ROLE OF CAPTIVE SUPPLIES

IN BEEF PACKING

by

Clement E. Ward
Ted C. Schroeder
Andrew P. Barkley
Stephen R. Koontz

United States Department of Agriculture

Packers and Stockyards Programs

Grain Inspection, Packers and Stockyards Administration

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PREFACE

Congress included $500,000 in the U.S. Department of Agriculture's (USDA) Packers and Stockyards Administration (now Grain Inspection, Packers and Stockyards Administration (GIPSA)) 1992 fiscal-year appropriation to conduct a study of concentration in the red meat packing industry. GIPSA solicited public comments on how to conduct the study and formed an interagency working group to advise the Agency on the study. Based on the public input and comments of the working group, GIPSA selected seven projects and contracted with university researchers for six of them.

The findings of the study are summarized in Packers and Stockyards Programs, GIPSA, USDA, *Concentration in the Red Meat Packing Industry*, February 1996. The technical reports of the contractors are published as a series of Grain Inspection, Packers and Stockyards Administration Research Reports (GIPSA-RR). The technical reports of the contractors are:

GIPSA-RR 96-1	Marvin L. Hayenga, Stephen R. Koontz, and Ted C. Schroeder, *Definition of Regional Cattle Procurement Markets*.
GIPSA-RR 96-2	Slaughter Cattle Procurement and Pricing Team, Texas A&M Agricultural Market Research Center, *Price Determination in Slaughter Cattle Procurement*.
GIPSA-RR 96-3	Clement E. Ward, Ted C. Schroeder, Andrew P. Barkley, and Stephen R. Koontz, *Role of Captive Supplies in Beef Packing*.
GIPSA-RR 96-4	S. Murthy Kambhampaty, Paul Driscoll, Wayne D. Purcell, and Everett D. Peterson, *Effects of Concentration on Prices Paid for Cattle*.
GIPSA-RR 96-5	Marvin L. Hayenga, V.J. Rhodes, Glenn A. Grimes, and John D. Lawrence, *Vertical Coordination in Hog Production*.
GIPSA-RR 96-6	Azzeddine Azzam and Dale Anderson, *Assessing Competition in Meatpacking: Economic History, Theory, and Evidence*. This project reviewed relevant research literature.

The seventh project analyzed hog procurement in the eastern Corn Belt and was conducted by the Economic Research Service, U.S. Department of Agriculture. The findings of this project are included in the summary report on the study referenced above and are not published in a separate technical report.

This report is based on work performed under contract for GIPSA, USDA. The views expressed in this report are those of the authors and are not necessarily those of GIPSA or USDA.

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LONG-RUN IMPACTS OF CAPTIVE SUPPLIES

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Andrew P. Barkley
Department of Agricultural Economics
Kansas State University

Ted C. Schroeder
Department of Agricultural Economics
Kansas State University

I. Introduction

Mergers involving several large meat packers in 1987 significantly increased the size of the second and third largest meat packing firms, creating what has been called the "Big Three" packers (IBP, Excel, and ConAgra). Those and other mergers continued structural changes toward fewer and larger firms and increased concentration in meat packing (Ward 1988). Behavioral changes in fed cattle procurement accompanied structural changes in meat packing. Some meat packers increased their use of non-cash-price coordination of fed cattle from feedlots to their slaughtering plants, rather than exclusive reliance on market price coordination.[1] Captive supplies take two forms: (1) *packer feeding* in packer-owned and commercial feedlots; and (2) *forward contracts*, which include cash price and basis forward contracts, and exclusive marketing agreements with individual cattle feeding firms.

Packer Feeding. Packer feeding of cattle parallels cattle feeding by cattle producers and investor-feeders prior to the time cattle are ready for slaughter. Packers purchase feeder cattle and place them on feed in packer-owned or commercial feedlots. When cattle reach slaughter weight and finish, packers transfer the cattle to their plants for slaughter. At the time the cattle are transferred from the feedlot to the slaughter plant, they are priced by a prearranged transfer pricing formula or accounting price.

Basis Forward Contracting. Basis contracting occurs for cattle on feed which are owned by cattle producers or investor-feeders. During the feeding period, a cattle owner and packer enter into a basis forward contract. A packer bids a futures market basis for the month cattle are expected to reach slaughter weight and finish. The feeder then has the option of determining when to price the cattle (i.e., select a futures market price). From that futures market price, a cash selling price is computed based on the agreed-upon basis. Sometimes the contract settlement price (i.e., futures market price) is chosen when the basis contract is signed. If so, the basis, futures market price, and cash sale price are all discovered on the date the contract is signed. If not, the bid price is discovered at a future date. For example, assume that after the basis contract is signed, a cattle feeder believes the futures market price for the specified contract month has attained a maximum value. The cattle feeder notifies the packer and chooses the then-current futures market price, thereby also determining the cash sale price based on the previously agreed-upon basis bid.

Exclusive Marketing/Purchasing Agreements. Exclusive feedlot marketing or packer purchasing agreements can take many forms. Essentially, they are exclusive supply contracts in which the cattle feeder agrees to market a specified number of cattle per some specified time

[1]Non-cash-price coordination is also referred to as packer-controlled supplies or captive supplies. The term “captive supplies” is used in this report.

period (e.g., week, month, or year) to a given buyer. Price is typically based on a prearranged formula. In one of the largest feeder-packer agreements, the base price is derived from the average price paid by the buyer for cattle delivered to one or more slaughter plants during a specified week. Premium and discount adjustments to the base price may reflect differences in cattle quality as well as other prearranged factors.

Three elements are common to each form of captive supplies. First, meat packers gain control over a portion of their slaughter volume weeks or months prior to the livestock being slaughtered. Second, meat packers gain increased control over the timing of delivery of purchased livestock for slaughter. Third, transactions between sellers and buyers do not result in a cash price which can be included in public market price reports.

Virtually the only form of captive supplies between cattle feedlots and packers in the early 1980s was packer-fed cattle in packer-owned feedlots, accounting for about 4 percent of steer and heifer slaughter in 1980 and 1985 (Packers and Stockyards Programs, Grain Inspection, Packers and Stockyards Administration).[2] The other two forms of captive supplies mentioned above grew in importance as the 1980s progressed. Special surveys conducted annually in leading cattle slaughtering states revealed that captive supplies accounted for 17 to 23 percent of annual steer and heifer slaughter over the 1988-1991 period. Most of the increase between the periods 1980-1985 and 1988-1991, and the variability in the level of captive supplies from 1988 to 1991, was due to the forward contracting of fed cattle.

A major question relating to structural and behavioral changes in meat packing is the effect of captive supplies on slaughter cattle prices. Little research has focused on why and how packers use captive supplies. While Packers and Stockyards Programs (P&S), Grain Inspection, Packers and Stockyards Administration, has conducted special surveys to determine the extent of captive supplies, little further analysis of that data has been done. It can be hypothesized that packers use captive supplies to secure a guaranteed quantity and quality of cattle in advance of slaughter to increase plant efficiency, reduce price risk, or gain leverage in the cash market, among other reasons. Questions remain regarding the long-run and short-run impacts of captive supplies, especially on fed cattle prices. Long-run and short-run impacts may be different. No research has recognized the interdependent nature of captive supplies and fed cattle prices. Captive supplies may affect plant costs and fed cattle price, while plant costs and fed cattle prices may simultaneously affect the extent of captive supplies. Nearly all research to date on captive supplies has been hampered by data limitations.

The next section delineates the research objectives. These objectives are followed by a review of the previous research in Section III. A theoretical model of forward contracting and captive supplies is developed in Section IV, and the model is further developed into an empirical

[2] The Packers and Stockyards Administration became Packers and Stockyards Programs within the Grain Inspection, Packers and Stockyards Administration (GIPSA) in 1994.

regression equation in Section V. The data are described in Section VI, and regression results are reported in Section VII. Conclusions comprise the final section.

II. Research Objectives

The overall objective of this research is to identify and quantify the determinants of captive supplies, and the effects of captive supplies on the beef market. Economists hypothesize (Purcell 1992; Ward 1991b) that captive supplies guarantee some portion of cattle supplies in advance of slaughter and smooth the flow of cattle to slaughter, thus increasing plant efficiency. No studies have examined the relationship over time between the form and level of captive supplies and plant utilization and gross margins. It is hypothesized that as the level of captive supplies increases, for a plant, the level of plant utilization increases, as does its gross margin.

Barkley and Schroeder applied previous theoretical work by Carlton to the supply of forward contract cattle by cattle feeders and the demand for forward contract cattle by beef packers. The model yields several important testable hypotheses. In particular, the model implies that the supply of contract cattle is an increasing function of the contract price, spot market price variability, and costs associated with price variability. The supply of contract cattle is a decreasing function of the expected spot market price. On the demand side, packers use contract cattle as a substitute for spot market purchases of fed cattle. As such, packer demand for spot market cattle depends on the level of captive supplies as well as relative prices.

The original objectives for this portion of the project included estimation of the supply of and demand for contracted cattle. This objective was based on the assumption that 5 years of monthly price data would be available. These data are not available, and as such we have not been able to pursue the formal estimation of supply and demand functions. However, we have estimated reduced-form models of possible determinants of contracted cattle. Estimation of the reduced form model yields statistical relationships between captive supplies and plant capacity and utilization, relative prices, price variability, and aggregate (national) supply conditions. As a result, a great deal has been learned about the causes and consequences of contracted cattle in beef markets, which was the original motivation for estimating the supply and demand functions.

III. Previous Research

Several studies suggest structural and behavioral changes in meat packing have lowered fed cattle prices over time. However, only a few recent studies have focused on captive supplies or included captive supplies explicitly in their analyses. These are: Elam; Eilrich et al.; Hayenga and O'Brien; Schroeder et al. 1992; Ward and Bliss; and Ward 1991b.

In one of the first studies on captive supplies, Ward and Bliss surveyed 3,700 cattle feedlots in 1989 to estimate the extent of forward contracting, and to obtain perceptions by cattle feeders of reasons for using contracts and their impacts. Survey results indicated that 12.7 percent of fed cattle in the major cattle feeding states in 1988 were procured using forward contracts. Ninety percent of forward contracting in 1988 occurred in the Plains states (Nebraska, Colorado, Kansas, Oklahoma, and Texas). Nearly two-thirds of all contracting was by cattle feedlots which marketed 20,000 or more cattle in 1988. Nearly all contracting (96 percent) was between feedlots and the Big Three packers.

Cattle feeders believed that the primary benefits to them from forward contracting were improved financing and locking in a known buyer (Ward and Bliss). They perceived that packers used forward contracts to guarantee a supply of cattle for slaughter and increase control over the timing of deliveries.

Elam focused on two aspects of captive supplies. First, he compared forward contracting in Texas feedlots with hedging fed cattle. Results indicated that contract prices were $0.28 to $0.59 per hundredweight (cwt) lower than hedge prices for steers and $0.86 to $1.64 per cwt lower for heifers. Cattle feeders were giving up a portion of the basis to packers when they forward contracted cattle.

Second, Elam studied the aggregate effect deliveries of captive supply cattle had on fed cattle prices in the U.S. and in four states (Texas, Kansas, Colorado, and Nebraska). Using time series regression analysis, he found that packer-controlled supplies lowered monthly average fed cattle prices over the period October 1988 to May 1991. For each 1,000 cattle delivered under captive supply arrangements, U.S. fed cattle prices declined by $0.01 per cwt. For individual states, the adverse price impact ranged from $0.003 to $0.05 per cwt.

Eilrich et al. also compared forward contracting with hedging fed cattle. Their results differed from Elam's in one significant way: Elam assumed that cattle feeders paid transportation costs for contracted cattle, as called for in most basis contracts. However, packers often waived that contract provision for cattle feeders and paid the transportation costs as they do in cash purchases of cattle. Eilrich et al. found that when transportation costs were waived, there was no significant difference between contract prices and hedge prices. When transportation costs were not waived, results were consistent with those of Elam.

Hayenga and O'Brien examined the effect captive supplies had on weekly average fed cattle prices. They used a seemingly unrelated regression analysis and found little evidence that forward contracting diminished fed cattle prices in Colorado relative to other market prices over the 15-month period from October 1988 to December 1989. Similarly, they found little evidence that forward contracting adversely affected the variability of fed cattle prices, providing support for Elam's results.

Schroeder et al. (1992) conducted the only study to date which examined the impacts of captive supplies on transactions prices for fed cattle. They collected data from feedlots in selected counties in southwest Kansas from May through November 1990. They used pooled cross-section, time-series regression analysis to determine the price effects of several factors. Results indicated a negative relationship between fed cattle prices and packer-controlled supplies. For the 6-month period, additional captive supplies decreased fed cattle prices in cooperating feedlots by $0.15 to $0.31 per cwt. Price impacts were not constant either for individual packers or for subperiods within the 6-month period. Ward (1991a) participated in a study with the Packers and Stockyards Administration to estimate impacts of captive supplies on fed cattle prices. However, no conclusive results were found.

IV. Theoretical Model of Fed Cattle Markets

Cattle feeding is characterized by price uncertainty: production decisions must be made before the spot price of fed cattle is known. Forward contracts introduce an element of certainty into an uncertain market environment. By selling cattle on contract, the feeder becomes capable of making production decisions given a certain market outlet and cattle price.[3] Forward contracts represent a risk-mitigating instrument for cattle feeders. Packers may also realize pecuniary benefits from forward contracting. There are large fixed costs associated with the operation of a large, modern slaughter facility. Therefore, securing a supply of cattle in advance of slaughter equal to plant capacity will reduce costs associated with operating the plant at a level different than the plant capacity.

A. The Supply of Forward Contracts by Feedlots

Cattle feedlots offer cattle on forward contract to packers to reduce the costs of operating in an uncertain environment.[4] This reduction of uncertainty takes two forms. First, price risk is reduced or eliminated. The contract specifies a legally enforceable formula-based price. For instance, basis contracts stipulate a guaranteed basis at the time of delivery, whereas flat price contracts stipulate a fixed delivery price. For the purposes of this report, these two are treated as identical because hedging allows cattle buyers and sellers to treat these as perfect substitutes. Second, search costs associated with finding a buyer are also reduced: a contractual arrangement can reduce or eliminate many of the costs associated with finding a buyer. Given the complex price discovery process, these savings may be substantial (Ward 1988). Risk-mitigation creates the incentive for feedlot managers to offer and/or accept forward contracts, and is the foundation of the theoretical model developed here.

Following Carlton, we assume that the costs associated with uncertainty can be represented by variability in the feedlot's cash flow. Costs to the cattle feeder are assumed to be

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[3]Throughout, we refer to fed cattle owners as "feedlots" or "feeders." Although feedlots often are not the owners of cattle, for the convenience of terminology we assume that they are. Implications of the model are not sensitive to this assumption.

[4]Cattle feeders are considered to be suppliers of contracts and packers are considered to be demanders of contracts.

a linearly increasing function of cash-flow variance. This assumption allows for the incorporation of uncertainty into the profit-maximization problem confronted by a representative cattle feeder. The assumption appears reasonable: Ward and Bliss found that, "The primary benefit to cattle feeders from forward contracting related to financing, according to cattle feeder [survey] respondents" (p. 6). The model does not rely on risk aversion as an incentive for contracting. Rather, the model asserts that there are real costs associated with price variability which result in the development of forward contracts to mitigate risk.

Assume that an individual feeder seeks to maximize expected profits, subject to a feedlot capacity of q head of cattle. The feeder is subject to fixed costs F and constant marginal costs c, and thus faces a downward-sloping average cost curve for all quantities of cattle produced up to q, the least-cost (optimal) quantity. Constant marginal costs is a reasonable assumption for the feedlot industry, because the major cost related to output is feed. We further assume n identical feedlots[5] all of which produce q cattle per market period.

Assume that there are two types of cattle markets, a spot market and a forward market. The production decisions of feedlots must be made prior to knowledge of the random spot price (p_2). The feedlot's optimization problem is to maximize profits by allocating the total quantity of fed cattle (q) between forward contracts (q_1) and the spot market (q_2), where $q = q_1 + q_2$. We assume that once cattle are finished, it is always more profitable to sell on the spot market than to dispose of cattle at positive disposal costs.

Expected feedlot profits are total revenues from the sale of cattle by contract (p_1q_1) and on the spot market ($E[p_2q_2]$) less fixed (F) and variable costs (cq) minus the costs associated with

$$\max_{q_1, q_2} E(\pi) = p_1 q_1 + E(p_2 q_2) - F - c(q_1 + q_2) - \lambda var[(p_2 - c) q_2].$$

cash flow variability. The feedlot's objective is profit maximization:

The allocation of fed cattle between forward contracts and the spot market is subject to the feedlot's capacity constraint $q = q_1 + q_2$. The spot price p_2 is assumed to be normally distributed around a mean of p_2^* with variance σ^2. The term λ is the degree that price variability

$$\max_{q_1} E(\pi) = p_1 q_1 + p_2^*(q - q_1) - F - cq - \lambda(q - q_1)^2 \sigma^2 .$$

enters the cost function. Incorporating these assumptions, (1) becomes:

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[5]This assumption is clearly violated in the real world: there is a wide dispersion of feedlot size, including both farmer-feeders and large commercial feedlots. The implications of the model remain valid when this assumption is relaxed.

Differentiation of the expected profit function (2) with respect to q_1 and q_2 yields the supply of forward contracts (3) and supply of cash cattle (4):

$$q_1 = q - [(p_2^* - p_1)/2\lambda \sigma^2] \quad [\text{Supply of forward contracts}]$$

A deeper understanding of the supply of forward contracts can be gleaned from equation (3). First, as variability in spot market price (σ^2) increases, or as the costs associated with price variability (λ) increase, more cattle will be sold on forward contract. Intuitively, as price risk

$$q_2 = [(p_2^* - p_1)/2\lambda \sigma^2] \quad [\text{Supply of cash market cattle}]$$

increases, so does the cost associated with such risk, and steps are taken by feedlots to avoid this cost. Second, an increase in the expected spot market price (p_2*) reduces the quantity of cattle sold on contract. Third, the supply of forward contracts is upward-sloping: an increase in the forward price (p_1) causes an increase in the quantity of contracts.

The representative feedlot is capable of selling any quantity of finished cattle up to the capacity constraint (q) through forward contracts. The expected spot price (p_2*) must be greater than the forward contract price (p_1) for a spot market to exist: $p_2^* > p_1 > c$. Restated, if feedlots could contract cattle at prices consistently equal to or greater than spot prices they would contract all cattle. The price p_1 must be greater than the cost of production for any cattle to be supplied by feedlots. Few feedlots sell cattle exclusively on contract, implying that $p_2^* > p_1$. This does not imply that the actual realized spot price is always greater than the forward price, only that the expected value (average price) is; the distribution of p_2 includes values less than p_1. Feedlots are willing to pay for reductions in the costs of variability by accepting a discounted price for forward contracted fed cattle.

B. Packer Demand for Forward Contracts

We established that the supply of forward contracts by feedlots results in a price of forward contracts equal to p_1, where $p_2^* > p_1$. The lower price of contracted cattle, the desire to schedule available livestock, reduced transactions costs, and possible consolidation of market power all provide motivation for packers to demand contracts (Purcell 1990b) Given these incentives, it appears that beef packers would never buy cattle on spot markets. In reality, fed cattle are purchased on both spot and forward markets, with a majority of purchases occurring in the spot market.

Uncertainty in the demand for beef products may contribute to the continued existence of both spot and contract markets. Purchases on contract must be made well in advance of slaughter, resulting in the possibility of buying more or less than the profit-maximizing quantity of cattle. There are costs associated with over-contracting, and these costs may result in packers purchasing less than total slaughter needs on contract and buying the remainder on the spot market at a higher expected price ($p_2^* > p_1$).

Transactions costs are an important determinant of the demand for forward contracts. Acquisition of fed cattle that conform to both desired quality characteristics and slaughter schedule is costly. Forward contracts reduce transactions costs by decreasing the number of buyers necessary to acquire the target level of cattle for slaughter. However, there are also transactions costs associated with the use of contracts. When cattle are purchased in advance, the packer's ability to base price on quality characteristics at the time of slaughter is reduced. To the degree that finished cattle characteristics are unknown at the initiation of a forward contract, contracting introduces additional uncertainty (and hence, costs) to fed cattle purchases. Given this uncertainty, packers may concentrate contract purchases on characteristics (breed, sex, etc.) that conform to plant specification. For example, Excel has procured Holstein cattle exclusively though contracts in some regional markets.

Beef packers claim that they are reluctant to purchase a significant fraction of their slaughter on contract due to fear of monopoly power claims and possible government regulation of cattle markets. Monopoly power could exist in a specific location due to the high transactions costs of hauling cattle. Purcell (1990a) argues that the Justice Department's unrestrictive beef packer merger policies during the 1980s focused primarily on short-run issues. As long-run impacts have been realized, concerns have arisen regarding the possible negative influence of beef packer consolidation on producers and/or consumers (Schroeter; Schroeter and Azzam; Ward 1988 and 1991b; Connor; Marion et al.). Industry apprehension regarding concentration is also apparent. A task force report of the National Cattlemen's Association listed eight concerns regarding beef packer market structure (Lambert). The top five were concentration, integration, packer control of supplies, price discovery, and competitiveness. Other industry groups are voicing similar concerns (e.g., Center for Rural Affairs). With the recent anxiety regarding beef packer concentration and market performance, packers may be reluctant to increase activities such as contracting that could result in greater government involvement in the fed cattle industry.

In the short run, large slaughtering facilities are subject to high costs when full capacity is not achieved (Purcell 1990b; Ward 1990). Substantial labor and capital costs are fixed to the packer, resulting in a U-shaped average cost curve; costs increase dramatically when capacity is underutilized in the short run. Define Q^* as the "target" (optimal, or full capacity) level of slaughter for a given time period (say, one week). The packer will purchase Q^* head of cattle by allocating total cattle purchased between both contract purchases (Q_1) and spot market purchases (Q_2), where $Q^* = Q_1 + Q_2$. Given the diversity of packer incentives to contract cattle, packer demand for contracts must be simplified to effectively model fed cattle markets. We abstract from beef product demand uncertainty, transactions costs, risk reduction, and political motivations by assuming that an individual packer's demand for cattle can be characterized as:

$$Q_1 = C - Dp_1 \qquad \text{[Firm demand for contracts]}$$

$$Q_2 = A - Bp_2 + \varepsilon \qquad \text{[Firm demand for spot cattle]}$$

where $var(p_2) = var(\varepsilon) = \sigma^2$, $E(\varepsilon) = 0$. While these assumptions may appear to be rigid, the abstraction is necessary to model the real world in a tractable fashion.

