

Can Food Processors Use Contracts to Influence Farm Cash Prices? The Competitive Implications of Top-of-the-Market and related pricing Clauses

**Tian Xia
Richard J. Sexton**

*Department of Agricultural and Resource Economics
University of California, Davis*

May 8, 2002

Abstract: Contracts are an important dimension of modern agriculture because they facilitate vertical coordination between producers and downstream processors and handlers. Because contracts are normally not settled in an open-market environment, establishing price(s) for contract sales is a pressing issue. When contract production is marketed contemporaneously with production sold through a spot market, a convenient alternative is to specify the contract price in terms of the subsequent cash price. This paper examines the competitive implications of such pricing arrangements, focusing in particular upon so-called “top of the market pricing (TOMP)” in cattle procurement, wherein the contract guarantees the producer the highest cash price prevailing at the time of delivery. These contracts are 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. By committing to purchase cattle at a spot price to be determined later, beef packers’ incentives to compete aggressively in the spot market are attenuated. Although TOMP pricing is not in producers’ collective interest, rational sellers may nonetheless sign these contracts, in some cases with little or no financial inducement.

Acknowledgements: Without implicating them for the paper’s shortcomings, the authors wish to thank Giacomo Bonanno, John Crespi, Rachael Goodhue, and Rob Innes for helpful comments.

Can Food Processors Use Contracts to Influence Farm Cash Prices? The Competitive Implications of Top-of-the-Market and related pricing Clauses

Vertical coordination between producers and processor/marketers through various types of contracting is an important dimension of modern agriculture (e.g., Tweeten and Flora, 2001; Galizzi and Venturini, 1999). 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, 1999; Tweeten and Flora 2001).

In this paper 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 (2000). 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

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

straightforward—by having committed to purchase cattle at a spot price to be determined later, beef 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. 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 may be transacted either through contracts or cash exchange, some buyers participate in both contract and cash purchases, and contract terms are tied to the subsequent cash price.

Cattle Markets and Captive Supplies

Beef packing has become one of the most concentrated industries in the United States (Ward, 2002). From 1976 to 1998, the four-firm concentration ratio of U.S. steer and heifer slaughter increased from 25 to 80 percent (USDA, Grain Inspection, Packers and Stockyards Administration (GIPSA), 2000; Ward, 2002). 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 non-cash methods to procure cattle, including forward contracts, marketing agreements, and packer-owned cattle. Forward contracts include fixed-price contracts and basis contracts, which use a pricing formula. Marketing agreements set up a purchasing and selling relationship between packers and producers, usually based upon a

pricing formula. Cattle procured through these “captive supply” methods accounted for 32.3 percent of total slaughter of the four largest packers in 1999 (USDA GIPSA, 2002).

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.² 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.³ As Ward, Koontz, and Schroeder (1998) 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.⁴

A few studies have analyzed captive supplies in cattle markets using models of imperfect competition. Love and Burton (1999) 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 (1998) 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,

² This legislation passed in the U.S. Senate but was omitted from the Farm Bill that emerged ultimately from the House-Senate conference.

³ Studies finding a negative relationship between captive supplies and fed cattle cash prices include Elam (1992), Schroeder et al. (1993), and Schroeder and Azzam (1999). Ward, Koontz, and Schroeder (1998) 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 (1992) also found the effect of captive supplies on the cash price to be ambiguous.

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 packer will pay the producer the highest cash price in the market at the time of delivery (Davis, 2000). Davis argued that TOMP contracts may be anti-competitive because they resemble both a contemporary most-favored-customer (MFC) clause and a best-price clause. In a more general context, Schroeter and Azzam (1999) and Purcell (1999) 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 paid to others by the buyer” (Purcell, p. 18).⁵ 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, 1986). A

⁴ The conclusions from the considerable empirical research on the issue of processor market power in the U.S. beef sector are rather mixed, as surveys by Azzam and Anderson (1996) and Ward (2002) demonstrate.

⁵ Ward et al. (2000) report that formula-priced contracts based on cash-market prices are the most common method of hog procurement in the U.S., with 32.3% of sales in 1999. Similar contract pricing arrangements are in place in other countries as well. For example, Declerck, Fourcadet, and Faucher

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, 1987). Cooper (1986) 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 (1987) 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 (1994) 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 (e.g., 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.

(1999) report that price arrangements for forward-contract cattle in France are based upon the spot-market price.

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.

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

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, 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. 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

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.

⁷See Sexton (2000) for a discussion of the fixed-proportions assumption in modeling agricultural markets.

