^j + n_1^j q^c\right)/((N - S)f'(w_2)) = 0, \quad j = \text{A, B}.$$

Solving these two equations simultaneously, yields the equilibrium cash price, $w_2^*(S)$, as the solution to the equation,

$$\text{(A.3)} \quad w_2 + (N/(2(N - S)))(f(w_2)/f'(w_2)) = R.$$

In the contract market, packers each choose the optimal number of producers to offer TOMP contracts in order to maximize their total profits. Substituting equation (A.3) and making other substitutions into packer j's total profit function and differentiating it with respect to n_1^j, we obtain the following condition for j = A, B:

$$\text{(A.4)} \quad \partial\pi^j/\partial n_1^j = (N/2)\left(\partial w_2^*/\partial n_1^j\right) \times ((R - w_2)f'(w_2) - f(w_2))$$

$$\begin{aligned} &>0 \text{ if } 0 \le S < N/2 \\ \to\ &=0 \text{ if } S = N/2 \\ &<0 \text{ if } N/2 < S \le N. \end{aligned}$$

Define S^t as before. For this general case, we cannot obtain analytical solutions for the $\Delta PS(S^t)$ and $\Delta\pi(S^t)$ functions. Approximating them using Taylor's theorem obtains:

$$\begin{aligned} \Delta PS(S^t) &\approx -f\left(w_2^*\right)\left(\partial w_2^*/\partial n_1^A\right) \\ \Delta\pi(S^t) &\approx (\partial\pi/\partial S)\Delta S \\ &= (N/2)\left(\partial w_2^*/\partial S\right) \\ &\quad \times \left(\left(R - w_2^*\right)f'\left(w_2^*\right) - f\left(w_2^*\right)\right). \end{aligned}$$

Given these approximations, $D(S^t) = \Delta\pi(S^t) - \Delta PS(S^t) > 0$, for $0 \le S^t \le (N/2) - 2$ and $D(S^t) < 0$ for $S^t \ge (N/2) - 1$. Thus, the logic leading to Proposition 1 is unaffected by the generalization of the producer supply function. Accordingly, for the sequential-offer version of the game $(N/2) - 1$ producers can be convinced to sign the TOMP contracts with a zero bonus. By substituting $S = (N/2) - 1$ into (A.3), we obtain the equilibrium cash market price, w_2^*, as the solution to the equation,

$$\text{(A.5)} \quad F3(w_2) = w_2 + (N/(N+2)) \times (f(w_2)/f'(w_2)) = R.$$

Because $F3$ is a strictly monotonic increasing function of w_2, $F3(0) = 0$, and $F3(R) > R$, the equilibrium cash price is unique and between 0 and R. As $N \to \infty$, (A.5) converges to (A.2). Thus, the basic result, that the equilibrium price of the TOMP model approaches the monopsony price as N becomes large, is robust to a general specification of the producer supply function. For the case of simultaneous offers, the packers again have to offer positive bonuses to elicit producer acceptance, but the fundamental logic of that model is also unaffected by the generalized specification of producer supply.