Determinants of packer demand for spot and contract cattle are implicit in the parameters A, B, C, and D. Little is known about the relative importance of the motivations of packers to purchase cattle in forward markets. Information on the quantity of cattle contracted is limited, and price data were unavailable for this report. Without this information, knowledge regarding the causes of packer demand for contracts will remain inhibited (Purcell 1990b).

The packer allocation of the derived demand for fed cattle between spot and forward markets modeled here is of a simple form: the demand for cattle is allocated on the basis of relative prices alone. The model assumes a given level of demand in each market (the parameters C and A are exogenous). In a more realistic (and more complicated) model, these parameters could be made endogenous by incorporating the underlying economic forces such as slaughter scheduling and potential market power that determine the allocation of cattle purchases between spot and forward markets.

One such determinant of the demand for contracts may be price variability. Packers may purchase forward contracts to reduce price variability (or cattle availability) in a manner analogous to the model of feeder supply. A more elaborate model of packer demand could be derived from a cost-minimization model that includes the cost of price (or quantity) variation. This type of model, however, does not capture what is considered a primary motivation of packers to contract: the controlled flow of livestock into processing facilities (Purcell 1990b). Here, packers purchase cattle to meet plant capacity requirements from the least-cost source, given the underlying determinants of contract demand.

Given the lower expected price of forward contracts and the continued use of spot markets, packers must have sufficient economic incentive to buy fed cattle in cash markets. The demand specifications in (5) and (6) reveals one incentive: as packers demand greater numbers of contracts, the price of contracted cattle (p_1) rises relative to the expected price of cattle purchased on spot markets (p_2*). This tradeoff between the two markets results in an equilibrium condition where some cattle are contracted and the remainder are bought in spot markets. This theoretical result is in accordance with real-world coexistence of both spot and forward cattle markets. However, one limitation of the model is that it does not yield predictions about the relative magnitude of contracting (the percent of slaughter that is contracted).

C. Model Equilibrium

We assumed that there are n identical feedlots in the market. Assume also that there are m identical packers in each cattle market. Market equilibrium is found by equating supply and demand in both the spot and forward markets, as in (7) and (8):

$$nq_1 = m[C - Dp_1] \quad \textit{[Contract Market Equilibrum]}$$

$$nq_2 = m[A - Bp_2 + \varepsilon] \quad \textit{[Spot Market Equilibrium].}$$

Divide both sides of (7) and (8) by the number of individual packers (m), and define z as

$$zq_1 = C - Dp_1 \quad \textit{[Contract Market Equilibrium]}$$

$$zq_2 = A - BP_2 + \varepsilon \quad \textit{[Spot Market Equilibrium].}$$

z=(n/m), the ratio of feeders to packers:
Equilibrium prices are derived by combining equations (9) and (10) with supply equations (3)

$$p_1 = [1/G][A + (2B\lambda\sigma^2 + z)(C/z - q)]$$

$$p_2 = [1/G][(C/z - q)z + A(1 + 2\lambda\sigma^2/z)]$$

and (4). The resulting equilibrium prices are (see Carlton for a similar derivation):
where G = $B + D[1 + (2B\lambda\sigma^2/z)]$.

The benefits of the theoretical model derived above result from refutable hypotheses derived from the comparative statics of equations (11) and (12).

D. Fed Cattle Market Model Comparative Statics

The results of the comparative static analysis are presented in table 1, and the price impacts of a shock to each of the exogenous variables are discussed in the remainder of this section.

Changes in Variability of Spot Market Price: σ^2

An exogenous increase in spot market price variability results in a decrease in forward contract prices and an increase in the spot market price of fed cattle. Intuitively, as feedlots become subject to increased revenue variability, a greater share of cattle will be allocated to contracts, resulting in fewer cattle supplied to spot markets. These shifts in supply result in accompanying price movements in the two markets. Increases in the costs of variability (λ) have impacts identical to increases in price variability.

An important implication of this model is that the level of forward contracting and the variation in cattle prices may be simultaneously determined. The comparative statics indicate a positive relationship between the supply of contracts and price variability. However, the causality of this relationship is not forthcoming from the model. Increased variability may result in more contracting, or increased levels of contracting may result in larger variation in spot market prices. One refutable hypothesis generated from the model is the positive correlation between contracting and spot price variability. Further empirical work is needed to (1) determine if the predicted correlation exists, and (2) determine the direction of causality between contracting and spot price variability.

Changes in the Demand for Cattle: C and A

An increase in the demand for contracted cattle can be modeled as an increase in the intercept of the contracted cattle demand curve, C. An increase in demand for contracts by packers could result from the need to meet capacity requirements at large slaughtering facilities or attempts to secure localized market power. Contract demand expansion results in higher prices in both spot and forward markets, with a greater rise occurring in the contracted cattle market (table 1). Similarly, an increase in the demand for spot cattle (an increase in A) results in higher prices in both markets and a larger increase in the spot price. Note that A and C could be endogenized by the inclusion of other demand factors (e.g., prices of substitutes, price variability, etc.) with the same conclusions.

Suppose that the share of slaughter represented by captive supplies increased. An exogenous increase in captive supplies would decrease the demand for spot market purchases (a decline in A). A decline in A would result in price decreases in both forward and spot markets, and a larger relative decline in cash market prices (p_2* would decrease relative to p_1). This prediction is consistent with the empirical work of Schroeder et al. (1992) and Elam, who found spot price discounts associated with an increase in the use of captive supplies, holding other variables constant.

Changes in the Relative Number of Feedlots: z

It was assumed that all firms operate at a fixed feedlot capacity, q. If more feedlots entered the fed cattle market at this given capacity constraint, an increase in the supply of cattle (nq) would result. A shift in supply would have price-depressing effects in both spot and forward markets. Forward contract prices would fall to a greater extent than would spot prices. This relative decrease in contract price is explained by the potential costs of revenue variability increasing at an increasing rate as the quantity of cattle available for the spot market increases. Restated, from equation (2), the derivative of $E(\pi)$ with respect to σ^2 is an increasing function of q_2 and a decreasing function of q_1.

The lower relative price of contracts would result in an increase in the quantity of contracts demanded. This theoretical result leads to a testable hypothesis: increasing the number of feedlots in a regional cattle market is positively correlated to the use of contracts, holding all else constant.

Changes in Feedlot Capacity: q

Increases in feedlot capacity (assuming feedlots operate at capacity) are expected to have a price-depressing effect in both markets for the same reason as increases in the number of feedlots do. Increased supply drives prices down, with the forward contract price falling relatively more than the spot price.

V. Empirical Model of Fed Cattle Markets

The refutable hypotheses of the theoretical model rely heavily on prices for both spot transactions and contracted cattle. Data on contract prices were unavailable, resulting in necessary modifications to the original research objectives, which included the estimation of supply and demand functions for both spot and contract cattle markets. Instead, the theoretical model is utilized to generate a reduced-form model of the determinants of contracting behavior: those variables which the economic model of fed cattle markets described in the previous section predicts will be associated with the level of captive supplies of fed cattle.

In the reduced-form model, the included variables reflect actions of both the suppliers of captive supplies (feedlots) and the demanders of captive cattle (packers). For example, the theoretical model predicts that an increase in the expected spot price (p_2*) will result in an increase in the demand for captive supplies (q_1) by packers, and a decrease in the supply of captive supplies by feedlots. The actual change in the level of captive supplies will reflect the interaction of both simultaneous forces acting in the market. Therefore, the model which is specified and estimated below is an attempt to uncover those variables that are associated with captive supplies through either packer (demand) or feedlot (supply) behavior.

The theoretical model can be summarized by the following reduced-form equation:

$$CAPTIVES = f(CATTLE\ PRICES, PRICE\ VARIABILITY,$$
$$CATTLE\ AVAILABILITY, SCHEDULING\ COSTS)$$

where CAPTIVES refers to the level of captive supplies, including both contracted cattle and packer-fed cattle. The use of captive supplies is a relatively recent market phenomenon, and has increased steadily in the past several years.

The theoretical model presented in the previous section emphasized the allocation of cattle between cash sales and contracting, based on the price of each type of sale. Therefore, CATTLE PRICES are anticipated to be a major determinant of contracting and packer feeding behavior both among cattle feeders and packers, and are included in the model. Both cash and futures prices are information available both to feeders and packers at the time of contracting, assumed to be month t-4. As such, both cash prices and futures prices are included in the model

$$CATTLE\ PRICES_{t-4} = g(CASH_{t-4}, BASIS_{t-4})$$

with the inclusion of CASH and BASIS variables, as indicated in (14).
Price variability played a major role in the theoretical model: the model predicted a positive association between the level of contracting and the variability of prices, due to the costs

$$PRICE\ VARIABILITY_{t-4} = h(CASHVAR_{t-4})$$

associated with price variability.
Related to price variability is the availability of cattle: contracting is hypothesized to be a method of "locking in" cattle during times of low availability of cattle. Two variables that provide useful information about expected cattle availability are the total United States slaughter

$$CATTLE\ AVAILABILITY_{t} = k(KILL_{t-12}, UTILIZE_{it-12})$$

(KILL) and last year's plant utilization rate (UTILIZE), both lagged 12 months.
The variable KILL is the total number of cattle slaughtered in the United States (Western Livestock Market Information Project). Utilization is defined as the number of cattle slaughtered at plant I in month t, divided by plant capacity. The utilization variable for 12 months prior to slaughter is expected to indicate cattle availability in a given month t, which is subject to annual cyclicality in livestock production and marketing.

Ward (1990) and Purcell (1990b) have described the average costs facing a packer as U-shaped, with rapidly increasing costs for slaughter levels which differ from the optimal level, or "full capacity." To include these rising costs for sub- or super-optimal levels of slaughter, the capacity level of a given plant (CAPACITY) is included in the model. The capacity squared term, (CAPSQ) is also included to capture any nonlinear relationships between the CAPACITY variable and contracting behavior.

$$SCHEDULING\ COSTS_t = m(CAPACITY_t, CAPSQ_t)$$

The econometric model is found by combining equations (13) through (17) for each plant I in

$$CAPTIVES_{it} = \alpha + \beta_1(CASH_{t-4}) + \beta_2(BASIS_{t-4}) + \beta_3(CASHVAR_{t-4})$$
$$+ \beta_4(KILL_{t-12}) + \beta_5(UTILIZE_{it-12}) + \beta_6(CAPACITY_{it}) + \beta_7(CAPSQ_{it}) + \varepsilon_{it}$$

month t, as in equation (18).
To take into account the two major types of captive supplies, contracting and packer-fed cattle, the model is estimated for three different dependent variables ($CAPTIVES_{it}$), representing three types of captive supplies: (1) the total number of cattle contracted and packer-fed in month t at plant I ($FEDCON_{it}$), (2) contracted cattle only ($CONTRACT_{it}$), and (3) packer-fed cattle only ($PACKFED_{it}$).

The levels of contracted cattle and packer-fed cattle were expected to be related to each other. Specifically, contracted cattle may be substitutes for packer-fed cattle, as both types of captive supplies are used to "lock in" a predetermined supply of cattle for slaughter. To account for this possibility, the regression model with $CONTRACT_{it}$ as the dependent variable includes the level of packer-fed cattle ($PACKFED_{it}$) as a simultaneously-determined explanatory variable. Similarly, the regression with $PACKFED_{it}$ as the dependent variable includes $CONTRACT_{it}$ as a simultaneously-determined independent variable. The levels of contracted and packer-fed cattle are determined simultaneously in month t-4, four months prior to slaughter. This results in the possibility of simultaneity between $CONTRACT_{it}$ and $PACKFED_{it}$: the theoretical model indicates that packers will determine these two forms of captive supplies in a joint decision-making process.

To account for the possibility of simultaneity in the statistical model, two-stage least squares regression was employed. The first stage regressed the endogenous variable ($PACKFED_{it}$ in regression two, and $CONTRACT_{it}$ in regression three) on the instrumental variables of all exogenous and lagged endogenous variables. Next, the predicted values of the endogenous variables were used as an independent variable in the second-stage regressions.

The three regression models analyzed in this study are now summarized. In Regression One, the total number of contracted and packer-fed cattle ($FEDCON_{it}$) is the dependent variable. Substitute $FEDCON_{it}$ for $CAPTIVES_{it}$ in equation (18) to get the ordinary least squares model in equation (19).

$$FEDCON_{it} = \alpha + \beta_1(CASH_{t-4}) + \beta_2(BASIS_{t-4}) + \beta_3(CASHVAR_{t-4})$$
$$+ \beta_4(KILL_{t-12}) + \beta_5(UTILIZE_{it-12}) + \beta_6(CAPACITY_{it}) + \beta_7(CAPSQ_{it}) + \varepsilon_{it}$$

Regressions Two and Three capture the two types of captive supplies available to packers: contract cattle and packer-fed cattle. Intuitively, it appears plausible that these two methods of acquiring cattle prior to slaughter may be substitutes. Therefore, a simultaneous equation approach to the estimation of contracted and packer-fed cattle is necessary. Specifically, to test whether or not the level of packer-fed cattle is related to contracted cattle, the level of packer-fed cattle is included in the contract regression, and the level of contracted cattle in the packer-fed regression. These two types of captive supplies are likely to be simultaneously determined. As a result, two-stage least squares regression is employed to purge Regressions Two and Three of any simultaneity that may exist between the two variables.

In Regression Two, the level of contracted cattle ($CONTRACT_{it}$) is the dependent variable, and the predicted value of packer-fed cattle ($PACKFED_{it}$*) is included as an independent variable. The asterisk indicates the predicted value from the first stage of the two-stage least squares regression procedure. For the two stage least squares contracted cattle regression,
substitute $CONTRACT_{it}$ for $CAPTIVES_{it}$ in equation (18), and add an additional independent

$$CONTRACT_{it} = \alpha + \beta_1(CASH_{t-4}) + \beta_2(BASIS_{t-4}) + \beta_3(CASHVAR_{t-4}) + \beta_4(KILL_{t-12})$$
$$+ \beta_5(UTILIZE_{it-12}) + \beta_6(CAPACITY_{it}) + \beta_7(CAPSQ_{it}) + \beta_8(PACKFED^*_{it}) + \varepsilon_{it}$$

variable, as in equation (20).
Finally, packer-fed cattle are analyzed in Regression Three, where $PACKFED_{it}$ is the dependent variable and the predicted values of contracted cattle ($CONTRACT_{it}$*) are included as an

$$PACKFED_{it} = \alpha + \beta_1(CASH_{t-4}) + \beta_2(BASIS_{t-4}) + \beta_3(CASHVAR_{t-4}) + \beta_4(KILL_{t-12})$$
$$+ \beta_5(UTILIZE_{it-12}) + \beta_6(CAPACITY_{it}) + \beta_7(CAPSQ_{it}) + \beta_8(CONTRACT^*_{it}) + \varepsilon_{it}$$

independent variable, as in the two-stage least squares regression in equation (21).
It was anticipated that the level of captive supplies may be related to factors that are specific to each plant, such as plant location or the plant age, which are not captured by the included variables. To test for this possibility, fixed-effect regressions were estimated by inclusion of a qualitative (0-1) variable for each plant in the FEDCON, CONTRACT, and PACKFED regressions. One plant was selected as the reference plant, and was omitted from the fixed-effect regressions to avoid simultaneity, due to its minimal level of captive supplies.

The data employed in the three regression models will be described in the next section, followed by the regression results, and conclusions.

VI. Data Description and Analysis

The Packers and Stockyards Programs, Grain Inspection, Packers and Stockyards Administration, is the major source of data for this study: monthly data were collected over the period 1989 to 1993 by the GIPSA, at both the firm and plant levels.[6] The original data set included a different number of plants for each of the 6 years. The smallest number of included plants was 39 (1993). The econometric model specified in the previous section required a complete data set, including monthly data for each plant over the entire 6-year period. This reduced the original data set to 31 plants representing 12 firms between 1989 and 1993.

The data are at the monthly plant level for the period 1989 to 1993 for the level and percent of slaughter of (1) contracted cattle, which includes fixed price and basis contracts, marketing agreements, and "other contracts," (2) packer-fed cattle, and (3) contracted and packer-fed cattle. Also included are data for plant capacity, plant utilization, and slaughter levels. These data are presented as annual averages for the five years 1989 to 1993, and monthly averages in tables A1 to A9. These data also appear in figures A1 through A6.

Figure A1 summarizes the data presented in tables A1 through A3 by displaying the annual averages of captive supplies, by type, over the 5-year period 1989 to 1993. The figure shows that, as a percent of slaughter, packer feeding remained fairly constant at approximately 6 percent, whereas contracting decreased from 18 percent in 1989 to 14 percent in 1991, and remained at 14 to 15.5 percent until 1993. These data are shown in absolute level of captive supplies (head per month) in figure A2, which demonstrates the same relationship as the percentage data (tables A4 to A6).

Average monthly plant capacity levels increased steadily over the 5-year period, from 73,900 head per month in 1989 to 83,507 head per month in 1993 (table A7, figure A3). Similarly, average monthly slaughter levels increased from 57,123 in 1989 to 60,713 in 1993 (table A9, figure A3).

Average captive supply data by month are presented in figures A4 through A6. Both the level of packer-fed cattle and packer feeding as a percentage of slaughter remained fairly constant across months, whereas contracting behavior increased in April, June, and December (figures A4 and A5). The large level of captive supplies as a percentage of slaughter in June (figure A4) can be explained primarily as an increase in the level of contracting in that month (figure A5), whereas the peaks in April and December are due not only to increases in contracting, but also to decreases in slaughter levels for those 2 months (tables A4, A9; figures A5 and A6). Monthly slaughter was lowest in January and April, and relatively low in July and the October to December season (table A9, figure A6).

The empirical model developed above required 1-year (12 month) lagged observations of to define the capacity variable, which further reduced the data set by 12 monthly observations for each plant, resulting in 1,860 total observations (31 plants over the 5-year period 1989 to 1993).

[6]Data for 1988 were used for the lagged slaughter variable to define the capacity variable.

Finally, 8 temporary plant closings resulted in the elimination of 25 further observations, leaving the final number of observations included in the econometric analysis at 1,835.

Based on preliminary regressions, which demonstrated a high level of statistical significance of the $CAPACITY_{it}$ variable, contracting behavior was expected to be related to the size of the packing plant. Therefore, regression models were run on 3 data sets: (1) all 31 plants, (2) the largest 15 plants, with average monthly slaughter over 50,000 head, and (3) the smallest 16 firms, with less than 50,000 head killed per month on average. Summary statistics of the data for each of these three categories are reported in table 2.

CONTRACT cattle comprised approximately three-quarters of all captive supplies over the 60-month period investigated here (table 2). Contracted cattle and packer-fed cattle are highly variable, as evidenced in figures 1 and 2. The "sawtooth" pattern of both graphs indicates that captive supply levels fluctuate annually. The variable FEDCON, the sum of contracted and packer-fed cattle, appears in figure 3. There is a slight downward trend to the quantity of captive supplies over the period 1989 to 1993. This trend, however, is weak and a large degree of volatility exists in the FEDCON variable.

Price data are from Knight-Ridder, and include the variance of fed cattle cash price (CASHVAR, figure 4), the level of fed cattle cash price (CASH, figure 5), and the basis (BASIS, figure 6). Cash prices for fed cattle in the Texas Panhandle exhibited a distinct downward trend over the period of investigation, broken by a few shorter periods of sharp price increases (figure 5).

The variability of cash prices for fed cattle followed a relatively flat trend, accompanied by sharp one-period increases in late 1989 and 1991 (figure 4). Monthly fed cattle basis appeared to follow an annual cycle of lower basis early in the year and higher levels of basis late in the year (figure 6). Another explanatory variable that followed a cyclical pattern between 1989 and 1993 is KILL, the monthly federally-inspected U.S. cattle slaughter (figure 7). Total U.S. slaughter varied between approximately 2.4 and 2.9 million head over the 1989 to 1993 period.

Plant utilization (UTILIZE) is presented in figure 8. This variable is defined as the number of cattle slaughtered at plant I in month t, divided by plant capacity. Plant utilization was quite volatile, ranging from 65 to 85 percent, with an average plant utilization rate of 76.71 percent for all plants (table 2). The utilization rate for the 16 larger plants was 78.12 percent, slightly higher than the rate for small plants, whose average utilization rate was 75.18 percent (table 2). Plant capacity increased steadily throughout the 60-month period of investigation from approximately 73,000 head in 1989 to 85,000 head at the end of 1993.

VII. Results

Tables 3 through 5 report the regression results for the empirical models in equations (19) through (21). Table 3 reports the results for FEDCON, which includes both contracted and packer-fed cattle. A strong positive relationship exists between cash prices at the time of contracting (period t-4, four months prior to slaughter) and the level of captive supplies. The responsiveness of captive supplies to cash prices is relatively large, 1.715 for all plants and 2.706 for large plants. The association of captive supplies with higher cash price levels may reflect the attempt by packers to "lock in" a supply of cattle at a level near plant capacity in periods of "tight" or reduced cattle availability. To the extent that higher prices reflect reduced cattle availability, packers could be contracting cattle to avoid the possibility of paying high short-run cattle prices to meet slaughter capacity. Feedlots may desire to provide captive supply contracts in periods of higher prices in order to guarantee the relatively higher prices. In periods of low cattle prices, feedlots may be waiting for the price to rise in the future.

Futures prices are also important determinants of captive supply levels, as reflected in the highly significant negative coefficient on BASIS for large plants and all plants. However, the relative magnitude of the impact of BASIS on FEDCON is small, as evidenced by the estimated elasticity of -0.037 for all plants (table 3).

Since BASIS is defined as the cash price minus the futures price, smaller levels of BASIS are associated with a high futures price relative to the cash price. Feedlots are likely to be willing to supply more captive supply contracts in this situation of a narrow basis to capture the relatively high futures price. This hypothesis is confirmed by the negative and significant regression coefficient on the BASIS variable in table 3 for all plants and the 16 largest plants.

An unexpected result was the statistical insignificance of cash price variability for packer-fed cattle and total captive supplies. One of the major predictions of the theoretical model was a positive association between price variability and the level of captive supplies. The econometric analysis of contracted and packer-fed cattle, however, indicates that cash price variability is positively associated with only the level of contract cattle for only the 16 largest plants, but is not a determinant of packer-fed cattle or total levels of captive supplies. The regression results imply that cash and futures prices are more important determinants of captive supply levels than price variability.

Cattle availability, as measured by total United States slaughter (KILL) 1 year before the slaughter date, was statistically insignificant in all regressions. This result indicates that the variable, intended to capture cattle availability in a given month from the previous year's slaughter date, is not a good approximation of the amount of cattle available in the market. While KILL was statistically insignificant, the UTILIZE variable was highly significant with a large calculated elasticity of 0.894. Plant utilization is expected to be highly important for packing plants: the costs associated with slaughter levels below full capacity are very high for large plants, according to Ward (1990) and Purcell (1990b).