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, 1994).

contract in the basic model is a fixed price and quantity 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 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 $Q_{2,d} = Q_2^A + Q_2^B$. The market clears when $Q_{2,s} = Q_{2,d}$, from which we obtain $w_2 = (Q_2^A + Q_2^B)/(N - n_1)$.

Packer j 's profit function in the cash market is $\pi_2^j = (R - w_2)Q_2^j$, $j = 1, 2$. 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:

$$(1) \quad Q_2^A = (N - n_1)R/2 - Q_2^B/2.$$

$$(2) \quad Q_2^B = (N - n_1)R/2 - Q_2^A/2.$$

⁹The 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.

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 $Q_{1,d} = Q_1^A + Q_1^B$. The market clears when $Q_{1,s} = Q_{1,d}$, from which we obtain $w_1 = (Q_1^A + Q_1^B)/n_1$. 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 to 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. Because the equilibrium prices in the two markets are equal, each producer is indifferent between selling through the contract market or the cash market and, thus, randomly chooses one market in which to sell. Therefore, the shares of cattle sold through the contract market and cash market are indeterminate. In the equilibrium each producer sells $q = w_1 = w_2 = 2R/3$ cattle, and each packer purchases $Q^A = Q^R = RN/3$ cattle in total from the two markets.

The TOMP Model

Now consider the case when contracts have the TOMP clause. This model evolves in three stages. In Stage I, both packers compete 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. 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 and the cash market. Packer j chooses Q_2^j to maximize

$$\pi^j = \pi_1^j + \pi_2^j = (R - w_2)q^c n_1^j + (R - w_2)Q_2^j, \quad j = A, B,$$

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:

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

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

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:

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

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

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

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

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

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

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

Similarly,

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

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:

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

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

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

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

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 (2002). The impact on price of odd versus even N diminishes as N increases, as figure 1 illustrates.

$n_1 < N/2$ 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, 2000) and Segal and Whinston (SW, 2000) 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, thus, 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 monopoly 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

¹¹ This assumption is for convenience only and can be motivated by appeal to (unmodeled) costs associated with offering contracts. Results do not change if packers collectively offer $N/2$ contracts, but, possibly, less than $N/2$ are signed, based upon producers' rational accept/reject decisions.

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 $i = 1, \dots, N$ 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 it ($s_i = 1$) 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 the t^{th} producer ($2 \leq t \leq N$) 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 t^{th} producer signing a TOMP contract, given S^t , is

$$\Delta PS(S^t) = PS(S^t) - PS(S^t + 1) = \frac{1}{2} w_2(S^t)q(S^t) - \frac{1}{2} w_2(S^t + 1)q(S^t + 1).$$

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

$$(9) \quad \Delta PS(S^t) = \frac{1}{2} \left(\frac{(2N - 2S^t)R}{(3N - 2S^t)} \right)^2 - \frac{1}{2} \left(\frac{(2N - 2(S^t + 1))R}{(3N - 2(S^t + 1))} \right)^2 \\ = 2NR^2 \left(6N^2 - 10NS^t - 5N + 4(S^t)^2 + 4S^t \right) / \left((3N - 2S^t)^2 (3N - 2S^t - 2)^2 \right).$$

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

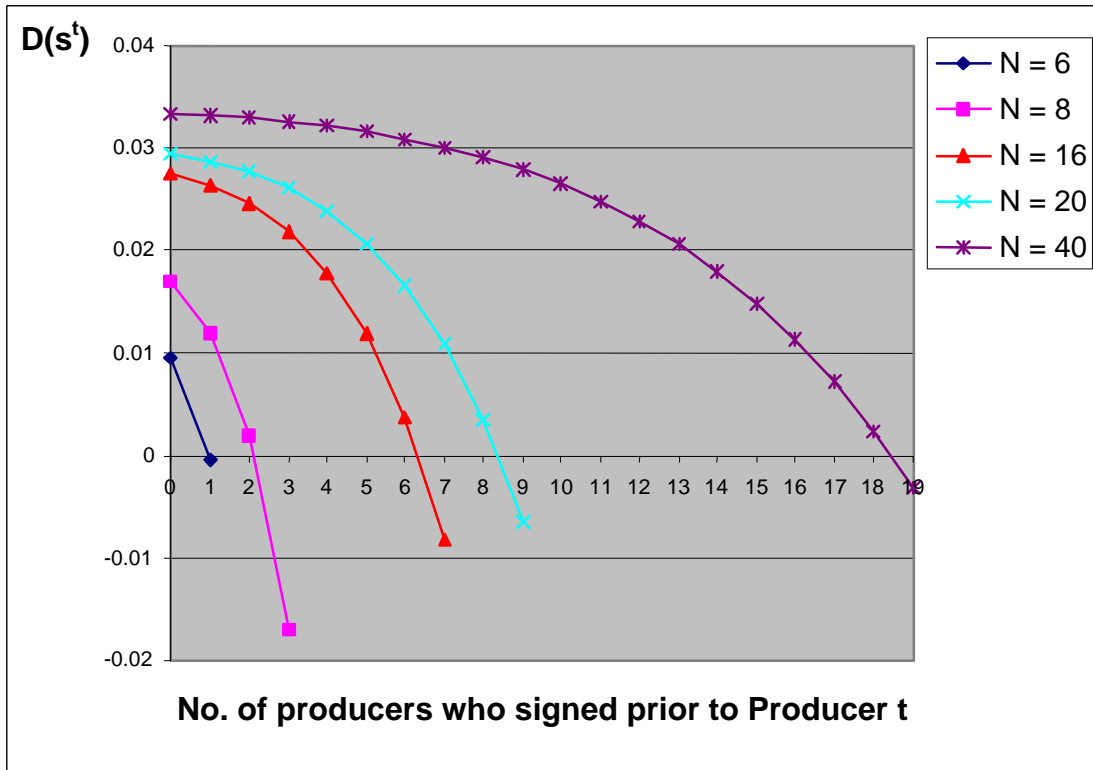
On the other hand, the signing of an additional contract by the t^{th} producer, given S^t , yields the following incremental profit to each packer:

$$\Delta \pi(S^t) = \pi(S^t + 1) - \pi(S^t) = \left(R - \frac{(2N - 2S^t - 2)R}{(3N - 2S^t - 2)} \right) \left(N - S^t - 1 \right) \frac{R}{(3N - 2S^t - 2)} \\ - \left(R - \frac{(2N - 2S^t)R}{(3N - 2S^t)} \right) \left(N - S^t \right) \frac{R}{(3N - 2S^t)} \\ = R^2 N^2 \left(3N^2 - 8NS^t - 4N + 4(S^t)^2 + 4S^t \right) / \left((3N - 2S^t)^2 (3N - 2S^t - 2)^2 \right).$$

$\Delta \pi(S^t)$ is positive when $0 \leq S^t \leq (N/2) - 1$, 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 1 for alternative N. If $D(S^t) > 0$, each packer has incentive to offer a large enough signing bonus to reimburse the t^{th} 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 $N \geq 8$, it is straightforward to show that $D > 0$ for $0 \leq S^t \leq (N/2) - 2$ and $D < 0$ for $S^t \geq (N/2) - 1$. Thus, if the total number of producers is sufficiently large, namely 8 or more, duopsony packers have incentive to jointly convince $\left[(N/2) - 2 \right] + 1 = (N/2) - 1$ producers to sign the contracts.

Figure 1: The Difference (D) between $\pi_B(S^t)$ and $\pi_{PS}(S^t)$ (unit: R^2).



Assume $N \geq 8$, 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 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. Thus, 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 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. 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.

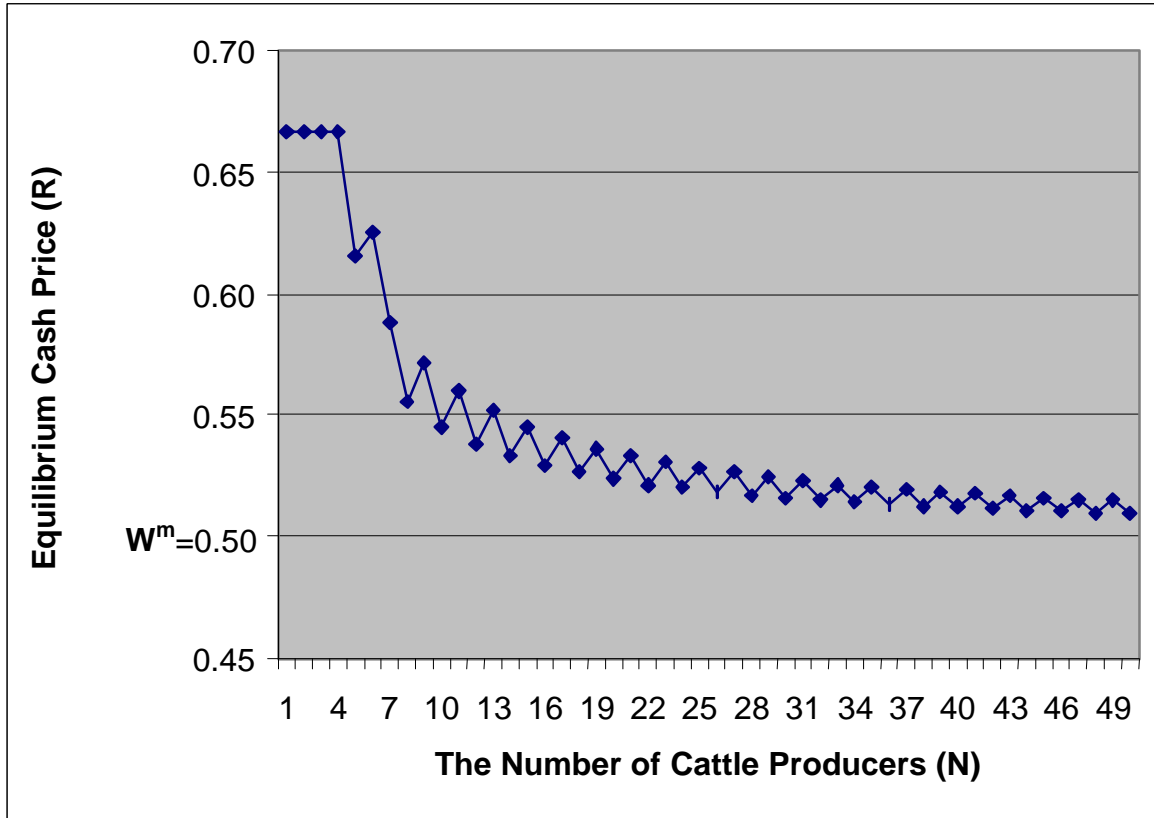
The results when N is odd and when $N < 8$ are provided in Xia and Sexton (2002). When N is odd, the packers are unable to offer contracts to $(N/2) - 1$ producers

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 (2002) 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 2 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.¹²

¹² The “sawtooth” pattern for the $R(N)$ function in figure 2 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 (2002) for more details.

Figure 2: 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. 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 $X^A = \Delta PS(S^o)$, where $S^o = n_1^A + n_1^B - 1$, and n_1^A is the number of contracts Packer A offers, given n_1^B . Similarly, for Packer B, the relation is $X^B = \Delta PS(S^o)$, where n_1^B is the number of contracts Packer B offers, given n_1^A , and $\Delta PS(\bullet)$ is defined in (9).*

PROOF: Suppose there is an SPNE equilibrium where $X^A < \Delta PS(S^o)$. Then each of the n_1^A producers who sign the contracts with Packer A under the proposed equilibrium has

incentive to deviate from his proposed equilibrium strategy because each of them can gain $\Delta PS(S^o) - X^A > 0$ by refusing to sign the contract. Thus, no SPNE equilibrium can include bonus payments $X^A < \Delta PS(S^o)$. On the other hand, suppose there is an SPNE equilibrium when $X^A > \Delta PS(S^o)$. Then Packer A has 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 $X^A > \Delta PS(S^o)$. The same logic applies to Packer B. Thus, only when $X^j \geq \Delta PS(S^o)$, does none of the producers who signed the contracts have incentive to change his decision given other players' decisions. Also, given n_1^A and n_1^B , no packer has incentive to increase or reduce her signing bonus from the amount $\Delta PS(S^o)$, given the producers' decision rule. Therefore, only the offers $X^A = X^B = \Delta PS(S^o)$ are consistent with any SPNE equilibrium.¹³

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

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

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

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

¹³ Based upon Lemma 1, the contracts that emerge in equilibrium are nondiscriminatory (among the subset of customers who receive contract offers).