The high level of statistical significance of the UTILIZE variable provides evidence that plants use captive supplies to maintain slaughter levels at full capacity. The results of the regressions reported in table 3 imply that maintaining slaughter levels at high rates of utilization, together with cash and futures prices, have a large impact on the level of contracted and packer-fed cattle. This result is consistent with the stated reasons that packers give for the increasing use of contracts and other forms of captive supplies: to maintain a steady flow of cattle to the plant. The association between plant utilization and captive supplies is larger for small plants than for large plants, as reflected by the greater elasticity estimate (table 3).

The CAPACITY and CAPSQ variables were highly statistically significant for all plants in all regressions. By combining the regression coefficients for CAPACITY and CAPSQ, we find a parabolic relationship between plant capacity and the level of captive supplies: as capacity increases, captive supplies decrease, and then increase after a minimum level of captive supplies is attained at a plant capacity of approximately 57,600 head per month. Table 2 shows that this plant capacity is smaller than the average plant capacity. The nonlinear relationship captures an important result of this investigation: that captive supplies are undertaken at higher levels by (1) small plants and (2) large plants, whereas "average" sized plants use captive supplies relatively less.

Table 4 presents the two-stage least squares regression results for contracted cattle only. The explanatory power is fairly good for all plants and large plants, but less good for small plants only. Contracted cattle comprise approximately 75 percent of all captive supplies, as measured in this study (table 2). Thus, it is no surprise that the qualitative regression results for CONTRACT are similar to those for FEDCON reported in table 3. One significant difference is the inclusion of the endogenous variable PACKFED. The statistically significant negative sign on the PACKFED variable for all plants and large plants indicates that contracting and packer-feeding may be "substitutes" for packers, who will use either method of captive supplies to reach their target level of captive cattle in a given month. A second notable difference between the CONTRACT and FEDCON regressions is the positive association between cash price variability and contracted cattle. This result complies with the theoretical expectation that contracting increases when cash price volatility is higher.

The regression results for packer-fed cattle appear in table 5. The explanatory power of the PACKFED regressions is quite low, with adjusted R-Square values ranging between 0.1347 for all plants and 0.1557 for the 16 largest plants. Packer-fed cattle are roughly one-quarter of total captive supplies, so some divergence from the FEDCON regression results in table 3 is anticipated. As expected, the negative sign on the CONTRACT variable for all plants and large plants demonstrates that contracting and packer-feeding are "substitutes." This indicates that large plants and more likely to allocate the total level of captive supplies between packer-fed cattle and contracted livestock. The UTILIZE variable was highly significant for all plants and small plants, confirming a strong positive relationship between plant utilization and (1) captive supplies, (2) contracted cattle, and (3) packer-fed cattle.

Regression results for fixed plant effects are presented in tables 6 through 8. The overall results of the regressions were good, with an adjusted R-Square of 0.7853 for FEDCON (table 6), 0.7645 for CONTRACT (table 7), and 0.9136 for PACKFED (table 8). The high level of statistical significance for 26 of the 30 included plants in the FEDCON regression, together with the insignificant estimated coefficients on prices, indicates that captive supplies are determined by each individual plant.

The UTILIZE, CAPACITY, and CAPSQ variables all remain significant, and of the anticipated sign. Cash price volatility was found to be positively related to the level of captive supplies in the CONTRACT regression (table 7). However, PACKFED was statistically insignificant in the fixed effect model reported in table 7. Similarly, CONTRACT was not a significant determinant of PACKFED (table 8). Packer-feeding was found to be associated with high levels of BASIS, indicating that packers may purchase more cattle on feed when futures prices are high relative to the cash price.

VIII. Conclusions

The major results of this analysis include: (1) The most notable feature of captive supply behavior across plants is the huge variability of contracting and packer-feeding. This variability does not appear to be systematically related to firms, plant locations, or regions. (2) Relative prices play a major role in determining the level of captive supplies among the 16 largest plants, but do not influence captive supply levels of the 15 small plants. (3) Cash price variability is positively associated with the level of contract cattle for the 16 largest plants, but is not a determinant of packer-fed cattle or total levels of captive supplies. (4) Plant utilization is an important determinant of captive supplies for both large and small cattle packing plants, with a relatively larger impact on small plants, reflecting high costs of slaughter levels below full capacity. (5) Information on cattle availability, as measured by total United States slaughter from 1 year prior to slaughter, does not appear to be a consistently important determinant of captive supplies. (6) Contracted cattle and packer-fed livestock appear to be substitute methods of meeting slaughter capacity for packers, particularly for the 16 largest plants. (7) The level of captive supplies is higher among small plants and large plants, whereas plants characterized by average capacity levels were found to use captive supplies to a smaller degree, all else held constant.

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Western Livestock Market Information Project.

Tables and Figures

Table 1. Comparative Statics of Fed Cattle Market Model.

Forward Contract Price (p_1)	Expected Spot Price (p_2*)	Price Difference (p_2* - p_1)
$\frac{\delta p_1}{\delta \sigma^2} < 0$	$\frac{\delta p_2}{\delta \sigma^2} > 0$	$\frac{\delta (p_2 - p_1)}{\delta \sigma^2} > 0$
$\frac{\delta p_1}{\delta C} = \frac{(2B\lambda \sigma^2 + z)/z}{G} > 0$	$\frac{\delta p_2}{\delta C} = \frac{1}{G} > 0$	$\frac{\delta (p_2 - p_1)}{\delta C} < 0$
$\frac{\delta p_1}{\delta A} = \frac{1}{G} > 0$	$\frac{\delta p_2}{\delta A} = \frac{[1 + (2D\lambda \sigma^2)/z]}{G} > 0$	$\frac{\delta (p_2 - p_1)}{\delta A} > 0$
$\frac{\delta p_1}{\delta z} < 0$	$\frac{\delta p_2}{\delta z} < 0$	$\frac{\delta (p_2 - p_1)}{\delta z} > 0^a$
$\frac{\delta p_1}{\delta q} = \frac{-(2B\lambda \sigma^2 + z)}{G} < 0$	$\frac{\delta p_2}{\delta q} = \frac{-z}{q} < 0$	$\frac{\delta (p_2 - p_1)}{\delta q} > 0$

[a]Assume that (C/z - q) < 0; (BC/D) > A.

Table 2. Summary Statistics of Variables Used in Captive Supply Regressions, 1989-1993.

Variable	Definition	All 31 Plants 60 months n=1,835 Mean	Std. Dev.	15 Small Plants 60 months n = 882 Mean	Std. Dev.	16 Large Plants 60 months n = 953 Mean	Std. Dev.
$CONTRACT_t$	Contracted Cattle	9,101.00	14,088.45	4,074.75	6,221.37	13,752.79	17,363.42
$PACKFED_t$	Packer-Fed Cattle	2,977.03	7,697.56	1,743.09	3,736.43	4,119.03	9,925.33
$FEDCON_t$	Cont. & Fed Cattle	12,078.03	15,726.11	5,817.84	7,438.61	17,871.83	18,849.90
$CASHVAR_{t-4}$	Variance of CASH	0.83	0.68	0.84	0.69	0.83	0.68
$CASH_{t-4}$	Cash Price	65.09	4.238	65.112	4.24	65.06	4.24
$BASIS_{t-4}$	Cash-Futures Price	1.83	3.259	1.817	3.27	1.84	3.25
$KILL_{t-12}$	US Slaughter (1000s)	2,724.53	166.194	2,724.64	166.34	2,724.42	166.15
$UTILIZE_{t-12}$	Plant Utilization	76.71	14.103	75.18	15.17	78.12	12.89
$CAPACITY_t$	Plant Capacity	7.83E4	4.18E4	4.16E4	1.47E4	1.12E5	2.77E4
$CAPSQ_t$	CAPACITY Squared	7.78E9	7.27E9	1.95E9	1.16E9	1.34E10	6.16E9

Sources: Cash price data are the Texas Panhandle-Oklahoma direct Fed Steer price ($/cwt) from the USDA Marketing Service (Knight-Ridder CD-ROM), deflated by the personal consumption expenditures implicit price deflator (PCE), where 1987=100 (United States Department of Commerce).

Futures price data are from the Chicago Mercantile Exchange (Knight-Ridder CD-ROM).
United States slaughter data (in 1,000 head) are from Western Livestock Market Information Project.
Plant utilization is defined as the plant slaughter level divided by the plant capacity level (PSA).
Capacity is defined as maximum plant slaughter attained prior to the date of slaughter, 1988 to 1993 (PSA).

Table 3. O.L.S. Regression Results for Fed and Contracted Cattle.[a]

Regression One: dependent variable = total number of packer-fed cattle and contracted by plant I ($FEDCON_{it}$).

Independent Variables:	All 31 Plants: Estimated Parameter	All 31 Plants: Elasticity[b]	15 Small Plants: Estimated Parameter	15 Small Plants: Elasticity[b]	16 Large Plants: Estimated Parameter	16 Large Plants: Elasticity[b]
INTERCEPT	-11256.0** (-1.955)	--	7,419.964 (1.441)	--	-47,710.0*** (-3.999)	--
$CASHVAR_{t-4}$	514.941 (1.182)	0.035	-166.170 (-0.449)	-0.024	1,110.643 (1.479)	0.052
$CASH_{t-4}$	318.280*** (3.791)	1.715	-123.350* (-1.733)	-1.381	743.274*** (5.089)	2.706
$BASIS_{t-4}$	-246.862** (-2.445)	-0.037	111.192 (1.288)	0.035	-624.784*** (-3.590)	-0.064
$KILL_{t-12}$	-1.457 (-0.739)	-0.329	-2.325 (-1.382)	-1.089	-0.779 (-0.230)	-0.119
$UTILIZE_{t-12}$	140.776*** (6.865)	0.894	132.342*** (8.063)	1.710	187.342*** (4.865)	0.819
$CAPACITY_t$	-0.425*** (-14.062)	-2.755	0.343*** (3.615)	2.455	-0.395*** (-3.709)	-2.473
$CAPSQ_t$	3.69E-6*** (21.196)	2.379	-5.92E-6*** (-4.912)	-1.984	3.7E-6*** (7.716)	2.763

	All 31 Plants	15 Small Plants	16 Large Plants
NO. OBSERVATIONS	1835	882	953
R-SQUARE	0.4526	0.1493	0.4179
ADJUSTED R-SQUARE	0.4505	0.1424	0.4135
F-TEST	215.800***	21.905***	96.901***
ROOT MSE	11657.454	6888.495	14435.333

[a]T-statistics appear in parentheses under the parameter estimates. Three asterisks represent statistical significance at the 0.01 level; two asterisks, the 0.05 level, and one asterisk, the 0.10 level.
[b]Elasticities are calculated at the mean value of the independent variables.

Table 4. Two-Stage Least Squares Results for Contracted Cattle.[a]

Regression Two: dependent variable = total number of cattle contracted by plant I ($CONTRACT_{it}$).

	All 31 Plants		15 Small Plants		16 Large Plants	
Independent Variables:	Estimated Parameter	Elasticity[b]	Estimated Parameter	Elasticity[b]	Estimated Parameter	Elasticity[b]
INTERCEPT	-8820.362*	--	5,171.918	--	-30,531.0***	--
	(-1.674)		(1.145)		(-2.762)	
$PACKFED_t$	0.415***	-0.136	-0.079	-0.034	-0.453***	-0.136
	(-11.855)		(-1.247)		(-9.673)	
$CASHVAR_{t-4}$	559.706	0.051	-63.904	-0.013	1121.156*	0.068
	(1.405)		(-0.197)		(1.625)	
$CASH_{t-4}$	273.184***	1.954	-67.179	-1.073	605.242***	2.863
	(3.555)		(-1.074)		(4.494)	
$BASIS_{t-4}$	-234.419***	-0.047	61.143	0.027	-571.265***	-0.076
	(-2.539)		(0.807)		(-3.572)	
$KILL_{t-12}$	-1.805	-0.054	-2.198	-1.470	-1.506	-0.298
	(-1.001)		(-1.491)		(-0.484)	
$UTILIZE_{t-12}$	133.010***	1.121	98.032***	1.809	198.756***	1.129
	(7.089)		(6.724)		(5.617)	
$CAPACITY_t$	-0.387***	-3.331	0.189**	1.928	-0.528***	-4.302
	(-13.960)		(2.249)		(-5.367)	
$CAPSQ_t$	3.35E-6***	2.862	-3.02E-6***	-1.444	4.1E-6***	3.993
	(20.834)		(-2.808)		(9.312)	
NO. OBSERVATIONS	1835		882		953	
R-SQUARE	0.4330		0.0680		0.4256	
ADJUSTED R-SQUARE	0.4305		0.0594		0.4207	
F-TEST	174.309***		7.956***		87.430***	
ROOT MSE	10663.360		6038.443		13259.001	

[a]T-statistics appear in parentheses under the parameter estimates. Three asterisks represent statistical significance at the 0.01 level; two asterisks, the 0.05 level, and one asterisk, the 0.10 level.
[b]Elasticities are calculated at the mean value of the independent variables.

Table 5. Two-Stage Least Squares Results for Packer-Fed Cattle.[a]

Regression Three: dependent variable = number of cattle fed by plant I ($PACKFED_{it}$).

Independent Variables:	All 31 Plants Estimated Parameter	All 31 Plants Elasticity[b]	15 Small Plants Estimated Parameter	15 Small Plants Elasticity[b]	16 Large Plants Estimated Parameter	16 Large Plants Elasticity[b]
INTERCEPT	-5,970.309* (-1.651)	--	2,577.168 (0.993)	--	36,411.0*** (-4.676)	--
$CONTRACT_t$	-0.255*** (-13.537)	-0.779	-0.028 (-1.283)	-0.064	-0.307*** (-11.233)	-1.027
$CASHVAR_{t-4}$	74.212 (0.271)	0.021	-112.521 (-0.604)	-0.054	328.179 (0.669)	0.066
$CASH_{t-4}$	138.540*** (2.619)	3.029	-62.686* (-1.747)	-2.342	403.230*** (4.195)	6.369
$BASIS_{t-4}$	-78.755 (-1.240)	-0.048	55.890 (1.285)	0.058	-259.835** (-2.273)	-0.116
$KILL_{t-12}$	0.071 (0.058)	0.065	-0.198 (-0.233)	-0.309	0.680 (0.308)	0.450
$UTILIZE_{t-12}$	45.764*** (3.495)	1.179	39.859*** (4.681)	1.719	43.155* (1.677)	0.818
$CAPACITY_t$	-0.156*** (-7.762)	-4.114	0.173*** (3.597)	4.119	0.048 (0.666)	1.296
$CAPSQ_t$	1.38E-6*** (11.132)	3.606	-3.23E-6*** (-5.289)	-3.609	6.1E-7* (1.827)	1.984

	All 31 Plants	15 Small Plants	16 Large Plants
NO. OBSERVATIONS	1835	882	953
R-SQUARE	0.1385	0.1472	0.1628
ADJUSTED R- SQUARE	0.1347	1394	0.1557
F-TEST	36.686***	18.831***	22.942***
ROOT MSE	7318.372	3469.142	9407.487

[a]T-statistics appear in parentheses under the parameter estimates. Three asterisks represent statistical significance at the 0.01 level; two asterisks, the 0.05 level, and one asterisk, the 0.10 level.
[b]Elasticities are calculated at the mean value of the independent variables.

Table 6. O.L.S. Regression Results for Fed and Contracted Cattle With Fixed Plant Effects.[a]

Regression One: dependent variable = total number of packer-fed cattle and contracted by plant I ($FEDCON_{it}$).

Independent Variables:	Estimated Parameter	Elasticity[b]
INTERCEPT	-26376.0***	--
	(-4.030)	
$CASHVAR_{t-4}$	313.985	0.022
	(1.150)	
$CASH_{t-4}$	53.104	0.286
	(0.906)	
$BASIS_{t-4}$	-12.174	-0.002
	(-0.184)	
$KILL_{t-12}$	-0.916	-0.207
	(-0.743)	
$UTILIZE_{t-12}$	92.453***	0.587
	(6.731)	
$CAPACITY_t$	0.375***	2.430
	(3.941)	
$CAPSQ_t$	-1.854E-6***	-1.209
	(-3.794)	

Fixed Plant Effect Variables

Independent Variables:	Estimated Parameter	Independent Variables:	Estimated Parameter
P1	56,965***	P16	46907***
	(21.50)		(22.44)
P2	16,177***	P17	16443***
	(7.38)		(4.24)
P3	11,728***	P18	37551***
	(4.18)		(11.44)
P4	11188***	P19	25677***
	(6.78)		(11.19)
P5	41061***	P20	459
	(19.71)		(0.26)
P6	2,376	P21	4,763**
	(1.41)		(2.30)
P7	3,599**	P22	10,890***
	(2.41)		(6.40)
P8	9,065***	P23	25,570***
	(5.90)		(17.95)
P9	5,581***	P24	21338***
	(3.23)		(6.15)
P10	13,393***	P25	6,964***
	(6.68)		(5.12)
P11	15,631***	P26	11,544***
	(10.19)		(6.20)
P12	19,007***	P27	8,468***
	(13.39)		(3.35)
P13	7,408***	P28	9,807***
	(3.88)		(3.83)
P14	1653	P29	26,135***
	(1.20)		(7.65)
P15	7,446***	P30	2,315
	(4.89)		(1.45)

NO. OBSERVATIONS	1835
R-SQUARE	0.7897
ADJUSTED R-SQUARE	0.7853
F-TEST	182.341***
ROOT MSE	7286.180

[a]T-statistics appear in parentheses under the parameter estimates. Three asterisks represent statistical significance at the 0.01 level; two asterisks, the 0.05 level, and one asterisk, the 0.10 level.
[b]Elasticities are calculated at the mean value of the independent variables.
[c]One plant was omitted to avoid simultaneity.

Table 7. Two-Stage Least Squares Results for Contracted Cattle With Fixed Plant Effects.[a]

Regression Two: dependent variable = total number of cattle contracted by plant I (CONTRACT$_{it}$).

Independent Variables:	Estimated Parameter	Elasticity[b]
INTERCEPT	-17894***	--
	(-2.887)	
PACKFED$_{t}$	0.114	0.037
	(1.077)	
CASHVAR$_{t-4}$	455.384*	0.042
	(1.775)	
CASH$_{t-4}$	42.725	0.306
	(0.777)	
BASIS$_{t-4}$	-53.362	-0.011
	(-0.858)	
KILL$_{t-12}$	-1.701	-0.509
	(-1.467)	
UTILIZE$_{t-12}$	85.278***	0.719
	(6.604)	
CAPACITY$_{t}$	0.248***	2.133
	(2.757)	
CAPSQ$_{t}$	1.082E-6**	-0.937
	(-2.335)	

Fixed Plant Effect Variables

Independent Variables:	Estimated Parameter	Independent Variables:	Estimated Parameter
P1	53439***	P16	530
	(21.38)		(0.11)
P2	15051***	P17	12573***
	(7.31)		(3.43)
P3	7070***	P18	32716***
	(2.66)		(10.54)
P4	9984***	P19	13005***
	(6.44)		(5.35)
P5	36855***	P20	-1108
	(18.57)		(-0.66)
P6	1981	P21	3,796**
	(1.26)		(1.95)
P7	2840**	P22	10,427***
	(2.02)		(6.53)
P8	-387	P23	18,627***
	(-0.23)		(1,2.57)
P9	5095***	P24	7,004**
	(3.14)		(1.98)
P10	13109***	P25	6,666***
	(10.09)		(5.22)
P11	12,318***	P26	10,020***
	(8.38)		(5.71)
P12	13473***	P27	6521***
	(9.47)		(2.74)
P13	6271***	P28	7,055***
	(3.49)		(2.92)
P14	1647	P29	23,115***
	(1.28)		(7.18)
P15	2796*	P30	2005
	(1.87)		(1.34)

NO. OBSERVATIONS	1835
R-SQUARE	0.7694
ADJUSTED R-SQUARE	0.7645
F-TEST	157.650***
ROOT MSE	6836.694

[a]T-statistics appear in parentheses under the parameter estimates. Three asterisks represent statistical significance at the 0.01 level; two asterisks, the 0.05 level, and one asterisk, the 0.10 level.
[b]Elasticities are calculated at the mean value of the independent variables.

[c]One plant was omitted to avoid simultaneity.

Table 8. Two-Stage Least Squares Results for Packer-Fed Cattle With Fixed Plant Effects.[a]

Regression Three: dependent variable = number of cattle fed by plant I ($PACKFED_{it}$).

Independent Variables:	Estimated Parameter	Elasticity[b]	Fixed Plant Effect Variables: Independent Variables:	Estimated Parameter	Independent Variables:	Estimated Parameter
INTERCEPT	-7,349.161*** (-3.605)	--	P1	2470*** (2.53)	P16	41770*** (64.34)
$CONTRACT_t$	0.018 (1.485)	0.054	P2	794 (1.14)	P17	3,310*** (2.74)
$CASHVAR_{t-4}$	-135.979 (-1.599)	0.038	P3	4152*** (4.76)	P18	3,980*** (3.75)
$CASH_{t-4}$	6.989 (0.383)	0.153	P4	958* (1.83)	P19	11241*** (15.45)
$BASIS_{t-4}$	39.154* (1.903)	0.024	P5	3252*** (4.30)	P20	1,467*** (2.66)
$KILL_{t-12}$	0.735* (1.916)	0.672	P6	320 (0.61)	P21	813 (1.26)
$UTILIZE_{t-12}$	4.840 (1.105)	0.125	P7	643 (1.38)	P22	273 (0.51)
$CAPACITY_t$	0.114*** (3.845)	2.988	P8	8580*** (17.97)	P23	5942*** (12.14)
$CAPSQ_t$	-0.703E-7*** (-4.632)	-1.860	P9	356 (6.61)	P24	12790*** (11.86)
			P10	62 (0.14)	P25	176 (0.41)
			P11	2797*** (5.65)	P26	1,198** (2.03)
			P12	4771*** (10.25)	P27	1,658** (2.11)
			P13	924 (1.55)	P28	2,408*** (3.02)
			P14	-22 (-0.05)	P29	2,391** (2.21)
			P15	4118*** (8.68)	P30	248 (0.50)

NO. OBSERVATIONS	1835
R-SQUARE	0.9154
ADJUSTED R- SQUARE	0.9136
F-TEST	511.081***
ROOT MSE	2263.141

[a]T-statistics appear in parentheses under the parameter estimates. Three asterisks represent statistical significance at the 0.01 level; two asterisks, the 0.05 level, and one asterisk, the 0.10 level.
[b]Elasticities are calculated at the mean value of the independent variables.
[c]One plant was omitted to avoid simultaneity.