The analogous condition for Packer B is

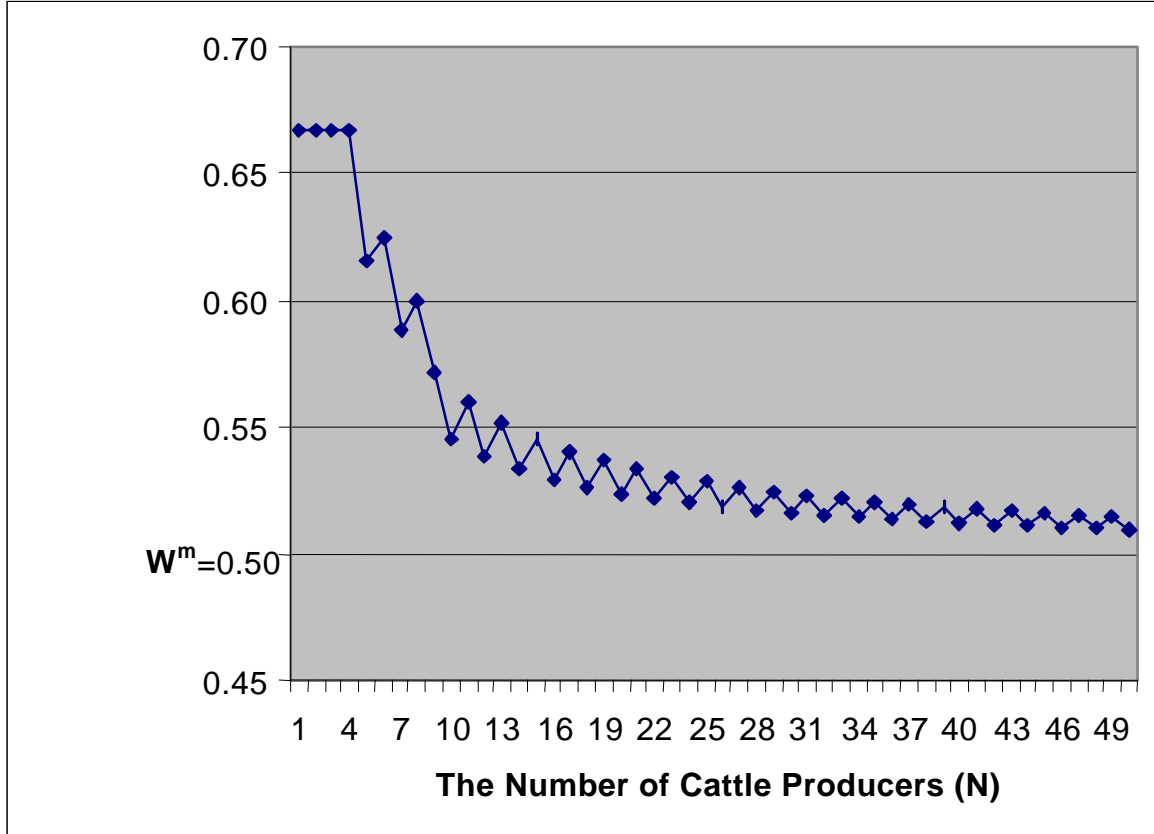
$$(11) \quad \frac{\partial \pi^B}{\partial n_1^B} \rightarrow \begin{cases} > 0 & \text{if } 0 \leq n_1^A + n_1^B \leq (N/2) - 2 \\ < 0 & \text{if } (N/2) - 1 \leq n_1^A + n_1^B \leq N. \end{cases}$$

Because the packers can offer the contracts to only integer number of producers, 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 ($N \geq 10$), all pure-strategy, SPNE are characterized by packers collectively offering the contracts with the positive bonus, $X^A = X^B = \Delta PS((N/2) - 1 - 1) = (2N^3 + 9N^2 + 8N)R^2 / (8(N+2)^2(N+1)^2)$, 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 monopoly level, $w^m = R/2$, as N becomes large.*

Xia and Sexton (2002) 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 3 summarizes the relationship between the equilibrium cash price and the number of cattle producers for the game with simultaneous offers.

Figure 3: The Equilibrium Cash Price with Simultaneous Contract Offers



Perfectly Coalition-Proof Nash Equilibria

The SPNE for either the sequential- or simultaneous-offer versions of the game are not perfectly coalition-proof Nash equilibria (Bernheim, Peleg, and Whinston, 1987; SW, 2000) in the sense that if producers were able to coordinate their decisions, they could form a self-enforcing coalition (e.g., a producer cooperative) that would agree to reject the offers. Even in the simultaneous-offer game, producers receive signing bonuses equal to the *marginal* loss in surplus that each can associate with his agreeing to a TOMP contract, an amount that is always less than the *total* loss in surplus if packers implement any of the equilibria described in Proposition 2. In this sense, the equilibria rely upon

producers' inability to coordinate their actions to reject a mutually disadvantageous outcome.

Although agricultural producers' inability to coordinate for their mutual betterment is well known, it is worth considering whether the packers have incentive to offer TOMP contracts that are coalition proof, especially given laws, such as the U.S. Capper-Volstead Act, that facilitate producer coordination. Assume the packers can sequentially offer TOMP contracts to producers with discriminatory signing bonuses and, as before, identify producers according to $1, \dots, N$ by the order in which they are considered for a TOMP contract offer. Denote equilibrium prices in the cash and, thus, contract market by $w(S)$, where S is the number of producers who have signed TOMP contracts, where $w'(S) < 0$, $w(0) = 2/3$ (the Cournot price), and $w[(N/2)-1]$ is the price if the packers sign their preferred number of TOMP contracts.