FIGURE 1

FIGURE 2

FIGURE 3

FIGURE 4

FIGURE 5

FIGURE 6

FIGURE 7

FIGURE 8

FIGURE 9

Data Appendix

For

Long-run Impacts of Captive Supplies

Table A1. Percent of Slaughter Contracted by All Firms and Plants, by Year and Month.

Year	Month	Observations	Mean	Std. Dev.	Min.	Max.
1989-1993	All	1,835	15.50	21.85	0	100.00
----by Month----						
1989-1993	January	152	16.61	23.15	0	100.00
1989-1993	February	153	16.84	22.79	0	100.00
1989-1993	March	154	14.86	22.14	0	100.00
1989-1993	April	151	19.06	23.16	0	100.00
1989-1993	May	153	13.67	20.40	0	100.00
1989-1993	June	155	18.04	22.67	0	100.00
1989-1993	July	154	13.64	21.32	0	100.00
1989-1993	August	153	13.31	20.92	0	100.00
1989-1993	September	153	13.89	21.44	0	100.00
1989-1993	October	153	14.07	20.26	0	100.00
1989-1993	November	153	13.80	20.40	0	100.00
1989-1993	December	151	18.25	22.89	0	100.00
----by Year----						
1989	All	372	18.08	24.71	0	100.00
1990	All	371	15.04	20.79	0	94.92
1991	All	362	13.96	20.15	0	90.51
1992	All	366	15.54	22.51	0	100.00
1993	All	364	14.82	20.59	0	99.66

Table A2. Percent of Slaughter Packer-Fed by All Firms and Plants, by Year and Month.

Year	Month	Observations	Mean	S.D.	Min.	Max.
1989-1993	All	1,835	6.44	15.76	0	107.62[a]
----by Month----						
1989-1993	January	152	5.93	14.47	0	95.38
1989-1993	February	153	5.62	12.87	0	91.84
1989-1993	March	154	5.86	14.23	0	100.00
1989-1993	April	151	5.88	13.03	0	67.42
1989-1993	May	153	6.11	14.03	0	75.18
1989-1993	June	155	6.17	14.84	0	86.96
1989-1993	July	154	7.07	17.40	0	95.59
1989-1993	August	153	6.78	17.47	0	107.62[a]
1989-1993	September	153	7.11	16.47	0	82.51
1989-1993	October	153	7.43	18.60	0	100.00
1989-1993	November	153	6.81	18.42	0	100.00
1989-1993	December	151	6.52	16.29	0	92.37
----by Year----						
1989	All	372	6.76	14.87	0	100.00
1990	All	371	6.65	17.53	0	100.00
1991	All	362	5.99	14.81	0	107.62[a]
1992	All	366	6.08	15.74	0	100.00
1993	All	364	6.71	15.74	0	86.96

[a]In August, 1991, one plant had a level of packer-fed cattle greater than the slaughter level, resulting in a ratio of packer-fed cattle to slaughter of over 100 percent.

Table A3. Percent of Slaughter Contracted or Packer-Fed by All Firms and Plants, by Year and Month.

Year	Month	Observations	Mean	S.D.	Min.	Max.
1989-1993	All	1,835	21.94	25.56	0	107.62[a]
--by Month--						
1989-1993	January	152	22.54	26.32	0	100.00
1989-1993	February	153	22.46	24.93	0	100.00
1989-1993	March	154	20.72	25.10	0	100.00
1989-1993	April	151	24.94	25.38	0	100.00
1989-1993	May	153	19.78	23.44	0	100.00
1989-1993	June	155	24.22	25.52	0	100.00
1989-1993	July	154	20.71	25.97	0	100.00
1989-1993	August	153	20.09	25.83	0	107.62[a]
1989-1993	September	153	21.00	25.82	0	100.00
1989-1993	October	153	21.50	26.14	0	100.00
1989-1993	November	153	20.61	25.94	0	100.00
1989-1993	December	151	24.77	26.45	0	100.00
--by Year--						
1989	All	372	24.84	28.41	0	100.00
1990	All	371	21.68	25.83	0	100.00
1991	All	362	19.95	23.28	0	107.62[a]
1992	All	366	21.62	25.41	0	100.00
1993	All	364	21.54	24.40	0	99.84

[a]In August, 1991, one plant had a level of packer-fed cattle greater than the slaughter level, resulting in a ratio of packer-fed cattle to slaughter of over 100 percent.

Table A4. Level of Slaughter Contracted by All Firms and Plants, by Year and Month.

Year	Month	Observations	Mean	S.D.	Min.	Max.
1989-1993	All	1,835	9,101	14,088	0	87,862
---by Month---						
1989-1993	January	152	8,601	12,671	0	64,379
1989-1993	February	153	9,538	14,477	0	68,319
1989-1993	March	154	8,866	15,189	0	84,718
1989-1993	April	151	10,544	14,655	0	65,294
1989-1993	May	153	8,958	14,771	0	87,862
1989-1993	June	155	12,356	17,437	0	68,926
1989-1993	July	154	8,265	13,995	0	73,152
1989-1993	August	153	8,610	14,455	0	76,885
1989-1993	September	153	8,553	14,082	0	73,847
1989-1993	October	153	7,451	10,730	0	56,564
1989-1993	November	153	7,112	10,580	0	44,407
1989-1993	December	151	10,355	14,271	0	56,541
---by Year---						
1989	All	372	10,633	15,940	0	76,885
1990	All	371	8,648	13,575	0	78,238
1991	All	362	7,769	12,161	0	65,041
1992	All	366	9,699	15,046	0	87,862
1993	All	364	8,720	13,254	0	84,718

Table A5. Level of Slaughter Packer-Fed by All Firms and Plants, by Year and Month.

Year	Month	Observations	Mean	S.D.	Min.	Max.
1989-1993	All	1,835	2,977	7,698	0	58,973
----------by Month----------						
1989-1993	January	152	2,481	6,932	0	43,553
1989-1993	February	153	2,842	6,922	0	42,645
1989-1993	March	154	2,863	7,744	0	49,750
1989-1993	April	151	2,809	7,237	0	42,034
1989-1993	May	153	3,454	8,920	0	58,973
1989-1993	June	155	3,058	8,022	0	53,179
1989-1993	July	154	3,227	8,041	0	48,127
1989-1993	August	153	3,366	8,939	0	53,318
1989-1993	September	153	3,248	7,561	0	45,330
1989-1993	October	153	3,128	7,317	0	42,301
1989-1993	November	153	2,739	7,775	0	46,147
1989-1993	December	151	2,497	6,767	0	48,879
----------by Year----------						
1989	All	372	3,296	7,851	0	53,318
1990	All	371	3,081	7,910	0	53,179
1991	All	362	2,947	7,834	0	49,750
1992	All	366	2,721	7,448	0	58,973
1993	All	364	2,833	7,454	0	49,532

Table A6. Level of Slaughter Contracted or Packer Fed by All Firms and Plants, by Year and Month.

Year	Month	Observations	Mean	S.D.	Min.	Max.
1989-1993	All	1,835	12,078	15,726	0	89,027
---by Month---						
1989-1993	January	152	11,081	14,443	0	64,379
1989-1993	February	153	12,380	16,013	0	73,299
1989-1993	March	154	11,728	16,817	0	84,718
1989-1993	April	151	13,352	16,509	0	67,229
1989-1993	May	153	12,412	16,735	0	89,027
1989-1993	June	155	15,415	18,631	0	72,603
1989-1993	July	154	11,492	15,326	0	73,152
1989-1993	August	153	11,976	16,453	0	76,885
1989-1993	September	153	11,801	15,576	0	73,847
1989-1993	October	153	10,579	12,935	0	56,564
1989-1993	November	153	9,851	12,910	0	49,980
1989-1993	December	151	12,852	15,220	0	57,284
---by Year---						
1989	All	372	13,929	17,778	0	76,885
1990	All	371	11,730	15,622	0	78,238
1991	All	362	10,715	13,655	0	65,041
1992	All	366	12,420	16,287	0	89,027
1993	All	364	11,553	14,820	0	84,718

Table A7. Plant Capacity of All Firms and Plants, by Year and Month.

Year	Month	Observations	Mean	S.D.	Min.	Max.
1989-1993	All	1,835	78,309	41,792	13,973	163,051
----by Month----						
1989-1993	January	152	77,071	41,271	13,973	163,051
1989-1993	February	153	77,154	41,150	13,973	163,051
1989-1993	March	154	76,998	41,151	13,973	163,051
1989-1993	April	151	77,559	41,380	13,973	163,051
1989-1993	May	153	78,264	42,073	13,973	163,051
1989-1993	June	155	78,331	41,961	13,973	163,051
1989-1993	July	154	78,638	41,923	13,973	163,051
1989-1993	August	153	79,085	42,196	13,973	163,051
1989-1993	September	153	79,078	42,407	13,973	163,051
1989-1993	October	153	79,078	42,407	13,973	163,051
1989-1993	November	153	79,139	42,388	13,973	163,051
1989-1993	December	151	79,318	42,568	13,973	163,051
----by Year----						
1989	All	372	73,900	39,123	13,973	160,101
1990	All	371	75,251	40,083	13,973	163,051
1991	All	362	77,743	40,731	14,569	163,051
1992	All	366	81,282	43,473	14,569	163,051
1993	All	364	83,507	44,793	14,569	163,051

Table A8. Plant Utilization of All Firms and Plants, by Year and Month.

Year	Month	Observations	Mean	S.D.	Min.	Max.
1989-1993	All	1,835	73.86	13.39	8.86	100.00
---by Month---						
1989-1993	January	152	67.99	12.06	21.53	95.80
1989-1993	February	153	72.70	14.05	19.22	100.00
1989-1993	March	154	74.10	13.60	11.87	100.00
1989-1993	April	151	69.82	10.15	40.78	100.00
1989-1993	May	153	80.09	13.38	30.21	100.00
1989-1993	June	155	80.37	14.53	16.97	100.00
1989-1993	July	154	72.36	11.71	8.86	98.98
1989-1993	August	153	78.26	12.98	11.01	100.00
1989-1993	September	153	78.04	14.56	34.51	100.00
1989-1993	October	153	71.05	9.75	32.17	94.56
1989-1993	November	153	70.19	12.60	14.96	100.00
1989-1993	December	151	71.12	12.95	34.77	99.00
---by Year---						
1989	All	372	76.59	12.38	22.22	100.00
1990	All	371	75.39	12.57	14.96	100.00
1991	All	362	72.74	13.78	35.34	100.00
1992	All	366	72.13	14.40	8.86	100.00
1993	All	364	72.36	13.21	36.26	100.00

Table A9. Slaughter Level of All Firms and Plants, by Year and Month.

Year	Month	Observations	Mean	S.D.	Min.	Max.
1989-1993	All	1,835	58,285	33,756	4,832	163,051
---by Month---						
1989-1993	January	152	51,808	28,654	8,009	119,327
1989-1993	February	153	57,474	33,946	7,250	128,546
1989-1993	March	154	57,321	33,456	6,471	144,813
1989-1993	April	151	53,573	29,247	9,030	122,615
1989-1993	May	153	64,559	38,638	8,632	151,070
1989-1993	June	155	63,643	37,942	9,255	163,051
1989-1993	July	154	57,498	33,410	4,832	130,197
1989-1993	August	153	63,741	37,612	6,004	133,588
1989-1993	September	153	62,157	36,416	8,954	162,971
1989-1993	October	153	55,928	30,436	9,179	120,728
1989-1993	November	153	55,996	30,971	6,608	112,808
1989-1993	December	151	55,523	30,365	9,740	138,292
---by Year---						
1989	All	372	57,123	32,930	8,009	160,101
1990	All	371	57,323	33,273	6,608	163,051
1991	All	362	57,110	33,250	9,453	162,971
1992	All	366	59,188	34,791	4,832	156,354
1993	All	364	60,713	34,544	7,250	159,346

SHORT-RUN CAPTIVE SUPPLY RELATIONSHIPS WITH FED CATTLE TRANSACTION PRICES

Clement E. Ward, Professor
Department of Agricultural Economics
Oklahoma State University

Stephen R. Koontz, Associate Professor
Department of Agricultural Economics
Oklahoma State University

Ted C. Schroeder, Professor
Department of Agricultural Economics
Kansas State University

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SHORT-RUN CAPTIVE SUPPLY RELATIONSHIPS WITH FED CATTLE TRANSACTION PRICES

Background

Mergers involving several large meatpackers in 1987 significantly increased the size of the second and third largest meatpacking firms, creating what has been called the "Big Three" packers (IBP, Excel, and ConAgra). Those and other mergers continued structural change trends toward fewer and larger firms, and increased concentration in meatpacking (Ward 1988).

Behavioral changes in fed cattle procurement accompanied structural changes in meatpacking. Some meatpackers increased their use of non-cash-price coordination of fed cattle from feedlots to their slaughtering plants, rather than rely exclusively on market price coordination.[7] Captive supplies take three forms: (1) packer feeding in packer-owned and commercial feedlots; (2) fixed price and basis forward contracts; and (3) exclusive marketing and purchasing agreements with individual cattle feeding firms.

Packer Feeding -- Packer feeding of cattle parallels cattle feeding by cattle producers and investor-feeders prior to the time cattle are ready for slaughter. Packers purchase feeder cattle and place them on feed in packer-owned or commercial feedlots. When cattle reach slaughter weight and finish, packers transfer the cattle to their plants for slaughter. At the time cattle are transferred from the feedlot to the slaughter plant, they are priced by a transfer pricing formula or cost accounting price.

Basis Forward Contracting -- Basis forward contracting occurs for cattle on feed which are owned by cattle producers or investor-feeders. During the feeding period, a cattle owner and packer enter into a basis forward contract. A packer bids a futures market basis for the month cattle are expected to reach slaughter weight and finish. The feeder then has the option of determining when to price the cattle (i.e., select a futures market price). From that futures market price, a cash selling price is computed, based on the agreed-upon basis. Sometimes the contract settlement price (i.e., futures market price) is chosen when the basis contract is signed. If so, the basis, the futures market price, and the cash sale price are all discovered on the date the contract is signed. If not, the bid price (i.e., the basis) is discovered on the contract date but the contract settlement price and cash sale price are discovered at a future date. For example, assume that after the basis contract is signed, a cattle feeder believes the futures market price for the specified contract month has peaked. The cattle feeder notifies the packer and chooses the then-current futures market price, thereby also determining the cash sale price, based on the previously-agreed basis bid.

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[7] Non-cash-price coordination is also referred to as packer-controlled supplies or captive supplies. The term “captive supplies” is used in this report.

Exclusive Marketing/Purchasing Agreements -- Exclusive feedlot marketing or packer purchasing agreements can take many forms. Essentially, they are exclusive supply contracts in which the cattle feeder agrees to market a specified number of cattle per some specified time period (e.g., week, month, or year) to a given buyer. Price is typically based on a prearranged formula. In one of the largest feeder-packer agreements, the base price is derived from the average price paid by the buyer for all cattle delivered during the week to the slaughter plant where the marketing agreement cattle will be delivered. Premium and discount adjustments to the base price may reflect differences in cattle quality as well as other prearranged factors.

Two elements are common to each form of captive supplies. First, meatpackers have a portion of their slaughter volume needs purchased weeks or months prior to the livestock being slaughtered. These forward purchases enable meatpackers to plan cash market purchases and deliveries in coordination with purchases by captive supply methods. Second, captive supply transactions between sellers and buyers do not result in a cash price which can be included in public market price reports.

Virtually the only form of captive supplies between cattle feedlots and packers in the early 1980s was packer-fed cattle in packer-owned feedlots, accounting for about 4 percent of steer and heifer slaughter in 1980 and 1985 (Packers and Stockyards Administration).[8] The other two forms of captive supplies mentioned above grew in importance in the 1980s. Special surveys conducted annually in 1989-94 by the Packers and Stockyards Administration of the 15 largest meatpacking firms in the 5 leading cattle slaughtering states revealed that captive supplies accounted for 17 to 23 percent of annual steer and heifer slaughter over the 1988-94 period. Industry analysts believe that much of the year-to-year variability in the amount of captive supplies from 1988 to 1994 was due to the extent of forward contracting of fed cattle. Industry estimates suggest forward contracting has declined while marketing agreement purchases have increased.

A major question relating to structural and behavioral changes in meatpacking pertains to the net effect captive supplies have on slaughter cattle prices. Relatively little research has focused on why and how packers use captive supplies. It is hypothesized by industry analysts that packers use captive supplies to secure a guaranteed quantity and quality of cattle in advance of slaughter to increase plant efficiency, reduce price risk, and gain leverage in the cash market. Questions remain regarding impacts from captive supplies, especially on cash or spot fed-cattle prices. Each form of captive supplies may have differential net impacts. No research has recognized the interdependent nature of deciding to deliver cattle from an inventory of captive supplies and the prices paid for fed cattle in the cash market. Captive supplies may affect plant costs and fed cattle prices, while plant costs and fed cattle prices may simultaneously affect the

[8] The Packers and Stockyards Administration became Packers and Stockyards Programs within the Grain Inspection, Packers and Stockyards Administration (GIPSA) in 1994.

extent of captive supplies. Nearly all research to date on captive supplies has been hampered by data limitations.

Important in explaining and predicting impacts of captive supplies is the development and empirical estimation of models based on motivation by packers and feedlots for using captive supplies. Understanding the underlying motivation for using captive supplies, followed by theoretical modeling and empirical estimation will provide needed insight into factors contributing to captive supply arrangements and their potential impacts.

Objectives

This study focused on some of the unanswered questions related to captive supplies. The overall objective was to determine the impacts of captive supplies on cash or spot-transaction prices for fed cattle. Specific objectives were to:

(1) Estimate the interdependent relationship between use of captive supplies and impacts on transaction prices for fed cattle;
(2) Estimate the impact on fed cattle transaction prices from buyers having an inventory of fed cattle procured by captive supply methods from which to deliver cattle for slaughter; and
(3) Estimate the price differences between cash transaction prices for fed cattle and prices for fed cattle purchased under different captive supply methods.

Previous Research

Only a few studies have focused on captive supplies or explicitly included captive supplies in studies examining impacts from structural and behavioral changes in meatpacking (Elam; Eilrich et al.; Hayenga and O'Brien; Schroeder et al. 1993; Ward and Bliss).

In one of the first studies on captive supplies, Ward and Bliss surveyed 3,700 cattle feedlots in 1989 to estimate the extent of forward contracting and to obtain cattle feeders' perceptions of reasons for using contracts and their impacts. Survey results indicated that 12.7 percent of fed cattle in the major cattle feeding states in 1988 were procured by forward contract. Ninety percent of forward contracting in 1988 occurred in the Plains states (Nebraska, Colorado, Kansas, Oklahoma, and Texas). Nearly two-thirds of all contracting was found in just two states (Texas and Kansas). Eighty-four percent of forward contracting was by cattle feedlots which marketed 20,000 or more cattle in 1988. Nearly all contracting (96 percent) was between cattle feedlots and the Big Three packers.

Cattle feeders thought the primary benefits to them from forward contracting were improved financing and locking in a known buyer (Ward and Bliss). They perceived that packers used forward contracts to guarantee a supply of cattle for slaughter and increase control over timing of deliveries.

Elam looked at two aspects of captive supplies. First, he compared forward contracting in six Texas feedlots with hedging fed cattle over the period May 1987 to September 1989. Results indicated that contract prices were $0.28-$0.59 per hundredweight (hereafter $/cwt) lower than hedge prices for steers and $0.86-$1.64/cwt lower for heifers. Cattle feeders were giving up a portion of the basis to packers when they forward contracted cattle. This difference was, in essence, a risk transfer premium from cattle feeders to packers.

Second, Elam studied the aggregate effect deliveries of captive supply cattle had on fed cattle prices in the U.S. and in four states (i.e., Texas, Kansas, Colorado, and Nebraska). Using time series regression, he found that packer-controlled supplies adversely affected monthly average fed cattle prices over the period October 1988 to May 1991. For each 10,000 cattle delivered under captive supply arrangements, U.S. fed cattle prices declined by $0.03-$0.09 per cwt. Results differed for individual states, ranging from no significant impacts to price impacts of minus $0.15-$0.37/cwt.

Eilrich et al. also compared forward contracting with hedging fed cattle using data from five feedlots and covering the period 1988 to 1990. Their results differed from Elam's in one significant way. Elam assumed that cattle feeders paid transportation costs for contracted cattle, as called for in most basis contracts. However, cattle feeders indicated that packers often waive that contract provision and paid the transportation costs as they do in cash purchases of cattle. Eilrich et al. found that when transportation costs were waived for cattle feeders, there was no significant difference between contract prices and hedge prices. When transportation costs were not waived, results paralleled Elam's findings for price differences between forward contracting and hedging fed cattle.

Eilrich et al. also compared the difference between net basis contract prices and similar hedged prices with estimated cash transaction prices for fed cattle. They found that both net basis contract prices and hedged prices were lower than estimated cash prices. Price differences ranged from $1.37-$1.77/cwt assuming either waived transportation costs or $0.40/cwt transportation costs, respectively. This difference, again, is the risk transfer premium for hedging a price level or locking in a basis.

Hayenga and O'Brien examined the effect captive supplies had on weekly average fed cattle prices and price variability in the major cattle feeding states (i.e., Kansas Colorado, Nebraska, and Texas) over the 15-month period from October 1988 to December 1989. They used seemingly unrelated regression and found effects that were usually not significant or had mixed positive and negative signs relative to other market prices.

Schroeder et al. (1993) conducted the sole study to date which examined the relationship between captive supplies and transaction prices for fed cattle. They collected data from feedlots in selected counties in southwest Kansas from May through November 1990. They used pooled cross-section, time-series regression to determine price effects of several factors. Results indicated a negative relationship between fed cattle prices and packer-controlled supplies. For the 6-month period, increased shipments of captive supply cattle were associated with decreased fed cattle prices ($0.15-$0.31/cwt) in cooperating feedlots. Price impacts differed among packers and subperiods within the 6-month period and price impacts were not significant for some packers and time periods.

Conceptual Framework and Methodology

Despite cattle feeders' perceptions (Ward and Bliss) and economists' hypotheses (Purcell 1992; Schroeder et al. 1993) there is little direct information from packers regarding the reasons they use captive supplies and how they use captive supplies as part of their overall cattle procurement program. Reasons for using each of the three types of captive supplies may vary across cattle feeding and beef packing firms. Capital requirements, procurement costs, and risk exposure differ among the 3 types. Packers may use each captive supply type differently in their overall cattle procurement programs.