Suppose a packer offers the first producer the following bonus:

$$X_1 = \int_{w[(N/2)-1]}^{w(0)} q(w)dw .$$

This producer is compensated fully for his loss in surplus if the packers implement their preferred scheme. This producer will sign the TOMP contract, and he cannot be persuaded to make an agreement with other producers to mutually agree not to sign, because he will receive at most $w(0)$ under such an arrangement. The second producer can, thus, receive the following offer to sign a TOMP contract:

$$X_2 = \int_{w[(N/2)-1]}^{w(1)} q(w)dw ,$$

where $X_2 < X_1$. Producer 2 will sign this contract, and he cannot be persuaded to join a coalition of producers who will mutually agree not to sign, because he can anticipate

receiving at most $w(1)$ under such an arrangement (because producer 1 will never join the coalition). Generalizing, let producer i , $1 \leq i \leq (N/2)-1$ receive the following signing bonus:

$$X_i = \int_{w[(N/2)-1]}^{w(i-1)} q(w)dw .$$

The vector $X = \{X_1, \dots, X_{(N/2)-1}\}$ of TOMP contract bonus offers derived in this manner “divides and conquers” the producers in the sense described by Innes and Sexton (1993). By construction TOMP contracts with these bonus offers are immune to the formation of coalitions by producers intended to elicit mutual defection from agreements to sign the contracts. Thus, such offers are consistent with the requirements for PCPNE.

Because the total bonus payments required to achieve a PCPNE exceed the bonuses paid in the SPNE for either the sequential- or simultaneous-offer game, it remains to ask whether the packers have incentive to offer these bonuses. Define

$$\Psi = \sum_{i=1}^{(N/2)-1} X_i$$

as the total bonus payment and let $\Delta\pi^j = \pi^j(w[(N/2)-1]) - \pi^j(w(0))$,

$j=A,B$ denote the increase in each packer’s profit from implementing the preferred number of TOMP contracts, relative to the equilibrium with no contracts. In the expanded version of our paper, we demonstrate that $\Psi < 2\Delta\pi^j$, and, therefore, packers mutually have incentive to implement the TOMP contracts even if they must pay signing bonuses that are immune to the formation of self-enforcing producer coalitions. Packers nonetheless face a coordination problem in implementing these contracts because of their

discriminatory nature; each would prefer to have the other offer the more expensive contracts.¹⁴

The PCPNE achieves the same cash- and contract-market price as the equilibrium described in Proposition 1, albeit with less transfer of rents from producers to packers. Unlike the SPNE with either sequential or simultaneous offers, the PCPNE does not rely upon lack of coordination among producers, but, rather, it exploits only the externality that signing producers impose upon other producers, including those who are not offered a contract. Although all producers receive the same unit price, regardless of whether they sell in the contract or cash market, those without a contract receive no signing bonus and, thus, are harmed by the collective actions of those who sign—a fact which is external to the decision of the signatories.

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.¹⁵ 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

¹⁴ In practice, the coordination problem may not be that difficult to surmount in situations, such as real-world cattle markets, where the same players interact repeatedly. Although overt communication between packers would normally be illegal, subtle conventions or “focal points” can help players choose from among multiple solutions (Kreps, 1990).

¹⁵ We use the term “perceived marginal cost” because under Cournot competition, each packer takes her rival's action as given, i.e., “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.

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:

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

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

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:

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

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 and whether producers can coordinate their actions through a coalition or cooperative, those who are offered contracts may be able to recapture some of the surplus lost from TOMP 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.

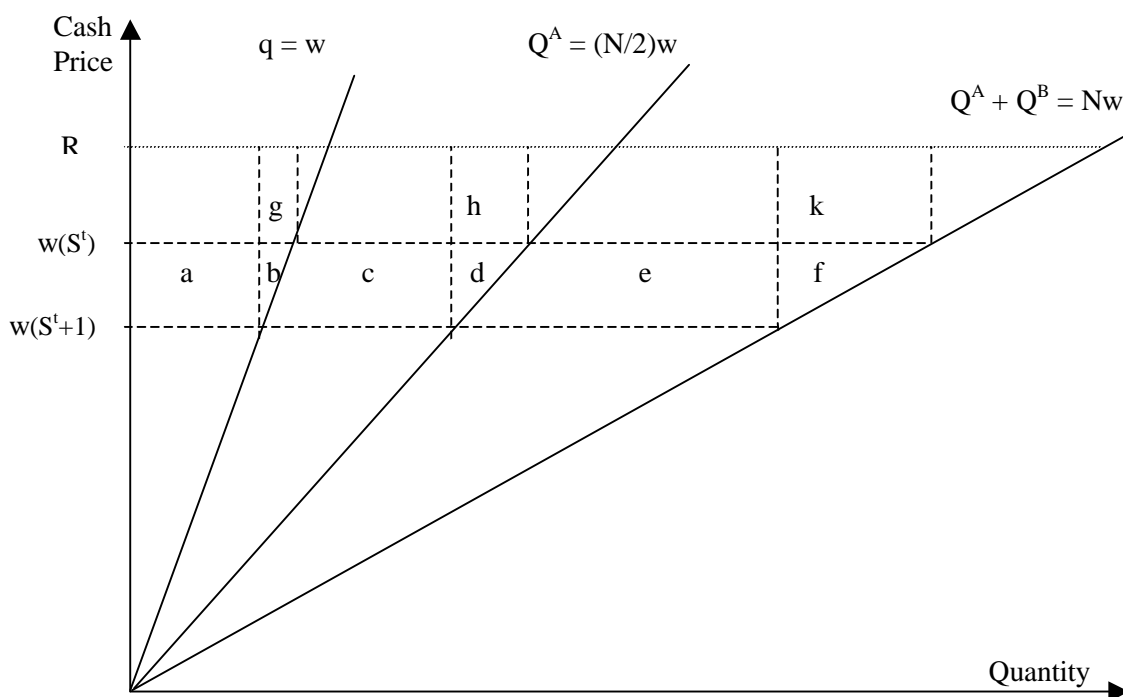
Figure 4 illustrates the benefits and costs of TOMP contracts from packers' and producers' perspectives. For large N , packers are able to elicit signing of TOMP contracts because each producer's signing, up to $N/2$ producers, depresses the future cash price and allows a packer to increase profit not 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 (a) the sequential-offer case (no signing bonuses), (b) the simultaneous offer case, and (c) the case of coalition-proof contract offers. In all scenarios, packers' gain in profits from TOMP contracts is increasing in N , and, not surprisingly, packers gain more when they are able to exploit both externalities and disorganization among producers, as in the sequential- and simultaneous-offer cases. 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. If packers must

offer coalition-proof contracts, most of their benefit from implementing the TOMP regime is consumed by the signing bonuses.

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 4. Table 1 identifies the loss in producer surplus for both those who sign contracts and those who are not offered a contract. Naturally, except for the sequential offer SPNE, those with contracts lose less than those without them, but the bonus payments in the simultaneous-offer equilibrium 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 , unless coalition-proof bonuses are offered, producer surplus losses can exceed 40% of the surplus attainable in the no-contract, duopsony equilibrium.

Figure 4: Welfare Effects from Imposition of TOMP Contracts



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 paper has focused 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 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. 2000) misses the key point that contracts can be individually rational for producers to sign but mutually damaging for producers as a group. Only in the case where sellers could form self-enforcing coalitions were processors compelled to offer substantial inducements to sign the contracts. Even in this case, more than half of the sellers received no bonus.

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 paper do not apply when contract prices are pegged to prices in markets where the contract purchaser lacks market power, as would typically be true of futures markets.

Table 1: Simulation Results

	Scenario	Increase in packer profits	Reduction in producer surplus	
			Signers	Non-signers
N = 8	Sequential offer	11.1%	30.6%	30.6%
	Simultaneous offer	6.8	19.0	30.6
	Coalition proof	3.1	9.3 ¹	30.6
N= 16	Sequential offer	12.1	36.9	36.9
	Simultaneous offer	9.3	30.6	36.9
	Coalition proof	2.3	14.4 ¹	36.9
N= 20	Sequential offer	12.2	38.3	38.3
	Simultaneous offer	9.9	33.1	38.3
	Coalition proof	2.0	15.5 ¹	38.3
N= 40	Sequential offer	12.4	41.0	41.0
	Simultaneous offer	11.2	38.3	41.0
	Coalition proof	1.4	17.7 ¹	41.0

¹ Reported number is the average bonus among signing producers.

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 B with respect to choice of Q , the equilibrium monopsony price, w^m , is obtained as the solution to the equation,

$$(14) \quad F1(w_2) = w_2 + f(w_2)/f'(w_2) = R.$$

$F1$ is a 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,

$$(15) \quad F2(w_2) = w_2 + f(w_2)/(2f'(w_2)) = R,$$

where $F2$ is a 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 (15). 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:

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

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

$$(16) \quad w_2 + (N / (2(N - S))) (f(w_2) / f'(w_2)) = R.$$

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 (16) 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 $j = A, B$.

$$(17) \quad \begin{aligned} &> 0 && \text{if } 0 \leq S < N/2 \\ \partial \pi^j / \partial n_1^j = (N/2) (\partial w_2^* / \partial n_1^j) ((R - w_2) f'(w_2) - f(w_2)) &\rightarrow = 0 && \text{if } S = N/2 \\ &< 0 && \text{if } N/2 < S \leq N. \end{aligned}$$