Cattle Feeder and Beefpacker Survey

To obtain additional information on various aspects of captive supplies, a mail survey was conducted of the largest 25 beefpacking firms and 25 largest cattle feeding firms.[9] Responses by beefpacking and cattle feeding firms were voluntary. Six beefpacking and 15 cattle feeding firms responded to the initial mailing plus one follow-up mailing. The limited number of responses combined with incomplete responses by some respondents resulted in low reliability of results and little usefulness of the survey information in later modeling of captive supply impacts.

Selected survey results based on the number and consistency of responses are presented in Appendix A. Survey responses supported the industry's perception that use of captive supplies has a seasonal component. Captive supply usage tends to be highest in the late spring and early summer months, especially in April and June. Perceptions of cattle feeder respondents regarding why meatpackers use captive supplies tended to support earlier survey work by Ward and Bliss. Primary reasons included guaranteeing a given quantity of cattle, gaining leverage in the cash market, gaining increased control over deliveries of fed cattle, and guaranteeing a given quality of cattle. Insufficient information was received from packers as to their reasons for using captive supplies. Cattle feeder and beefpacker respondents tended to agree that current cash market prices were the most important among several factors determining the day and time captive supply cattle would be delivered.

[9] The authors proposed to conduct personal interviews for this portion of the study but were restricted to a mail survey. As a result, considerably less information was obtained regarding how and why beefpackers and cattle feeders use captive supplies than was expected.

Cattle feeder and beefpacker respondents tended to agree on three impacts from use of captive supplies: (1) they benefit the packers who use them; (2) they insure a given supply of cattle for packers; and (3) they reduce market information. Cattle feeders also believed that captive supplies benefit the feeders who use them, result in lower cash market prices, and benefit packers more than feeders.

Conceptual Model of Captive Supply Impacts

Ward (1987) discussed the conceptual nature of forward contracts and their potential price impacts. His discussion is generalized here to include all types of captive supplies.

Procurement of fed cattle by each type of captive supplies reduces the supply of available cattle that can be purchased in the cash market just prior to slaughter (i.e., within the normal week or 2 prior to slaughter). Effectively, the short-run supply curve for available fed cattle shifts to the left.

There are two demand effects. Packers procuring cattle by each type of captive supplies may not bid as aggressively for cash market cattle because some percentage of their slaughter needs have been purchased previously by the various types of captive supplies. By itself, this suggests the short-run demand curve for fed cattle shifts to the left also. The combined theoretical effect to this point is a decline in fed cattle prices.

The second demand effect comes from the behavior of packers who do not use captive supplies as a procurement method. The effective supply of available fed cattle has been reduced, but packers not using captive supplies have the same short-run demands for cattle to operate their plants efficiently as they did prior to packers using captive supplies. Therefore, the competition among buyers for the remaining supply of fed cattle may increase, thereby effectively shifting the demand curve back to the right. This shift alone has a positive effect in theory on fed cattle prices.

The combined supply and demand effects from captive suppliers are theoretically ambiguous. The increased competition from remaining packers for the reduced supply of available fed cattle could more than offset the decreased competition by packers using captive supplies to procure cattle. Potentially, however, the reduction in competition for the reduced supply of available fed cattle among buyers who use captive supplies could more than offset the increased competition by the remaining buyers and fed cattle prices might decline.

Purcell (1990) extends the above by recognizing that packers likely have a minimum plant utilization goal to keep them cost competitive. He recognizes that the drive to achieve a plant utilization goal is affected in the short-run by the extent to which packers use or do not use captive supplies. While in one scenario described by Purcell, the result is lower-than-expected fed cattle prices, he states that other scenarios and outcomes are possible and empirical research is needed to determine the short-run price impacts from use of captive supplies.

Only one study to date examined the relationship between captive supplies and transaction prices (Schroeder et al. 1993) and results indicated captive supplies had small negative price effects. Three limitations of the study were: (1) lack of access to all captive supply data during the study period; (2) no breakdown of captive supplies into the three component types; and (3) only considering one-way causality from captive supplies to transactions prices.

The third limitation is especially relevant for this study. One hypothesis in this study is that packers' decisions to deliver captive supply cattle and decisions to purchase cash market cattle are determined simultaneously.

The quantity of cattle which will be delivered for slaughter over a relatively short period (i.e., about 1 month) is predetermined to a considerable extent. Cattle placed on feed will reach desirable slaughter weight and quality after a relatively predictable period on feed, usually 90 days or more. Thus, cattle placed on feed by packers will be ready for slaughter at some predictable later period. Cattle placed on feed by feeders who have a marketing agreement with packers will be ready for slaughter at some predictable later period, also usually 90 days or more. Ward and Bliss found that most cattle contracted to packers are contracted 2 to 4 months prior to slaughter. Thus, cattle contracted for future delivery will be available at some predictable later period. As cattle reach the desired slaughter weight and quality, there is a market window of about 3 to 4 weeks during which to deliver cattle for slaughter such that the cattle remain in an acceptable range of weight and quality. Early in that market window period, cattle may tend to be lower in quality or marketed earlier than desirable. Conversely, later in that market window period, cattle may tend to be over-fat or marketed later than desirable.

Conceivably, packers could purchase some given number of cattle in the cash market and then determine how many captive supply cattle to deliver and when to have them delivered. Alternatively, packers could decide how many captive supply cattle to deliver and when to have them delivered, and then determine how many cattle to purchase in the cash market. In reality, the decision to deliver captive supply cattle and to purchase cash market cattle is likely determined simultaneously. That simultaneity is a central hypothesis for Model 1.

Therefore, one hypothesis is that the decision to deliver captive supply cattle influences cash price levels and variability. If a relatively high percentage of slaughter capacity during some time period is filled with captive supply cattle, packers using captive supplies need not be as aggressive in the cash market to obtain cattle. The decreased demand for cash market cattle results in lower cash prices. However, increased demand for cash market cattle by packers not using captive supplies may partially, or more than completely, offset the price decline.

Another hypothesis is that the level and movement of cash prices influences packers' decisions regarding the number and timing of captive supply cattle delivered during some time period. If prices are declining, packers may prefer to purchase relatively less expensive cattle in the cash market, which would tend to bid prices up. When cash market prices are increasing, packers may prefer to use more captive supply cattle, bid less aggressively in the cash market, and allow cash market prices to decline temporarily.

Increased use of captive supplies may turn the cash cattle market into a residual market, where demand is more inelastic and cash prices are more variable. For example, if packers have most of their short-run capacity purchased by captive supplies, short-run prices for cash cattle may be relatively weak. However, if their short-run capacity is underutilized, cash market buying could be aggressive. Variability in the numbers of cattle under captive supplies may create variability in short-run cash cattle prices.

The discussion thus far considers the decisions related to use of captive supplies as resting exclusively with packers. However, cattle feeders play a significant role in the use of captive supplies. The three models discussed below examine captive supply impacts without explicitly incorporating short-run demands by cattle feeders to market fed cattle by captive supply methods.

Captive Supply Shipments-Price Relationships Model

The following system of equations attempts to model the simultaneity of decisions regarding delivery flow of cattle from the captive supplies inventory and cash market purchasing behavior as measured by the impact on transaction prices. The unit of observation is a transaction record for a sale lot of fed cattle purchased on day t. Thus, the subscript t refers to the purchase date for cash market cattle, not the delivery date or slaughter date.

(1) $$UTILN_t = [(NFC_t + NPF_t + NMA_t + NSP_t) / CAP_t]$$

$UTILN_t$ = Percentage of each plant's utilization from captive supplies and cash (i.e. spot) market purchases of cattle on the day cash market cattle were purchased
NFC_t = Number of head of forward contracted cattle purchased by each plant on day t
NPF_t = Number of head of packer-fed cattle purchased by each plant on day t
NMA_t = Number of head of marketing agreement cattle purchased by each plant on day t
NSP_t = Number of head of cash market cattle purchased by each plant on day t
CAP_t = Maximum daily plant capacity for each plant during the data period

Percentage plant utilization ($UTILN_t$) is the sum of cattle purchased by the three forms of captive supply [i.e., forward contract (NFC_t), packer feeding (NPF_t), and marketing agreement (NMA_t)] plus cattle purchased in the cash market (NSP_t) for each purchase day (t), all divided by the maximum daily slaughter for the plant where cattle are slaughtered (CAP_t). Maximum daily slaughter was based on the largest number of cattle slaughtered any 1 day during the data period. Percentage plant utilization was computed for each cash market purchase day (t) and assigned to all transaction records for cash market purchases of cattle on each respective day. On any given day, more cattle may be purchased by a packer than are slaughtered. Two studies found more cattle were purchased earlier in the week (Monday through Wednesday) than later in the week (Ward 1992; Schroeder et al. 1993).

(2) $$PQFC_t = f(BSS_t, TRPRC_t, UTILN_t, DDOW_{i,t}, DMON_{i,t})$$

$PQFC_t$ = Percentage of forward contracted cattle during the market window period (i.e. t plus 28 days) which were delivered to each plant on the day cash market cattle were purchased
BSS_t = Basis on the day cash market cattle were purchased (i.e. dressed weight cash market price converted to a live weight price minus the preceding day's closing live cattle futures market price for the nearby contract)
$TRPRC_t$ = Cash market transaction price on the day cash market cattle were purchased
$DDOW_{i,t}$ = Zero-one dummy variable for day of the week cash market cattle were purchased (i.e., Monday, Tuesday, ..., Saturday-Sunday)
$DMON_{i,t}$ = Zero-one dummy variable for month of the year cash market cattle were purchased (i.e., January, February, ..., December)

Several instrumental variables are included in equation (2) to explain the delivery of forward contracted cattle. The percentage of forward contracted cattle during the market window period which will be delivered ($PQFC_t$) is dependent on basis (BSS_t), market price level ($TRPRC_t$), and percentage plant utilization ($UTILN_t$). As computed here, the inventory of forward contracted cattle does not represent the total inventory of forward contracted cattle at the time cash market cattle are purchased, only the number of forward contracted cattle actually delivered during the following 28 days. The percentage of forward contracted cattle delivered was computed for each cash market purchase day (t) and assigned to all transaction records for cash market purchases of cattle on each respective day. The percentage of available contracted cattle which are delivered varied by day and month. Therefore, dummy variables were added for day of the week ($DDOW_{i,t}$) and month of the year ($DMON_{i,t}$). Basis (BSS_t) was calculated by taking the dressed weight price times 63 percent (i.e. an estimated average dressing percentage) to convert the dressed weight price to a live weight price, minus the preceding day's closing live cattle futures market price for the nearby contract ($LCFMP_{t-1}$).

(3) $$PQPF_t = f(LCFMP_{t-1}, TRPRC_t, UTILN_t, DDOW_{i,t}, DMON_{i,t})$$

$PQPF_t$ = Percentage of packer fed cattle during the market window period (i.e. t plus 28 days) which were delivered to each plant on the day cash market cattle are purchased
$LCFMP_{t-1}$ = Preceding day's closing live cattle futures market price for the nearby contract

Instrumental variables are specified in equation (3) to explain the delivery of packer-fed cattle. The percentage of available packer-fed cattle during the market window period which will be delivered ($PQPF_t$) is dependent on expected market prices as measured by the nearby futures market price ($LCFMP_{t-1}$)[10], market price level ($TRPRC_t$), and percentage plant utilization ($UTILN_t$). The lagged live cattle futures market price was assigned to all transaction records for

[10] The nearby contract was moved to the next contract at the beginning of the contract maturity month. For example, if the purchase date was in December or January, the nearby futures market contract used was February. If the purchase date was in February, the nearby futures market contract became the April contract.

cash market purchases of cattle on each respective day. As computed here, the inventory of packer-fed cattle does not represent the total inventory of packer-fed cattle at the time cash market cattle are purchased, only the number of packer-fed cattle actually delivered during the following 28 days. The percentage of packer fed cattle delivered was computed for each cash market purchase day (t) and assigned to all transaction records for cash market purchases of cattle on each respective day. The percentage of available packer fed cattle which are delivered varied by day and month. Therefore, dummy variables were added for day of the week ($DDOW_{i,t}$) and month of the year ($DMON_{i,t}$).

(4) $$PQMA_t = f(LCFMP_{t-1}, TRPRC_t, UTILN_t, DDOW_{i,t}, DMON_{i,t})$$

$PQMA_t$ = Percentage of marketing agreement cattle during the market window period (i.e., t plus 28 days) which were delivered to each plant on the day cash market cattle were purchased

Equation (4) is specified to explain the delivery of marketing agreement cattle. The percentage of available marketing agreement cattle during the market window period which will be delivered ($PQMA_t$) is dependent on expected market prices as measured by the nearby futures market price ($LCFMP_{t-1}$), the market price level ($TRPRC_t$), and percentage plant utilization ($UTILN_t$). As computed here, the inventory of marketing agreement cattle does not represent the total inventory of marketing agreement cattle at the time cash market cattle are purchased, only the number of marketing agreement cattle actually delivered during the following 28 days. The percentage of marketing agreement cattle delivered was computed for each cash market purchase day (t) and assigned to all transaction records for cash market purchases of cattle on each respective day. The percentage of available marketing agreement cattle which are delivered varied by day and month. Therefore, dummy variables were added for day of the week ($DDOW_{i,t}$) and month of the year ($DMON_{i,t}$).

(5) $$TRPRC_t = f(ABBCV_{t-1}, LCFMP_{t-1}, DTYP_{i,t}, AHotWt_t, AHotWt_t^2, NoHd_t, NoHd^2, PYG1\text{-}3_t, FWD_t, DDOW_{i,t}, UTILN_t, TRND_i, TRND^2_i, TRND^3_i, DPLT_{i,t}, PQFC_t, PQPF_t, PQMA_t)$$

$TRPRC_t$ = Cash market transaction price on the day cash market cattle were purchased

$ABBCV_{t-1}$ = Preceding day's boxed beef cutout value on the day cash market cattle were purchased, adjusted for the percentage of the sale lot grading USDA Choice grade and above or Select grade and below

$DTYP_{i,t}$ = Zero-one dummy variable for the type of cattle purchased (i.e., steers, heifers, mixed sex, Holstein, and dairy cattle)

$AHotWt_t$ = Average dressed weight of the sale lot

$AHotWt_t^2$ = Square of the average dressed weight of the sale lot

$NoHd_t$ = Number of head in the sale lot

$NoHd^2$ = Square of the number of head in the sale lot

$PYG1\text{-}3_t$ = Percentage of USDA Yield Grade 1-3 cattle in the sale lot

FWD_t = Number of days between purchase and delivery for cash market cattle on the day cash market cattle were purchased

$TRND_i$ = Month cattle were purchased, I=1-n

$TRND^2_i$ = Square of the month cattle were purchased

$TRND^3_i$ = Cube of the month cattle were purchased

$DPLT_{i,t}$ = Zero-one dummy variable for packing plant that purchased cash market cattle (i.e., plant 1, plant 2, ..., plant 28)

Equation (5) explains the variation in cash market transaction prices for fed cattle. Several variables included in Equation (5) are based on previous studies of fed cattle transaction prices. Those studies (Jones et al. 1992; Schroeder et al. 1993; Ward 1981, 1982, 1992) provide ample justification for inclusion of such variables in a transaction price equation and variable justification is not discussed here. Variables in the model based on previous research include: boxed beef cutout value adjusted for the percentage of the sale lot grading USDA Choice grade and above or Select grade and below ($ABBCV_{t-1}$) {i.e., [BBCV - ($BBCV_{Choice}$ * %Choice) + ($BBCV_{Select}$ * %Select)]}[11]; live cattle futures market price ($LCFMP_{t-1}$); type of cattle ($DTYP_{i,t}$); weight of the cattle ($AHotWt_t$ and $AHotWt_t^2$); number of head in the sale lot ($NoHd_t$ and $NoHd^2$); percentage of cattle which yield grade 1-3 ($PYG1\text{-}3_t$); number of days between purchase and delivery (FWD_t); day of the week ($DDOW_{i,t}$); and plant purchasing cattle ($DPLT_{i,t}$). Cash market prices are expected to be dependent on percentage plant utilization ($UTILN_t$), which is included in the model to proxy the functional relationship between plant utilization and slaughter-processing costs (Sersland; Duewer and Nelson; Ward 1993). Cash market prices are expected to depend on the extent of captive supply deliveries ($PQFC_t$, $PQPF_t$, $PQMA_t$). During the study period, prices trended downward then reversed and trended upward for the remainder of the period. Therefore, cubic time-trend variables ($TRND_i$, $TRND^2_i$, $TRND^3_i$) were included to remove the trend in fed cattle prices.

Captive Supply Inventory-Price Relationships Model

A second model was estimated to determine the impact on fed cattle transaction prices from buyers having an inventory of fed cattle procured by captive supply methods. This model assumed no simultaneity between procuring cattle in the cash market and using alternative procurement methods. The focus of Model 2 is on the impact of having a given inventory of captive supplies at the time cash market cattle are purchased. The focus of Model 1 was on the impact from delivering fed cattle from that captive supply inventory at the same time cash market cattle are purchased. Thus, no simultaneous decision is implied in estimating the relationship between the size of captive supply inventory at the time cash market cattle are purchased and cash market prices. Coefficients on captive supply variables in Model 1 indicate the relationship between percentage deliveries from captive supply inventories and cash market transaction prices. Coefficients on captive supply variables in Model 2 indicate the relationship

[11] Four boxed beef cutout value data series were used (Choice, YG1-3, 550-700 lbs.; Choice, YG1-3, 700-850 lbs.; Select, YG1-3, 550-700 lbs.;and Select, YG1-3, 700-850 lbs.). Each transaction was matched with the appropriate boxed beef cutout value based on the average dressed weight of the sale lot.

between size (i.e., number of head) of captive supply inventories and cash market transaction prices.

(6) $TRPRC_t = f(ABBCV_{t-1}, LCFMP_{t-1}, DTYP_{i,t}, AHotWt_t, AHotWt_t^2, NoHd_t, NoHd^2, PYG1\text{-}3_t, FWD_t, DDOW_{i,t}, UTILN_t, TRND_i, TRND^2_i, TRND^3_i, DPLT_{i,t}, QFC_t, QPF_t, QMA_t)$

$TRPRC_t$ = Cash market transaction price on the day cash market cattle were purchased

$ABBCV_{t-1}$ = Preceding day's boxed beef cutout value on the day cash market cattle were purchased, adjusted for the percentage of the sale lot grading USDA Choice grade and above or Select grade and below

$LCFMP_{t-1}$ = Preceding day's closing live cattle futures market price for the nearby contract

$DTYP_{i,t}$ = Zero-one dummy variable for the type of cattle purchased (i.e., steers, heifers, mixed sex, Holstein, and dairy cattle)

$AHotWt_t$ = Average dressed weight of the sale lot

$AHotWt_t^2$ = Square of the average dressed weight of the sale lot

$NoHd_t$ = Number of head in the sale lot

$NoHd^2$ = Square of the number of head in the sale lot

$PYG1\text{-}3_t$ = Percentage of USDA Yield Grade 1-3 cattle in the sale lot

FWD_t = Number of days between purchase and delivery for cash market cattle on the day cash market cattle were purchased

$DDOW_{i,t}$ = Zero-one dummy variable for day of the week cash market cattle were purchased (i.e. Monday, Tuesday, ..., Saturday-Sunday)

$UTILN_t$ = Percentage of each plant's utilization from captive supplies and cash (i.e., spot) market purchases of cattle on the day cattle were purchased

$TRND_i$ = Month cattle were purchased, I=1-n

$TRND^2_i$ = Square of the month cattle were purchased

$TRND^3_i$ = Cube of the month cattle were purchased

$DPLT_{i,t}$ = Zero-one dummy variable for packing plant purchasing cattle

QFC_t = Number of forward contracted cattle available for delivery over the next 28 days, on the day cash market cattle were purchased

QPF_t = Number of packer fed cattle available for delivery over the next 28 days, on the day cash market cattle were purchased

QMA_t = Number of marketing agreement cattle available for delivery over the next 28 days, on the day cash market cattle were purchased

Model 2 is similar to equation 5 of Model 1 in that several variables are included to explain the variation in fed cattle transaction prices, but Model 2 differs in two important ways. First, Model 2 is a single-equation model, rather than a system of equations which assume simultaneity of decisions to deliver cattle from the inventory of captive supplies and to purchase cattle in the cash market. Second, the variables in equation 5 of Model 1 for percentage delivery from captive supply inventory when cash market cattle are purchased are replaced in Model 2 by variables for the inventory of captive supplies (QFC_t, QPF_t, QMA_t) at the time cash market cattle are purchased. As computed here, captive supply inventory variables (QFC_t, QPF_t, QMA_t) do not represent the total inventory of captive supplies at the time cash market cattle are purchased, only the number of captive supply cattle actually delivered during the following 28 days. The inventory of captive supply cattle was computed for each cash market purchase day (t) and assigned to all transaction records for cash market purchases of cattle on each respective day.

Captive Supply-Cash Price Differences Model

Previous research found price differences between forward contracted prices or hedged prices and estimated cash transaction prices (Eilrich, et al). To date, data have not been available to estimate the price difference between various methods of procuring fed cattle. Thus, Model 3 is specified to estimate the price difference between cash transaction prices for fed cattle and prices for fed cattle purchased under captive supply methods.