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:

$$\Delta PS(S^t) \approx -f(w_2^*) \left(\frac{\partial w_2^*}{\partial n_1^A} \right)$$

$$\Delta \pi(S^t) \approx (\partial \pi / \partial S) \Delta S = (N/2) \left(\frac{\partial w_2^*}{\partial S} \right) \left((R - w_2^*) f'(w_2^*) - f(w_2^*) \right).$$

Given these approximations, $D(S^t) = \Delta \pi(S^t) - \Delta PS(S^t) > 0$, for $0 \leq S^t \leq (N/2) - 2$ and $D(S^t) < 0$ for $S^t \geq (N/2) - 1$. 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 (16), we obtain the equilibrium cash market price, w_2^* , as the solution to the equation,

$$(19) \quad F3(w_2) = w_2 + \left(N / (N + 2) \right) \left(f(w_2) / f'(w_2) \right) = R.$$

Because $F3$ is a 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 $N \rightarrow \infty$, (19) converges to (15). 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.

References

- Azzam, A. "Captive Supplies, Market Conduct, and the Open-Market Price." *American Journal of Agricultural Economics* 80(February 1998): 76-83.
- Azzam, A. and D. Anderson. "Assessing Competition in Meatpacking: Economic History, Theory and Evidence," 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* 41(June 1987): 1-12.
- Cooper, T. E. "Most-Favored-Customer Pricing and Tacit Collusion." *Rand Journal of Economics* 17(Autumn 1986): 377-88.
- Davis, D. E. "Does Top of the Market Pricing Facilitate Oligopsony Coordination?" USDA/GIPSA discussion paper, August 2000.
- Declerck, F., O. Fourcadet, and H. Faucher. "Forward Contract Versus Spot Market: The Case of the French Beef Chain." 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(July 1992): 205-217.
- Galizzi, G. and L. Venturini (eds.). *Vertical Relationships and Coordination in the Food System*, Heidelberg, Germany: Physica-Verlag, 1999.
- Hayenga, M. L., R. D. Hook, and B. Jiang. "Fed Cattle Geographic Market Delineation: Slaughter Plant Procurement Area and Supply Response Analysis." Report to Packers & Stockyards Programs, USDA, GIPSA, 1995.
- Holt, C. A. and D. T. Scheffman. "Facilitating practices: the Effects of Advance Notice and Best-price Policies." *Rand Journal of Economics* 18(Summer 1987): 187-97.
- Innes, R. and R.J. Sexton. "Customer Coalitions, Monopoly Price Discrimination and Generic Entry Deterrence." *European Economic Review* 37(1993): 1569-1597.
- Kreps, D.M. *Game Theory and Economic Modelling*, Oxford: Oxford University Press, 1990.
- Love, H. A. and D. M. Burton. "A Strategic Rationale for Captive Supplies." *Journal of Agricultural and Resource Economics* 24(July 1999): 1-18.

- Purcell, W.D. "White Paper on Status, Conflicts, Issues, Opportunities, and Needs in the U.S. Beef Industry," 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(December 1991): 1137-45.
- Rasmusen, E. B., J. M. Ramseyer, and J. S. Wiley, Jr., "Naked Exclusion: Reply." *American Economic Review* 90(March 2000): 310-311.
- Rogers, R.T. and R.J. Sexton. "Assessing the Importance of Oligopsony Power in Agricultural Markets." *American Journal of Agricultural Economics* 76(1994): 1143-1150.
- Schnitzer, M. "Dynamic Duopoly with Best-price Clauses." *Rand Journal of Economics* 25(Spring 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(May 1993): 325-337.
- Schroeter, J. R. and A. Azzam. "Econometric Analysis of Fed Cattle Procurement in the Texas Panhandle," Report submitted to the USDA, Grain Inspection, Packers & Stockyards Administration, November, 1999.
- Segal, I. R. and M. D. Whinston. "Naked Exclusion: Comment." *American Economic Review* 90(March 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): 1087-1104.
- 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: 1998 Reporting Year*, Grain Inspection, Packers and Stockyards Administration., SR-00-1, July, 2000.
- U.S. Department of Agriculture, *Captive Supply of Cattle and GIPSA's Reporting of Captive Supply*, Grain Inspection, Packers and Stockyards Administration, January, 2002.
- 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): 629-639.

- 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., S. R. Koontz, and T. C. Schroeder. "Impacts from Captive Supplies on Fed Cattle Transaction Prices." *Journal of Agricultural and Resource Economics* 23(December 1998): 494-514.
- 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(July 2000): 88-108.
- Zhang, M. and R. J. Sexton. "FOB or Uniform Delivered Prices: Strategic Choice and Welfare Effects." *Journal of Industrial Economics* 49(June, 2001): 197-221.