(7) $PPRC_t = f(ABBCV_{t-1}, LCFMP_{t-1}, DTYP_{i,t}, AHotWt_t, AHotWt_t^2, NoHd_t, NoHd^2, PYG1\text{-}3_t, FWDALL_t, DDOW_{i,t}, UTILN_t, TRND_i, TRND^2_i, TRND^3_i, DPLT_{i,t}, DMETH_{i,t})$

$PPRC_t$ = Purchase price (i.e. purchase price or transfer price) on the day cattle were purchased

$ABBCV_{t-1}$ = Preceding day's boxed beef cutout value on the day cash market cattle are purchased, adjusted for the percentage of the sale lot grading USDA Choice grade and above or Select grade and below

$LCFMP_{t-1}$ = Preceding day's closing live cattle futures market price for the nearby contract

$DTYP_{i,t}$ = Zero-one dummy variable for the type of cattle purchased (i.e. steers, heifers, mixed sex, Holstein, and dairy cattle)

$AHotWt_t$ = Average dressed weight of the sale lot

$AHotWt_t^2$ = Square of the average dressed weight of the sale lot

$NoHd_t$ = Number of head in the sale lot

$NoHd^2$ = Square of the number of head in the sale lot

$PYG1\text{-}3_t$ = Percentage of USDA Yield Grade 1-3 cattle in the sale lot

$FWDALL_t$ = Number of days between purchase and delivery for cash market and captive supply cattle on the day cash market cattle were purchased

$DDOW_{i,t}$ = Zero-one dummy variable for day of the week cash market cattle are purchased (i.e. Monday, Tuesday, ..., Saturday-Sunday)

$UTILN_t$ = Percentage of each plant's utilization from captive supplies and cash (i.e. spot) market purchases of cattle on the day cattle were purchased

$TRND_i$ = Month cattle were purchased, I=1-n

$TRND^2_i$ = Square of the month cattle were purchased

$TRND^3_i$ = Cube of the month cattle were purchased

$DPLT_{i,t}$ = Zero-one dummy variable for packing plant that purchased cash market cattle (i.e., plant 1, plant 2, ..., plant 28)

$DMETH_{i,t}$ = Zero-one dummy variable for procurement methods (i.e. forward contract, packer fed, marketing agreement, and cash market)

Model 3 is also similar to equation 5 of Model 1 and to Model 2 in that several variables are included to explain the variation in fed cattle transaction prices. In this model, the dependent variable is the purchase price ($PPRC_t$) for cash market and captive supply cattle, rather than just cash market cattle as in Models 1 and 2. The purchase price may be a transaction price, as would be the case for cash market cattle, or it may be a transfer or cost accounting price, as in the case of packer-fed cattle.

Two independent variables in Model 3 differ from previous models. Previous research has found that the time between purchase date and slaughter date affected transaction prices (Ward 1981, 1992; Schroeder et al. 1993). In this model, a similar variable was added ($FWDALL_t$) to measure the difference between purchase and slaughter date for all purchases, regardless of procurement method, rather than just for cash market purchases as in previous studies and in the preceding two models. Second, a variable was added to measure the difference between cash market transaction prices and prices for fed cattle purchased by other methods ($DMETH_{i,t}$).

Data and Data Considerations

Data were collected by the Packers and Stockyards Administration from 43 plants owned by 25 firms. Data records consisted of several types of information for each transaction of 35 head or 40,000 pounds or more for slaughter days from April 5, 1992 to April 3, 1993. Each sale lot record included: (1) packing plant and firm identification; (2) date cattle were slaughtered; (3) date cattle were purchased or priced; (4) number of head; (5) cattle sex or type (i.e., steers, heifers, dairy, Holstein, or mixed lots of cattle); (6) pricing or purchasing method (i.e,. live weight cash-price purchase, dressed weight cash-price purchase, forward contract purchase, packer-fed transfer, or marketing agreement purchase); (7) total purchase weight (i.e., live weight and dressed weight); (8) average dressing percentage; (9) total delivered cost; (10) average cost/cwt. (i.e., dressed weight price/cwt.); (11) distribution of quality grade carcasses; (12) distribution of yield grade carcasses; and (13) transportation and commission costs.

The original data set consisted of transaction data for a total of 200,616 sale lots of cattle. Data kept by individual firms and plants differed, creating problems. Similarly, firms and plants retain data for reasons other than research and do not carefully check data for accuracy. Therefore, substantial time was spent finding and eliminating data errors and creating consistent data series across firms and plants. As a result of missing data, irreconcilable differences in data, incompatible data among plants, and data errors, the data set was reduced considerably. The final data set consisted of 139,189 sale lot observations from 28 plants owned by 9 firms. Within that base data set for specific regression equations, missing data for selected variables further reduced the number of observations available for the specific estimation procedure.[12]

[12] Whenever observations are deleted from a data set, questions are raised as to the effect such deletions have on

Secondary data supplemented the primary data in the analysis. Secondary data included: (1) daily boxed beef cutout values from the Agricultural Marketing Service (AMS), U.S. Department of Agriculture (USDA); and (2) daily live cattle futures market prices from the Chicago Mercantile Exchange (CME).

Steps taken to correct data errors and create consistent data series in the primary data are discussed below. These steps were necessary to create variables used in the empirical analysis. Data problems resulted in multiple and intersecting numbers of deleted transactions making the number of observations removed by each step conditional on the order of deletion. Therefore, number of observations deleted at each step is not reported.

1. Data records on steers, heifers, mixed sex, Holsteins, and dairy cattle were retained. These cattle represent the bulk of fed cattle slaughter and represent reasonably the same market in terms of cattle type. Dairy cattle were retained when other information about the sale lot suggested these cattle entered the fed cattle mix. Cows, bulls, and stags represent a different market whose prices and quality differ from fed cattle.

2. Data records on sale lots that had kill and purchase dates recorded were retained. Transactions with dates outside the period of data collection were deleted with some exceptions. Purchase and kill dates were compared for those records which had either an outlier purchase or kill date. When the error could be determined with reasonable accuracy, purchase or kill records were corrected. For example, many records had an incorrect year, thus a comparison of purchase and kill dates often detected the error and data records were corrected. It was not possible to correct errors in purchase or kill dates for day and month. Purchase and kill dates were needed to identify the day cattle were procured and slaughtered for the empirical analysis. Missing or unusable purchase dates effectively eliminated some plants entirely from the data set.

3. Data records with 35 or more head in the sale lot were retained. This represented the minimum number of head per record the Packers and Stockyards Administration stipulated they would collect. Records containing less than 35 head were either erroneously collected or reported incorrectly and deleted.

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empirical results. Effects in this study from deleted data cannot be measured or estimated. Even with data deletions, this study had a more complete data set with which to conduct an empirical study of captive supply impacts on transaction prices than any previous study. However, the authors recognize that questions may still remain regarding impacts of data deletions. As data cleaning or filtering rules are relaxed, the size of the data set increases but the confidence associated with analyzing increasingly heterogeneous data records decreases.

4. Data records that had a recorded carcass weight (hot or cold) were retained. All carcass weights were converted to a hot weight basis. This was necessary because all prices analyzed were on a dressed weight basis. No pens remained in the final data set prior to this deletion that had a live weight and yield recorded but no carcass weight. Therefore, no pens were deleted that could have been assigned an estimated carcass weight.

5. Data records which had an average carcass yield recorded and had yield greater than or equal to 50 percent and less than or equal to 70 percent were retained. This represented the vast majority of the fed cattle in the original data set. Truncating the data at some reasonable range was necessary because the original data set had yields recorded ranging from 13 to 80 percent. These extreme values were considered errors, but identifying precisely which were erroneous and which were true extremes was not possible.

6. Data records that had the distribution of cattle slaughtered into yield grades were retained when it was possible to aggregate the distribution into yield grades 1-3 and yield grades 4-5. Plants recorded the distribution of cattle into yield grades either as number of head or percent of the sale lot total. In many cases, number of head in the sale lot did not correspond with the sum of cattle across the distribution of yield grades. Some plants only kept a partial distribution (e.g., yield grades 1-2, 3, and 4-5) while others kept a full distribution (i.e., yield grades 1, 2, 3, 4, and 5). Having two yield grade groups (i.e., 1-3 and 4-5) was the least restrictive means of retaining as many data records as possible and still maintain this relevant pricing variable. Data records without a yield grade had insufficient quality information to compare with the recorded price and were deleted.

7. Data problems and data filtering were similar for quality grade. Data records that had the distribution of cattle slaughtered in quality grades were retained when it was possible to aggregate the distribution into quality grades Choice or above and Select or below. Plants recorded the distribution of cattle into quality grades either as number of head or percent of the sale lot total. In many cases, number of head in the sale lot did not correspond with the sum of cattle across the distribution of quality grades. Some plants only kept a partial distribution (i.e., Choice, Select, and Standard) while others kept a full distribution (i.e., quality grades Prime, Choice, Select, and Standard). Having two quality grade groups (i.e., Choice or above and Select or below) was the least restrictive means of retaining as many data records as possible and still maintaining this relevant pricing variable. Data records without a quality grade had insufficient quality information to compare with the recorded price and were deleted.

8. Data records for which cost per hundredweight (i.e., dressed weight or carcass price) was between $105 and $142/cwt were retained. This resulted in deleting a few records which fell more than plus or minus three standard deviations from the mean. These extreme values were considered errors, but identifying precisely which were erroneous and which were true extremes was not possible.

9. On some data records, there were missing values for all types of information, obvious data errors, or unknown data codes. These observations were deleted.

Empirical Results

Cross section, time series data were analyzed using two-stage least squares regression (Model 1) and ordinary least squares regression (Models 2 and 3).[13] Reported significance of coefficients refers to the .01 confidence level. Appendix B provides summary statistics for selected variables used in the three models.[14]

Captive Supply Shipments-Price Relationships Model

Initially, four versions of Model 1 were estimated. Two versions using plant dummy variables in equation (5) ($DPLT_{i,t}$) and two using firm dummy variables ($DFIRM_{i,t}$). For each of those versions, alternative inventory periods were used from which forward contract, packer fed, and marketing agreement cattle could be delivered [i.e., 28 days ($PQFC_t$, $PQPF_t$, and $PQMA_t$, respectively) and 14 days ($PQFC14_t$, $PQPF14_t$, $PQMA14_t$, respectively)].

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[13] Difficulties were encountered with the Statistical Analysis System (SAS) software in testing for and correcting potential heteroskedasticity and serial correlations. Thus, reported results are uncorrected model estimates.

[14] Summary statistics for percentage plant utilization ($UTILN_t$) deserve an explanation. Percentage plant utilization averaged 155.9 percent and ranged from 1 to 1,501 percent. Percentage plant utilization was intended to be a relative measure of plant utilization at the time cash market cattle were purchased. Since cattle purchases on any given day may be significantly larger or smaller than daily slaughter capacity for each plant, the percentage plant utilization could be several times larger or smaller, respectively, than 100 percent. The mean percentage plant utilization is greater than 100 percent because the mean is computed for all transactions, and on days when purchases were several times greater than slaughter, the mean is weighted by the many more transactions for that day. Therefore, because percentage plant utilization ($UTILN_t$) was calculated in this study on the day cash market cattle were purchased, it varied more than had it been calculated on the day cattle were slaughtered.

Tables 1-4 provide the results for Model 1, using either a 28-day or 14-day captive supply inventory and using either plant dummy variables or firm dummy variables.[15] The percentage of available forward contracted, packer-fed, and marketing agreement cattle which were delivered varied by day and month (tables 5 and 6). Therefore, dummy variables for day of the week ($DDOW_{i,t}$) and month of the year ($DMON_{i,t}$) were added to account for this variation. Some day of week and month of year coefficients were significant, while others were not significant. Coefficients varied among the three equations (2-4) which incorporated these variables.

Percentage deliveries of forward contracted and packer fed cattle were highest later in the slaughter week (i.e., Monday to Friday) than earlier in the week (table 5). Percentage deliveries of marketing agreement cattle were less variable from day to day than for forward contracted and packer fed cattle. As expected, a higher percentage of deliveries were made from the 14-day inventory than the 28-day inventory, but the within-week pattern was similar.

Percentage deliveries of captive supply cattle were more variable from month-to-month than from day-to-day, especially for forward contracted cattle (table 6). Percentage deliveries of forward contracted cattle was highest in the live cattle futures market contract months (February, April, June, August, October, and December) compared with the preceding non-contract month. That pattern did not occur for percentage deliveries of packer-fed and marketing agreement cattle. Percentage deliveries for forward contracted cattle were highest in June, August, and December and lowest in September, July, and May during the study period. Percentage deliveries for packer fed cattle were highest in June, July, and March and lowest in August, September, and January. For marketing agreement cattle, percentage deliveries were relatively constant from month to month except March was considerably higher than other months.

Numerous factors explained the variation in fed cattle transaction prices, many of which were significant in previous research. Boxed beef cutout values, adjusted by quality grade of the cattle in the sale lot ($ABBCV_{t-1}$), positively and significantly affected transaction prices for fed cattle. Similarly, closing prices for the nearby live cattle futures market contract ($LCFMP_{t-1}$) positively and significantly affected fed cattle prices. Both results were consistent with prior research (Schroeder et al. 1993; Ward 1992).

Several variables which were related to cattle quality significantly affected fed cattle prices (Jones et al. 1992). Price discounts were found for certain types of cattle ($DTYP_{i,t}$), such as dairy breeds of cattle, fed Holstein cattle, heifers, and mixed pens of cattle, all compared with steers. A quadratic relationship was found between average dressed weight of cattle and prices paid ($AHotWt_t$ and $AHotWt_t^2$) (Jones et al. 1992; Schroeder et al. 1993). Prices increased at a decreasing rate as average dressed weights increased. A similar quadratic relationship was found

[15] Tables of regression results are several pages in length. Tables are formatted in columns, two tables per page, in order to make side-by-side comparisons of alternative versions of each model.

between number of head in the sale lot and prices paid ($NoHd_t$ and $NoHd^2$). Prices increased at a decreasing rate as sale lot size increased. This result was unlike previous research which modelled a linear relationship between lot size and transaction price (Jones et al. 1990; Ward 1992). Higher transaction prices were associated with an increased percentage of cattle in the sale lot which yield graded 1-3 ($PYG1\text{-}3_t$), which is similar to previous findings (Schroeder et al. 1992).

Fed cattle prices differed by day of the week when cattle were purchased ($DDOW_{i,t}$). In previous research, Monday was the highest price day of the week and Friday the lowest (Schroeder et al. 1993; Ward 1992). In this study, the within-week pattern differed from previous findings and differed among versions of Model 1. Monday was the highest price day in the plant versions of the model, whereas Thursday was the highest price day in the firm versions. These results combined with prior research confirm significant within-week price differences. The within-week pattern may vary due to differences in model specification, data, or study period.

Cubic trend variables ($TRND_i$, $TRND^2{}_i$, $TRND^3{}_i$) captured the decreasing then increasing pattern of fed cattle prices during the study period.

Number of days between purchase and delivery of cattle purchased in the cash market (FWD_t) was found to be significantly related to fed cattle prices. A similar variable had a negative relationship with fed cattle prices in 1979 (Ward 1981), but a positive effect in 1989 (Ward 1992) and 1990 (Schroeder et al. 1993). Here, as in the most recent prior research, as number of days between purchase and delivery increased, so did fed cattle prices.

Previous research found differences in prices paid for fed cattle between packers purchasing cattle (Ward 1982, 1992; Schroeder et al. 1993). Similar price differences were found here among some plants ($DPLT_{i,t}$) and firms ($DFIRM_{i,t}$). Significant price differences among plants ranged from $1.57/cwt above to $5.06/cwt below the base plant in the 28-day version of the model and from $2.30/cwt above to $5.11/cwt below the base plant in the 14-day version. There was some tendency for plants paying lower prices to be smaller or located farther from the primary cattle feeding area (i.e., the plains region of Texas, Oklahoma, Kansas, Colorado, and Nebraska) but there were exceptions.

Significant price differences among firms ranged from $0.35/cwt above to $5.13/cwt below the base plant in the 28-day version of the model and from $0.44/cwt below to $3.18/cwt below the base firm in the 14-day version. There was also a tendency for firms paying lower prices to be smaller firms with fewer plants or with plants located farther from the primary cattle feeding area.

Results here confirm that price differences can be expected among plants and firms, similar to previous research. However, variation among model versions and among studies suggests price differences vary according to the study period and geographic area from which data are collected, thus price differences are difficult to predict accurately.

Plant utilization ($UTILN_t$) was hypothesized to affect transaction prices for fed cattle. Coefficients on the plant utilization variable in equation (5) were consistently positive and significant, though not large. As plant utilization increased, so did fed cattle transaction prices. A 10 percent increase in plant utilization was associated with a $0.01 to $0.03/cwt increase in transaction prices. Ward (1990) confirmed that differences in plant utilization existed among plants and that significant economies of size existed in cattle slaughtering and carcass fabricating plants (Ward 1993). He argued that larger, more efficient plants could pay more for fed cattle than smaller, less efficient plants but would likely not do so if insufficient competition existed among firms. No comparable variable had been used in previous transaction price models. While results indicated packers paid significantly higher prices as plant utilization increased, the magnitude of the price increase was small and may not be economically significant.

Packers may use captive supplies to keep plant utilization high or at some target level. Therefore, an inverse relationship would be expected between plant utilization and captive supply deliveries. In the three equations for percentage delivery from captive supplies, results were mixed. Coefficients on the plant utilization variable were consistently larger in the 28-day versions of Model 1 than the 14-day versions. In three of the six equations in the 14-day versions (plant and firm), the plant utilization variable was not significant. Plant utilization was inversely associated with increased deliveries of packer fed and marketing agreement cattle ($PQPF_t$ and $PQMA_t$, respectively) as hypothesized, but positively associated with increased deliveries from the inventory of forward contracted cattle ($PQFC_t$).

Transaction prices ($TRPRC_t$) were included in each of the percentage deliveries equations as a measure of the market level. One argument is that deliveries of captive supplies will increase as the cash market price level increases, thus decreasing buying pressure on cash market prices and causing cash market prices to decline temporarily. In the 28-day version of Model 1, higher cash market prices were generally associated with increased percentage deliveries of captive supply cattle. An exception was a negative relationship in the 28-day firm version for marketing agreement cattle. Similar positive, significant results were found generally in the 14-day versions. There, the exceptions were a negative, significant and not significant relationship for packer fed cattle. Positive, significant results were found in all versions of the model for forward contracted cattle. The transaction price coefficients tended to be larger in the 14-day versions of the model than in the 28-day versions.

Basis (BSS_t) was hypothesized to affect deliveries of forward contracted cattle. When combined with the transaction price variable, it is argued that basis represents the movement of the futures market relative to the cash market. One argument is that as the basis narrows (i.e., assuming a positive basis), indicating that futures prices are increasing relative to cash, packers may deliver cattle from their forward contracted inventory. This could happen in anticipation that cash market prices may increase and to reduce buying pressure on cash market prices, thus allowing cash market prices to decline temporarily. However, a corollary, positive relationship could be argued in the basis is negative. In equation (2), consistent results were found. Basis was inversely related to deliveries of forward contracted cattle both in the 14-day versions and 28-day versions of the model.

Lagged futures market prices ($LCFMP_{t-1}$) were included as instrumental variables in the equations for percentage of packer fed and marketing agreement cattle [i.e., equations (2) and (3)]. As futures market prices increase, packers might be expected to increase deliveries from captive supply inventories to reduce buying pressure in the cash market and allow cash market prices to drift lower. Coefficients on the futures market variable were negative and significant rather than positive in the 28-day packer fed and marketing agreement equations of Model 1 and negative and significant in the 14-day version of the marketing agreement equation. Futures market prices were not significant in the 14-day version of the packer fed equation. Coefficients on the 14-day marketing agreement variables were larger than for the comparable 28-day marketing agreement variable, suggesting more importance for the 14-day inventory than the 28-day inventory.

A number of variables are of importance in this study. However, the focus is on the three endogenous variables included to measure price impacts from delivering cattle from an inventory of captive supply purchases at the time cattle are purchased in the cash market ($PQFC_t$, $PQPF_t$, $PQMA_t$). Generally from the discussion thus far, increases in the percentage deliveries of forward contracted cattle were associated with increases in plant utilization, increases in cash market prices, and decreases in basis. Generally, increases in the percentage deliveries of packer fed cattle were associated with increases in cash market prices, decreases in plant utilization, and declines in futures market prices, though not all coefficients were significant. Increases in percentage deliveries of marketing agreement cattle were consistently associated with increases in cash market prices, decreases in plant utilization, and decreases in futures market prices.

Results from the transaction price equation ($TRPRC_t$) indicate that increasing deliveries of cattle from each of the captive supply inventories was associated with lower transaction prices for fed cattle in two-thirds of the equations estimated (i.e., 8 of 12 equations). Coefficients were not significant in three equations and positive and significant in one equation.

The coefficient on the percentage deliveries of forward contracted cattle ($PQFC_t$) in equation (5) was negative and significant in the plant and firm, 28-day version of the model but not the 14-day versions. A 1-percent increase in percentage deliveries of forward contracted cattle was associated with a \$0.05/cwt decline in fed cattle transaction prices in the plant version of the model to a \$0.03/cwt. decline in the firm version. For perspective purposes, a 1-percent increase in percentage deliveries from the inventory of forward contracted cattle would represent a significant increase in use of forward contracts. The 28-day and 14-day percentage deliveries from forward contracted cattle inventories averaged 2.25 and 5.28 percent, respectively, over the 1-year data period.

Coefficients on the percentage deliveries of packer fed cattle ($PQPF_t$) were mixed positive and negative and mixed significant and not significant. Both coefficients in the 14-day versions were negative and significant, while in the 28-day version, the coefficient was positive and significant in the firm version but not significant in the plant version. A 1-percent increase in percentage deliveries of packer-fed cattle was associated with a \$0.30 to \$0.25/cwt decline in fed cattle transaction prices in the 14-day versions and with a $0.20/cwt increase in transaction prices in the 28-day, firm version. Again, for perspective purposes, a 1-percent increase in percentage deliveries from the inventory of packer-fed cattle would represent a significant increase in use of packer feeding. The 28-day and 14-day percentage deliveries from packer-fed cattle inventories averaged .53 and 1.02 percent, respectively, over the 1-year data period.

For each version (i.e., plant, firm, 28-day, and 14-day), the coefficient on the percentage deliveries of marketing agreement cattle ($PQMA_t$) was negative and significant. A 1-percent increase in percentage deliveries of captive supply cattle was associated with a $0.41 to $0.10/cwt decline in fed cattle transaction prices. Larger negative coefficients were found for the plant versions of the model than the firm versions and for the 14-day versions compared with the 28-day versions. A 1-percent increase in percentage deliveries from the inventory of marketing agreement cattle also would represent a significant increase in use of marketing agreements. The 28-day and 14-day percentage deliveries from marketing agreement inventories averaged 1.90 and 5.23 percent, respectively, over the one-year data period.

Instrumental variables explained only a small percentage of the variation in percentage deliveries from captive supply inventories. Thus, questions were raised regarding whether or not there was simultaneity between the percentage delivery of cattle from captive supply inventory and transaction prices for fed cattle. A modified-Hausman test was used to test for simultaneity (Godfrey). The Hausman test is based on the premise that results from an instrumental variable estimator will not be significantly different from an ordinary least squares estimator if there is no simultaneity. Test results at the 1-percent level indicated there was simultaneity between percentage deliveries from the inventory of forward contracted and marketing agreement cattle but not packer fed cattle. Results indicate that decisions by packers to deliver forward contracted and marketing agreement cattle are made at the same time as decisions to purchase cash market cattle. However, simultaneity tests indicate that the decision to deliver cattle fed by or for packers is made independently of the decision to purchase cash market cattle. Lack of simultaneity may explain in part the more diverse results on the percentage delivery variables for packer-fed cattle ($PQPF_t$ and $PQPF14_t$) in the transactions equation than for either of the other percentage delivery variables (i.e., for forward contracted and marketing agreement cattle).

Previous research did not consider the simultaneity question and considered only deliveries of forward contracted cattle. Thus, only a limited comparison can be made between results here and previous work. All previous studies which examined impacts from deliveries of forward contracted cattle (Elam; Hayenga and O'Brien; Schroeder et al. 1993) found some negative or mixed impacts on fed cattle prices from increased deliveries of forward contracted cattle.
However, not all results were statistically significant, either across geographic areas or time periods. Negative impacts found by Elam and Schroeder et al. were slightly larger than in this study, while negative impacts in the Hayenga and O'Brien study were much larger but results were mixed.

One version of the transaction price equation [i.e., equation (5)] of Model 1 was estimated using ordinary least squares regression (i.e., for the 14-day, plant version), thereby disregarding simultaneity and recognizing the possibility of simultaneity bias in the results. Coefficients on each of the three captive supply variables were negative and significant, but the coefficients were smaller compared with comparable results from the simultaneous model. While results were statistically significant, they may not be economically significant. Results for other variables were similar with the exception of coefficients on day of the week and plant dummy variables.

Captive Supply Inventory-Price Relationships Model

The basic inventory impacts model was based on previous price discovery research on fed cattle transaction prices (Jones et al. 1992; Schroeder et al. 1993; Ward 1981, 1982, 1992) and was similar to equation (5) of Model 1. Findings for comparable variables were similar to previously discussed results. Several versions of the base model were estimated. Tables 7-10 provide the results for Model 2, using either a 28-day or 14-day captive supply inventory and using either plant dummy variables or firm dummy variables. The focus here is on the variables included to measure price impacts from having an inventory of captive supply purchases when cattle are purchased in the cash market.

Two types of inventory variables were included in separate versions of Model 2. First were the inventory variables described previously (i.e., QFC_t, QPF_t, QMA_t), the number of forward contract, packer fed, and marketing agreement cattle, respectively, available for delivery over the next 28 days (and 14 days) at the time cash market cattle were purchased. Second was a single inventory variable ($QTOT_t$) which was the sum of all captive supply cattle available for delivery over the next 28 days (and 14 days) when cash market cattle were purchased.

Coefficients on individual captive supply inventory variables were mixed positive and negative and mixed significant and not significant. Coefficients on the total captive supplies variable were consistently negative but were mixed significant and not significant. Coefficients are strictly interpreted as price impacts associated with a one-head increase in the inventory. However, coefficients are quite small. Thus, for ease of presentation, coefficients are discussed in terms of price impacts from a 1,000 head increase in the respective type or sum of captive supplies, though a 1,000 head increase represents a significant increase in captive supplies relative to the level during the study period.

A 1,000 head increase in the forward contract inventory (QFC_t) was generally associated with a small but positive and significant impact on transaction prices. Significant coefficients ranged from \$0.02/cwt in the 14-day, firm version of Model 2 to \$0.01/cwt in the 28-day, firm version. The coefficient was not significant in the 14-day, plant version of the model. To keep these coefficients in perspective, the 28-day and 14-day inventories of forward contract cattle averaged 7,201 and 3,137 cattle, respectively.

These results differed from those found by Elam, though Elam's model differed significantly from Model 2. Elam estimated the impact on monthly average fed cattle prices from increased forward contracting. Overall, he found forward contracting negatively impacted fed cattle prices. His estimated negative impacts were slightly larger than the positive coefficients in this model. Recall that Model 2 estimated the impact on transaction prices, not monthly average prices, and that Model 2 also included impacts from inventories of packer-fed and marketing agreement cattle.

For packer-fed cattle, a 1,000 head increase in the inventory of packer-fed cattle (QPF_t) was associated with a generally negative and significant effect on fed cattle prices. Significant coefficients ranged from negative \$0.18/cwt in the 28-day, plant version of the model to positive \$0.07/cwt in the 14-day, plant version. The coefficient was not significant in the 14-day, firm version of the model. The negative relationship between packer fed cattle inventory and transaction prices was considerably larger relative to other coefficients for this model. The 28-day and 14-day inventories of packer fed cattle averaged 640 and 245, respectively, over the one-year data period.

The estimated impact from having an inventory of marketing agreement cattle (QMA_t) was consistently negative and significant but not large. The impact from a 1,000 head increase in the inventory of marketing agreement cattle ranged from a minus \$0.04/cwt. in the 14-day, plant version of the model to minus \$0.01/cwt. in the 28-day, firm version. For the data period, the 28-day and 14-day inventory of marketing agreement cattle, respectively, ranged from 11,929 to 5,325 head.

Above results suggest different types of captive supplies have differential impacts on fed cattle prices. Thus, a total inventory variable was included in Model 2 ($QTOT_t$) to assess the overall impact. Coefficients for this variable are summarized in tables 11 and 12, for each combination of the 28-day and 14-day and plant and firm versions of the model, as well as by calendar quarters. Impacts for the full year were consistently negative but not large, and in one version of the model (28-day, plant version), the coefficient was not significant. Significant coefficients ranged from a negative \$0.01/cwt in the 14-day, plant version to less than \$0.01/cwt in the 14-day, firm version of Model 2. These are the estimated impacts on fed cattle transaction prices from a 1,000-head increase in captive supply inventory. The mean 28-day and 14-day inventory of all captive supplies over the 1-year period ranged from 19,770 to 8,707 head, respectively. While coefficients were statistically significant, results may not be economically significant.

A comparison of overall captive supply impacts from Model 2 with Elam's estimated impacts from forward contracting only is quite limited. Elam measured impacts on monthly average prices, while estimated impacts here were on transaction prices. Both studies found a negative relationship between captive supplies and fed cattle prices. However, Elam's estimates were larger than the estimates in this study.

Results for the quarterly estimates of impacts from the total inventory of captive supplies were less consistent than for the full-year model. All significant coefficients had less than a \$0.01/cwt negative effect on fed cattle prices. All quarterly coefficients in the 28-day versions (plant and firm) were negative and significant. In the 14-day versions, second quarter 1992 estimated impacts both for the plant and firm model were not significant, and for the fourth quarter 1992, estimated impacts were not significant in the plant version but were significant in the firm version. Coefficients in other quarters were consistently negative and significant but coefficients were small and may not be economically significant.

Results for the quarterly estimates of Model 2 using separate variables for each type of captive supply inventory are shown in tables 13-14. Results varied. For forward contracted cattle (QFC_t), most coefficients in the 28-day version were significant, sometimes positive and sometimes negative. Estimated impacts were typically larger in the 28-day than the 14-day version of the model. For packer fed cattle (QPF_t), all significant coefficients were negative, and larger than coefficients for the other two types of captive supplies. Coefficients on the marketing agreement variable (QMA_t) were all significant in the firm version, generally negative but occasionally positive. In the plant version, all significant coefficients were negative, but not all coefficients were significant.

These quarterly estimates of the model suggest that captive supply inventory impacts differ by time of year as well as by type of captive supply. The overall tendency is for the inventory of captive supplies to be inversely related to transaction prices for fed cattle. However, in some quarters, impacts may be not significant, and may even be positive and significant. Thus, results are not robust and the magnitude of coefficients is generally quite small.

Captive Supply-Cash Price Differences Model

The basic price differences model was based on previous price discovery research on fed cattle transaction prices (Jones et al. 1992; Schroeder et al. 1993; Ward 1981, 1982, 1992) and was similar to equation (5) of Model 1 and Model 2. Note that the dependent variable in this model is purchase prices ($PPRC_t$) which may be transaction prices as in the case of cash market cattle, or may be a transfer or cost accounting price as in the case of packer fed cattle. Findings for comparable independent variables were similar to previously discussed results. Tables 15 and 16 provide the base results for Model 3, using either plant dummy variables or firm dummy variables. The focus here is on the dummy variables included to measure price differences among purchase prices ($DMETH_{i,t}$).

In addition to the captive supply variables, this model contained only one new variable compared with the two similar models previously discussed. Number of days between purchase and delivery for cash market and captive supply cattle on the day cash market cattle were purchased ($FWDALL_t$) was added to the model. In equation (5) of Model 1 a similar variable was included (i.e., number of days between purchase and delivery for cash market cattle only). FWDALL also includes the number of days between purchase and slaughter for the three types of captive supply procurement methods. FWDALL was included to capture some of the variation in prices which result from purchasing cattle by various methods at different times prior to slaughter. The coefficient on FWDALL was negative and significant, suggesting that purchase prices decline as buyers purchase cattle further ahead.

A dummy variable ($DMETH_{i,t}$) was included to measure the difference between cash market prices and prices for cattle purchased by other procurement methods (i.e., forward contract, packer feeding, and marketing agreements). The coefficients of these variables were mixed positive and negative and significant and not significant.

Negative, significant price differences were found between forward contract prices and cash market prices ($DFWDCON_t$). Coefficients in the two base models (tables 15 and 16) were $-3.16/cwt in the plant model and $-3.02/cwt. in the firm model. Those amounts translate to $-1.99 and $-1.90/cwt, respectively, on a live weight basis using a 63-percent dressing percentage. These results parallel finding by Eilrich et al. that net basis contracts and simulated hedged prices were $-1.37 to $-1.77/cwt. less than cash market prices on a live weight basis for data from 1988 to 1990. Results also support the theoretical conclusion (Carlton; Barkley and Schroeder) that forward contract prices must be lower than the expected value of cash market prices. This in turn provides an economic incentive for packers to forward price fed cattle.

Cattle feeders also have an incentive to use basis contracts. Koontz and Trapp studied cattle feeding profits for 33,250 pens of cattle fed in 64 southern plains feedlots from May 1986 to March 1993. They found that the contribution of basis risk to pen profit variability was four times greater than the contribution from price level risk. Reducing basis risk, such as by basis contracts, could reduce pen profit variability by 43 percent. Their results combined with results here suggest that basis contracting may reduce profit variability but only at some lower price and profit level.

Coefficients for the packer fed variable ($DPKRFED_t$) in both the plant and firm versions of Model 3 were not significant. The price recorded for packer-fed cattle is in essence an internal transfer or cost accounting price between the cattle feeding division and cattle slaughtering division of the packing company. This price might be expected to track cattle feeding costs or track the cash market price, so that transfer prices represent market conditions and do not give a consistent performance advantage to either the cattle feeding or cattle slaughtering profit center. Thus, insignificant price differences may indicate packers transferred packer fed cattle from feeding to slaughtering at a price which closely corresponded to cash market prices.

Prices for marketing agreement cattle ($DMKTAGREE_t$) were significantly higher than cash market cattle, ranging from $0.10/cwt in the plant version of the model to $0.07/cwt in the firm version. Theoretically, if marketing agreements result in better communication between feeders and packers, and provide additional information regarding how purchased cattle dressed, then one could expect a positive price difference between fed cattle purchased by marketing agreement compared with those purchased in the cash market. Over time, cattle feeders should use the additional information and improved communications to better feed and market fed cattle, which should be reflected in higher prices. Additionally, the incremental information may allow feeders to alter the type of feeder cattle purchased so as to better match the demands of packers when cattle reach market weight and finish. The higher price may represent a quality difference between marketing agreement and cash purchased cattle and reflect lower transactions costs associated with procuring cattle via marketing agreement.

Model 3 also was estimated by calendar quarters. As in previous models, results varied somewhat for a few variables but results were generally consistent for coefficient signs and significance. Results for the price difference variables are shown in tables 17 and 18.

Price differences between cash market and forward contract prices were consistently significant and negative. Forward contract prices ranged from $6.94/cwt lower than cash market cattle in the first quarter of 1993 to $1.69/cwt lower than cash market prices for the third quarter of 1992. This range translates to $4.37 and $1.06/cwt on a live weight basis assuming a 63 percent dressing percentage. Both the lowest and highest coefficients came from the firm version of Model 3. The smallest coefficients occurred in the quarter in which prices declined, reached a low, and began increasing. The largest coefficients occurred in the quarter in which prices increased sharply. These results suggest that the variable FWDALL model may not fully capture the temporal difference between when forward contracts are made and when cattle are slaughtered, and the model may overestimate the cash market-forward contract price difference.

Coefficients on the packer-fed variable were negative and significant in two quarters (second and third quarter of 1992) and were not significant in the other two quarters. Packer fed cattle prices were $0.76 to $0.51/cwt lower than cash market prices. Both the high and low price difference came from the second quarter of 1992, for the firm and plant versions of the model, respectively.

Quarterly results for price differences between marketing agreement prices and cash market prices were consistently significant but were mixed positive and negative. Marketing agreement prices were significantly lower in the first quarter of 1992 ($0.24 to $0.30/cwt) but significantly higher in the remaining three quarters ($0.12 to $0.76/cwt).

Summary and Conclusions

This study focused on unanswered questions related to the short-run impacts of captive supplies. The overall objective was to determine the relationships between captive supplies and cash market or spot transaction prices for fed cattle. Three specific objectives were: (1) estimate the interdependent relationship between delivering cattle from an inventory of captive supplies cattle and purchasing cash market cattle (Model 1); (2) estimate the relationship between the inventory of captive supplies and transaction prices for cash market cattle (Model 2); and (3) estimate price differences between cash transaction prices and prices for fed cattle purchased by each type of captive supply (Model 3).

Primary data were collected by the Packers and Stockyards Administration from 43 plants owned by 25 firms. Data were collected for each transaction of 35 head or 40,000 pounds or more for slaughter days from April 5, 1992, to April 3, 1993. Primary data were supplemented with secondary data from the Agricultural Marketing Service, U.S. Department of

Agriculture, and from the Chicago Mercantile Exchange. Due to missing data, irreconcilable differences in data, incompatible data among plants, and data errors, the original data set was reduced considerably. Observations in the final data set numbered 139,189 from 28 plants owned by 9 firms.

Readers are cautioned to recognize and understand how variables are specifically defined and computed in this study as they draw inferences from the results of this study.

Simultaneity was found in the decisions to deliver forward contracted and marketing agreement cattle and the decision to purchase cash market cattle (Model 1). Results were mixed significant and not significant for forward contracted cattle. The negative relationship between percentage deliveries from the inventory of forward contracted cattle and transaction prices was in the \$0.03-\$0.05/cwt range (i.e., in dressed weight prices) for each 1 percent increase in percentage deliveries. Significant coefficients on the variable for percentage delivery from the inventory of marketing agreement cattle were consistently negative, ranging from \$0.10-\$0.41/cwt for each 1 percent increase in percentage deliveries. For packer fed cattle, results were mixed, ranging from a negative impact of \$0.25-\$0.30/cwt to a positive \$0.20/cwt for each 1 percent increase in percentage deliveries.

Results estimating the relationship between the size of captive supply inventory and transaction prices were also mixed (Model 2). For the total inventory of captive supply cattle, the relationship was consistently negative for the entire data period. However, the impact was small and perhaps not economically significant. A 1,000-head increase in the total inventory of captive supply cattle (a significant increase relative to the mean total during the study period) was associated with a \$0.01/cwt or smaller decline in fed cattle transaction prices. When estimating the differential impacts of captive supply methods, results were mixed. The inventory of forward contracted cattle was associated with a generally positive effect on transaction prices. For packer fed cattle the inventory-price relationship was mixed negative and positive. The relationship for marketing agreement cattle was consistently negative.

Significant price differences were found among procurement methods (Model 3). Forward contract prices were \$3.02-\$3.16/cwt lower than transaction prices for cash market cattle over the 1-year study period. Prices for packer fed cattle were not significantly different than for cattle purchased in the cash market. Prices for cattle purchased via marketing agreements were \$0.07-\$0.10/cwt higher than transaction prices for cash-purchased cattle.

Drawing definitive conclusions from the three approaches taken in this study is difficult. A relatively weak negative relationship was found between transaction prices for cash market cattle and either delivering cattle from an inventory of captive supplies or having an inventory of captive supplies from which to deliver at a later time. Results were not robust. Several versions of the models were estimated and estimations over sub-periods within the 1-year study period yielded inconsistent results. The negative relationships between transaction prices and either the percentage deliveries of marketing agreement cattle or from having an inventory of marketing agreement cattle were relatively consistent. Percentage deliveries from the inventory of forward contracted cattle was associated with a generally negative impact on transaction prices while the absolute inventory of forward contracted cattle was associated with a generally positive impact. Results were most inconsistent for packer-fed cattle. Results were both positive and negative, and significant and not significant.

Prices paid for forward contracted cattle were significantly lower than for cash purchased cattle and were relatively large, (i.e., $3.02-$3.16/cwt on a dressed weight basis). Prices paid for marketing agreement cattle were significantly higher than cash purchased cattle but price differences were not large. Prices for packer-fed cattle were not significantly different than cash market cattle.

As indicated by results of the three models, numerous factors significantly explained the variation in transaction prices for fed cattle. However, at best, models estimated explained 86 percent of the variation, meaning that another 14 percent remained unexplained. Other variables could systematically account for additional variation in fed cattle prices. Inclusion of those variables in the models estimated could alter the signs and significance of coefficients in those models. Results also differed by time of year and by captive supply type. Consequently, the same analysis with data covering a different time period potentially could yield different findings.

The overall short-run impact on fed cattle transaction prices from captive supply deliveries or inventories based on this study was small and would be virtually impossible to observe in raw transaction price series. Price differences were found among procurement methods, but with the possible exception of price differences between forward contracts and cash market prices, observing such price differences in everyday transaction prices would be difficult.

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Appendix A - Cattle Feeder and Beefpacker Survey Summary

Captive Supplies Survey of Cattle Feeders - Selected Results

(Numbers to the right are respondents to each question or potential answer. A response followed by a number in parentheses represent number of respondents if more than one; and responses without numbers in parentheses indicate a single respondent.)

Fifteen Total Respondents

Captive supplies refer to three methods of procuring fed cattle by meatpackers: forward contract (quoted price or basis), by packer feeding, or an exclusive marketing agreement with a cattle feeder.

4. In which two months during 1993 were forward contract deliveries the largest?

a. Largest month	Apr (4)
b. Second largest month	May (2), Mar, Nov

21. In which two months during 1993 were packer-fed cattle deliveries the largest?

a. Largest month	Apr
b. Second largest month	Oct

36. In which two months during 1993 were marketing agreement deliveries the largest?

a. Largest month	Jun, Jul
b. Second largest month	Jul, Dec

12. How far in advance of delivery for forward contracted cattle is the delivery date (i.e. week) established?

b. 1-2 weeks	4
d. 3 or more weeks	2
e. varies	2

17. What advantages are there for meatpackers who forward contract? (Check one or more.)

c. Guarantee a given quantity of cattle	7
e. Gain leverage in the cash market	5
f. Gain increased control over deliveries	5

31. What advantages are there for packers who feed cattle? (Check one or more.)

b. Guarantee a given quantity of cattle	5	
c. Guarantee a given quality of cattle		6
g. Gain increased control over delivery	4	

47. What advantages are there for packers who enter into marketing agreements? (Check one or more.)

b. Guarantee a given quantity of cattle	4
e. Gain leverage in the cash market	4

18. What factors appear to you to be most important when packers determine the day and time contracted cattle will be delivered for slaughter? (Rank the three most important factors, where 1=most important, 2=second most important, and 3=third most important.)

a. Weight and finish of cattle	1 (3)
b. Current cash price level	1
d. Projected cash price trend	2
e. Current futures price level	1
g. Price (cost) of contracted cattle vs. cash purchased cattle	1, 2 (2)

i. Projected supply needs of competitors 1

32. What factors appear to be most important when packers determine the day and time packer-fed cattle will be delivered for slaughter? (Rank the three most important factors, where 1=most important, 2=second most important, and 3=third most important.)

a. Weight and finish of cattle	1 (4)
b. Current cash price level	1
c. Recent cash price trend	2
d. Projected cash price trend	2
f. Anticipated quantity needs to slaughter at X% plant utilization	2 (2)
g. Price (cost) of packer-fed cattle vs. cash purchasettle	1
i. Projected supply needs of competitors	2

48. What factors appear to be most important when determining the day and time marketing agreement cattle will be delivered for slaughter? (Rank the three most important factors, where 1=most important, 2=second most important, and 3=third most important.)

a. Weight and finish of cattle	1 (2), 2
b. Current cash price level	2
g. Price (cost) of formula-priced cattle vs. cash purchased cattle	1
h. Current price bids of competitors	2 (3)

25. Who is typically responsible for the following activities involving packer-fed cattle?

e. Decision to deliver cattle Packer or Joint

51. In your opinion, which of the following statements are correct?

a. Captive supplies benefit the packers who use them.	13
e. Captive supplies reduce market information.	10
h. Captive supplies insure a given supply of cattle for packers.	13
I. Captive supplies result in lower cash market prices.	9
h. Captive supplies benefit packers more than feeders.	9

Captive Supplies Survey of Beefpackers - Selected Results

Six Total Respondents (includes one returned pretest survey instrument)

Captive supplies refer to three methods of procuring fed cattle: by forward contract (quoted price or basis), by packer feeding, or by an exclusive marketing agreement with a cattle feeder.

4. In which two months during 1993 were forward contract deliveries the largest?

a. Largest month Jun, Apr
b. Second largest month Aug, Feb

22. In which two months during 1993 were deliveries of packer-fed cattle the largest?

a. Largest month Jun, Apr
b. Second largest month Jul, Oct

38. In which months during 1993 were deliveries of marketing agreement cattle the largest?

a. Largest month Jun

b. Second largest month Jul

18. What factors are most important when determining the day and time contracted cattle will be delivered for slaughter? (Rank the three most important factors, where 1=most important, 2=second most important, and 3=third most important.)

a. Weight and finish of cattle	1, 2
b. Current cash price level	2
f. Recent futures price trend	3
g. Price (cost) of contracted cattle vs. cash purchased cattle	3

34. What factors are most important when determining the day and time packer-fed cattle will be delivered for slaughter? (Rank the three most important factors, where 1=most important, 2=second most important, and 3=third most important.)

a. Weight and finish of cattle	1 (2), 2
b. Current cash price level	2
e. Current futures price level	3
g. Price (cost) of packer-fed cattle vs. cash purchased cattle	2, 3
h. Current price bids of competitors	1

50. What factors are most important when determining the day and time marketing agreement cattle will be delivered for slaughter? (Rank the three most important factors, where 1=most important, 2=second most important, and 3=third most important.)

a. Weight and finish of cattle	1, 2
b. Current cash price level	2
e. Current futures price level	3
h. Current price bids of competitors	1

53. In your opinion, which of the following statements are correct?

a. Captive supplies benefit the packers who use them	4
c. Captive supplies benefit the feeders who use them.	5
e. Captive supplies reduce market information.	6
h. Captive supplies insure a give supply of cattle for packers.	5

Captive Supplies Survey - Selected Combined Results

In which two months during 1993 were captive supply deliveries the largest?

Feeders

a. Largest month	Apr (5), Jun, Jul
b. Second largest month	Mar, May (2), Jul, Oct, Nov, Dec

Packers

a. Largest month	Apr (2), Jun (3)
b. Second largest month	Feb, Jul (2), Aug, Oct

(In the opinion of feeders) What advantages are there for meatpackers who use captive supplies?

Guarantee a given quantity of cattle	16
Gain leverage in the cash market	9
Gain increased control over deliveries	9
Guarantee a given quality of cattle	6

What factors appear to you to be most important when packers determine the day and time captive supply cattle will be delivered for slaughter?

Feeders	Rank = 1	2
Weight and finish of cattle	9	1
Current cash price level	2	1
Recent cash price trend	1	
Projected cash price trend		2
Anticipated quantity needs to slaughter at X% plant utilization		2
Current futures price level	1	
Price (cost) of captive supply cattle vs. cash purchased cattle	3	2
Projected supply needs of competitors	1	1
Current price bids of competitors	3	

Packers	Rank = 1	2	3
Weight and finish of cattle	4	3	
Current cash price level		3	
Current futures price level			2
Recent futures price trend			1
Price (cost) of contracted cattle vs. cash purchased cattle		1	2
Current price bids of competitors	2		

In your opinion, which of the following statements are correct?

	Feeders	Packers
Captive supplies benefit the packers who use them.	13	4
Captive supplies benefit the feeders who use them.	5	
Captive supplies reduce market information.	10	6
Captive supplies insure a given supply of cattle for packers.	13	5
Captive supplies result in lower cash market prices.	9	
Captive supplies benefit packers more than feeders.	9	

Appendix B - Summary Statistics

Variable	Mean	Standard Deviation	Minimum	Maximum
$TRPRC_{t-1}$ ($/cwt.)	121.10	5.98	105.00	142.00
$ABBCV_{t-1}$ ($/cwt.)	115.60	4.53	107.07	128.93
$LCFMP_{t-1}$ ($/cwt.)	75.55	3.08	70.10	83.72
BSS_t ($/cwt.)	.74	2.34	-15.89	15.29
$UTILN_t$ (%)	155.9	123.8	1	1,501
$AHotWt_t$ (lbs)	731.8	60.4	442	1,028
$NoHd_t$ (No. of herd)	118.3	94.0	35	1,116
PYG1-3_t (%)	95.9	5.7	0	100
FWD_t (No. of days)	5.8	3.0	0	14
$FWDALL_t$ (No. of days)	13.3	31.0	0	390
$PQFC_t$ (%)	5.8	11.0	0	100
$PQPF_t$ (%)	5.7	11.1	0	100
$PQMA_t$ (%)	5.2	5.4	0	100
$PQFC14_t$ (%)	10.7	16.4	0	100
$PQPF14_t$(%)	9.4	17.5	0	100
$PQMA14_t$ (%)	10.6	12.4	0	100
QFC_t (No. of head)	7,201	12,149	0	67,398
QPF_t (No. of head)	640	1,748	0	10,877
QMA_t (No. of head)	11,929	14,785	0	66,985
$QFC14_t$ (No. of head)	3,137	5,388	0	28,472
$QPF14_t$ (No. of head)	245	825	0	6,203
$QMA14_t$ (No. of head)	5,325	7,542	0	40,665

Tables

Table 1. Model 1 Regression Results, 28-Day Inventory, Plant Version.

Dependent Variable = $PQFC_t$

Instrumental Variable	Coefficient[1]
Intercept	-13.16* (7.15)
BSS_t	-.08* (5.65)
$TRPRC_t$	.10* (7.00)
$UTILN_t$	.003* (15.75)
$DMON_{i,t}$	Base
$DTUES_{i,t}$	.10 (1.62)
$DWED_{i,t}$	.84* (12.14)
$DTHURS_{i,t}$	1.23* (15.28)
$DFRI_{i,t}$	1.22* (12.56)
$DSAT\text{-}SUN_{i,t}$	-.57 (1.89)
$DJAN_{i,t}$	1.14* (7.67)
$DFEB_{i,t}$	1.15* (7.63)
$DMAR_{i,t}$	Base
$DAPR_{i,t}$	3.78* (20.22)
$DMAY_{i,t}$	1.72* (8.78)
$DJUN_{i,t}$	5.98* (25.96)
$DJUL_{i,t}$	1.40* (6.02)
$DAUG_{i,t}$	3.90* (12.69)
$DSEP_{i,t}$	.67* (3.23)
$DOCT_{i,t}$	1.75* (8.62)
$DNOV_{i,t}$	1.77* (9.05)
$DDEC_{i,t}$	3.17* (19.14)

Dep. Mean = 2.25
Root MSE = 7.192
Adj. R^2 = 0.040

Table 2. Model 1 Regression Results, 28-Day Inventory, Firm Version.

Dependent Variable = $PQFC_t$

Instrumental Variable	Coefficient[1]
Intercept	-6.25* (3.31)
BSS_t	-.06* (4.22)
$TRPRC_t$	.05* (3.16)
$UTILN_t$	.004* (16.16)
$DMON_{i,t}$	Base
$DTUES_{i,t}$	.09 (1.43)
$DWED_{i,t}$	.82* (11.77)
$DTHURS_{i,t}$	1.20* (14.87)
$DFRI_{i,t}$	1.19* (12.27)
$DSAT\text{-}SUN_{i,t}$	-.58 (1.93)
$DJAN_{i,t}$	1.11* (7.42)
$DFEB_{i,t}$	1.16* (7.73)
$DMAR_{i,t}$	Base
$DAPR_{i,t}$	3.43* (18.18)
$DMAY_{i,t}$	1.26* (6.40)
$DJUN_{i,t}$	5.32* (22.77)
$DJUL_{i,t}$	0.74* (3.11)
$DAUG_{i,t}$	3.31* (14.77)
$DSEP_{i,t}$	.13* (6.65)
$DOCT_{i,t}$	1.24* (6.02)
$DNOV_{i,t}$	1.30* (6.55)
$DDEC_{i,t}$	2.92* (17.54)

Dep. Mean = 2.25
Root MSE = 7.187
Adj. R^2 = 0.040

Dependent Variable = $PQPF_t$

Instrumental Variable	Coefficient
Intercept	3.95*
	(3.28)
$LCFMP_{t-1}$	-.10*
	(5.68)
$TRPRC_t$	.03*
	(4.00)
$UTILN_t$	-.0006*
	(4.21)
$DMON_{i,t}$	Base
$DTUES_{i,t}$	.03
	(.91)
$DWED_{i,t}$	-.10*
	(2.76)
$DTHURS_{i,t}$	-.19*
	(4.52)
$DFRI_{i,t}$	-.20*
	(3.81)
$DSAT\text{-}SUN_{i,t}$	-.57*
	(3.57)
$DJAN_{i,t}$	.13
	(1.66)
$DFEB_{i,t}$	-.03
	(.35)
$DMAR_{i,t}$	Base
$DAPR_{i,t}$	-.53*
	(4.50)
$DMAY_{i,t}$	-.31
	(2.55)
$DJUN_{i,t}$	.27
	(1.84)
$DJUL_{i,t}$	.62*
	(4.62)
$DAUG_{i,t}$	-.35*
	(2.86)
$DSEP_{i,t}$	-.21
	(1.86)
$DOCT_{i,t}$	-.16
	(1.36)
$DNOV_{i,t}$	-.04
	(.40)
$DDEC_{i,t}$	-.17
	(1.73)

Dep. Mean = .53
Root MSE = 3.841
Adj. R^2 = .008

Dependent Variable = $PQPF_t$

Instrumental Variable	Coefficient
Intercept	4.24*
	(3.51)
$LCFMP_{t-1}$	-.09*
	(5.17)
$TRPRC_t$	.03*
	(3.04)
$UTILN_t$	-.0005*

	(4.07)
$DMON_{i,t}$	Base
$DTUES_{i,t}$	.03
	(.84)
$DWED_{i,t}$	-.104*
	(2.82)
$DTHURS_{i,t}$	-.20*
	(4.59)
$DFRI_{i,t}$	-.20*
	(3.87)
$DSAT\text{-}SUN_{i,t}$	-.57*
	(3.58)
$DJAN_{i,t}$	.13
	(1.64)
$DFEB_{i,t}$	-.02
	(.20)
$DMAR_{i,t}$	Base
$DAPR_{i,t}$	-.53*
	(4.47)

Dependent Variable = $PQMA_t$

Instrumental Variable	Coefficient
Intercept	6.86*
	(5.87)
$LCFMP_{t-1}$	-.21*
	(12.64)
$TRPRC_t$	.09*
	(10.82)
$UTILN_t$	-.0008*
	(6.47)
$DMON_{i,t}$	Base
$DTUES_{i,t}$	.25*
	(7.72)
$DWED_{i,t}$	-.04
	(1.05)
$DTHURS_{i,t}$	.30*
	(7.08)
$DFRI_{i,t}$	-.28*
	(5.48)
$DSAT\text{-}SUN_{i,t}$	-1.20*
	(7.69)
$DJAN_{i,t}$	.49*
	(6.35)
$DFEB_{i,t}$	.08
	(1.07)
$DMAR_{i,t}$	Base
$DAPR_{i,t}$	.26
	(2.23)
$DMAY_{i,t}$	-.12

$DMAY_{i,t}$	-.32
	(2.62)
$DJUN_{i,t}$	.26
	(1.74)
$DJUL_{i,t}$	.58*
	(4.30)
$DAUG_{i,t}$	-.39*
	(3.18)
$DSEP_{i,t}$	-.25
	(2.23)
$DOCT_{i,t}$	-.18
	(1.57)
$DNOV_{i,t}$	-.07
	(.60)
$DDEC_{i,t}$	-.17
	(1.70)

Dep. Mean = .53
Root MSE = 3.841
Adj. R^2 = .008

	(1.04)
$DJUN_{i,t}$	-.58*
	(3.96)
$DJUL_{i,t}$	.77*
	(5.97)
$DAUG_{i,t}$	.28
	(2.34)
$DSEP_{i,t}$	.75*
	(6.77)
$DOCT_{i,t}$	.18
	(1.56)
$DNOV_{i,t}$	-.03
	(.27)
$DDEC_{i,t}$	-.36*
	(3.68)

Dep. Mean = 1.90
Root. MSE = 3.732
Adj. R^2 = .009

Dependent Variable = $PQMA_t$

Instrumental Variable	Coefficient
Intercept	9.24*
	(7.89)
$LCFMP_{t-1}$	-.15*
	(8.73)
$TRPRC_t$	-.03*
	(3.58)
$UTILN_t$	-.0007*
	(5.32)
$DMON_{i,t}$	Base

			(1.57)
$DTUES_{i,t}$	.24*	$DJUN_{i,t}$	-.69*
	(7.22)		(4.77)
$DWED_{i,t}$	-.06	$DJUL_{i,t}$	.45*
	(1.56)		(3.43)
$DTHURS_{i,t}$	.27*	$DAUG_{i,t}$	-.06
	(6.55)		(.48)
$DFRI_{i,t}$	-.30*	$DSEP_{i,t}$	.40*
	(5.99)		(3.60)
$DSAT\text{-}SUN_{i,t}$	1.21*	$DOCT_{i,t}$	-.02
	(7.76)		(.15)
$DJAN_{i,t}$	.49*	$DNOV_{i,t}$	-.22
	(6.26)		(2.00)
$DFEB_{i,t}$	.18	$DDEC_{i,t}$	-.33*
	(2.30)		(3.38)
$DMAR_{i,t}$	Base	Dep. Mean	= 1.90
		Root. MSE	= 3.728
$DAPR_{i,t}$	.28	Adj. R^2	= .008
	(2.46)		
$DMAY_{i,t}$	-.18		
Dependent Variable = $TRPRC_t$		$ABBCV_{t-1}$	.51*
Instrumental			(105.77)
Variable	Coefficient	$LCFMP_{t-1}$	.28*
			(32.36)
Intercept	59.82*	$DSTR_{t-1}$	Base
	(51.24)		
$PQFC_t$	-.05*	$DDAIRY_{i,t}$	-4.79*
	(7.40)		(28.55)
$PQPF_t$	-.06	$DFEDHOL_{i,t}$	-5.91*
	(1.74)		(103.70)
$PQMA_t$	-.36*	$DHFR_{i,t}$	-.92*
	(13.87)		(45.32)

Model 1 - 28 Day, Plant

$DMIX_{i,t}$	-.87*
	(19.36)
$AHotWt_t$	.01*
	(4.39)
$AHotWt_t^2$	-.00001*
	(7.07)
$NoHd_t$	.004*
	(19.89)
$NoHd^2$	-.000006*
	(13.83)
$PYG1\text{-}3_t$	.05*
	(35.06)
FWD_t	.08*
	(28.81)
$DMON_{i,t}$	Base
$DTUES_{i,t}$	-.36*
	(15.59)
$DWED_{i,t}$	-.54*
	(22.67)
$DTHURS_{i,t}$	-.24*
	(7.85)
$DFRI_{i,t}$	-.18*
	(5.33)
$DSAT\text{-}SUN_{i,t}$	-.95*
	(8.42)
$UTILN_t$	.003*
	(28.02)

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Dependent Variable = $TRPRC_t$

Instrumental Variable	Coefficient
Intercept	56.33*
	(50.94)
$PQFC_t$	-.03*
	(4.16)
$PQPF_t$	.20*
	(6.76)
$PQMA_t$	-.10*
	(4.17)
$TRND_i$	-7.78*
	(82.96)
$TRND^2_i$	.71*
	(76.54)
$TRND^3_i$	-.02*
	(63.92)
$DPLT1_{i,t}$	Base
$DPLT2_{i,t}$	-5.06*
	(28.59)
$DPLT3_{i,t}$	.20*
	(4.38)
$DPLT4_{i,t}$	-2.01*

Model 1 - 28 Day, Firm

$ABBCV_{t-1}$	.50*
	(117.90)
$LCFMP_{t-1}$	.34*
	(43.41)
$DSTR_{t-1}$	Base
$DDAIRY_{i,t}$	-4.61*
	(29.19)
$DFEDHOL_{i,t}$	-5.98*
	(108.24)
$DHFR_{i,t}$	-.92*
	(48.44)
$DMIX_{i,t}$	-.77*
	(17.99)
$AHotWt_t$	.01*
	(4.59)
$AHotWt_t^2$	-.00001*
	(7.30)
$NoHd_t$	.004*
	(19.36)
$NoHd^2$	-.000006*
	(13.69)
$PYG1\text{-}3_t$	.05*
	(35.82)
FWD_t	.09*
	(32.94)
$DMON_{i,t}$	Base
$DTUES_{i,t}$	-.35*
	(16.13)
$DWED_{i,t}$	-.49*
	(21.66)
$DTHURS_{i,t}$	-.43*
	(15.14)
$DFRI_{i,t}$	-.37*
	(11.59)
$DSAT\text{-}SUN_{i,t}$	-.38*
	(3.61)
$UTILN_t$	.002*
	(24.28)

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	(15.38)
$DPLT5_{i,t}$	.53*
	(4.10)
$DPLT6_{i,t}$	-.96*
	(8.30)
$DPLT7_{i,t}$	-.47*
	(4.20)
$DPLT8_{i,t}$	-3.41*
	(13.61)
$DPLT9_{i,t}$	-.64*
	(6.48)
$DPLT10_{i,t}$	-.71*
	(13.15)

$DPLT11_{i,t}$	.49*	$TRND_i$	-8.108*
	(10.91)		(90.97)
$DPLT12_{i,t}$	-.44*	$TRND^2_i$	.75*
	(3.90)		(83.78)
$DPLT13_{i,t}$	1.04*	$TRND^3_i$	-.02*
	(5.45)		(70.55)
$DPLT14_{i,t}$	.14*	$DFIRM1_{i,t}$	Base
	(2.95)		
$DPLT15_{i,t}$	-.83*	$DFIRM2_{i,t}$	-.51*
	(6.64)		(6.01)
$DPLT16_{i,t}$	1.57*	$DFIRM3_{i,t}$	-.22
	(12.34)		(2.33)
$DPLT17_{i,t}$	-2.44*	$DFIRM4_{i,t}$	-.37*
	(26.43)		(4.30)
$DPLT18_{i,t}$	.71*	$DFIRM5_{i,t}$	.35*
	(14.28)		(3.91)
$DPLT19_{i,t}$	-.94*	$DFIRM6_{i,t}$	-5.13*
	(5.24)		(33.53)
$DPLT20_{i,t}$	-1.66*	$DFIRM7_{i,t}$	-3.45*
	(13.79)		(15.24)
$DPLT21_{i,t}$	-1.35*	$DFIRM8_{i,t}$	-1.34*
	(10.59)		(13.11)
$DPLT22_{i,t}$	-1.27*	$DFIRM9_{i,t}$	-1.98*
	(10.28)		(19.73)
$DPLT23_{i,t}$	-1.26*		
	(9.91)		

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n	=	105,612
Dep. Mean	=	120.64
Root MSE	=	2.321
Adj. R^2	=	.812

Model 1 - 28 Day, Plant

Model 1 - 28 Day, Firm

[1]Numbers in parenthesis are absolute values of calculated t statistics; * = .01 significance level.

Model 1 - 28 Day, Plant

$DPLT24_{i,t}$	-1.95*	
	(19.84)	
$DPLT25_{i,t}$	-2.48*	
	(18.06)	
$DPLT26_{i,t}$	-3.12*	
	(22.66)	
$DPLT27_{i,t}$	-1.96*	
	(14.58)	
$DPLT28_{i,t}$	-1.36*	
	(10.49)	
n	=	105,612
Dep. Mean	=	120.64
Root MSE	=	2.445
Adj. R^2	=	.797

[1]Numbers in parenthesis are absolute values of calculated t statistics; * = .01 significance level.

Table 3. Model 1 Regression Results, 14-Day Inventory, Plant Version.

Dependent Variable = $PQFC_t$

Instrumental Variable	Coefficient[1]
Intercept	-48.54*
	(15.93)
BSS_t	-.14*
	(5.65)
$TRPRC_t$	.41*
	(17.48)
$UTILN_t$	.001*
	(2.44)
$DMON_{i,t}$	Base
$DTUES_{i,t}$	.59
	(5.49)
$DWED_{i,t}$	1.38*
	(11.68)
$DTHURS_{i,t}$	1.64*
	(11.87)
$DFRI_{i,t}$	2.41*
	(14.45)
$DSAT\text{-}SUN_{i,t}$	-1.19
	(2.29)
$DJAN_{i,t}$	-.27
	(1.36)
$DFEB_{i,t}$	1.15*
	(5.79)
$DMAR_{i,t}$	Base
$DAPR_{i,t}$	6.17*
	(20.50)
$DMAY_{i,t}$	2.41*
	(7.52)
$DJUN_{i,t}$	8.77*
	(22.61)
$DJUL_{i,t}$	2.78*
	(7.09)
$DAUG_{i,t}$	6.61*
	(17.90)
$DSEP_{i,t}$	1.42*
	(4.13)
$DOCT_{i,t}$	3.21*
	(9.55)
$DNOV_{i,t}$	3.14*
	(9.80)
$DDEC_{i,t}$	4.67*
	(18.42)

Dep. Mean	=	5.28
Root MSE	=	12.637
Adj. R^2	=	0.030

Table 4. Model 1 Regression Results, 14-Day Inventory, Firm Version.

Dependent Variable = $PQFC_t$

Instrumental Variable	Coefficient[1]
Intercept	-50.24*
	(16.06)
BSS_t	-.15*
	(5.84)
$TRPRC_t$	.42*
	(17.57)
$UTILN_t$	.001
	(2.38)
$DMON_{i,t}$	Base
$DTUES_{i,t}$	.59*
	(5.52)
$DWED_{i,t}$	1.39*
	(11.72)
$DTHURS_{i,t}$	1.65*
	(11.92)
$DFRI_{i,t}$	2.42*
	(14.48)
$DSAT\text{-}SUN_{i,t}$	-1.19
	(2.28)
$DJAN_{i,t}$	-.24
	(1.17)
$DFEB_{i,t}$	1.17*
	(5.91)
$DMAR_{i,t}$	Base
$DAPR_{i,t}$	6.29*
	(20.62)
$DMAY_{i,t}$	2.55*
	(7.83)
$DJUN_{i,t}$	8.96*
	(22.63)
$DJUL_{i,t}$	2.97*
	(7.42)
$DAUG_{i,t}$	6.78*
	(18.02)
$DSEP_{i,t}$	1.58*
	(4.51)
$DOCT_{i,t}$	3.36*
	(9.83)
$DNOV_{i,t}$	3.28*
	(10.07)
$DDEC_{i,t}$	4.76*
	(18.57)

Dep. Mean	=	5.28
Root MSE	=	12.639
Adj. R^2	=	0.030

Dependent Variable = $PQPF_t$

Instrumental Variable	Coefficient
Intercept	6.00*
	(3.17)
$LCFMP_{t-1}$	.03
	(1.04)
$TRPRC_t$	-.05*
	(3.98)
$UTILN_t$	-.0001
	(.53)
$DMON_{i,t}$	Base
$DTUES_{i,t}$	-.17*
	(3.13)
$DWED_{i,t}$	-.10
	(1.69)
$DTHURS_{i,t}$	.10
	(1.37)
$DFRI_{i,t}$	.06
	(.72)
$DSAT\text{-}SUN_{i,t}$	-1.04*
	(3.91)
$DJAN_{i,t}$	.10
	(.98)
$DFEB_{i,t}$	.93*
	(8.34)
$DMAR_{i,t}$	Base
$DAPR_{i,t}$	-1.32*
	(6.75)
$DMAY_{i,t}$	-1.40*
	(-6.95)
$DJUN_{i,t}$	-.85*
	(3.39)
$DJUL_{i,t}$	-1.54*
	(6.99)
$DAUG_{i,t}$	-1.40*
	(6.94)
$DSEP_{i,t}$	-.51*
	(2.79)
$DOCT_{i,t}$	.02
	(.10)
$DNOV_{i,t}$	.11
	(.60)
$DDEC_{i,t}$	.31
	(1.96)

Dep. Mean	=	1.02
Root MSE	=	6.48
Adj. R^2	=	.011

Dependent Variable = $PQPF_t$

Instrumental Variable	Coefficient
Intercept	4.46
	(2.36)
$LCFMP_{t-1}$	-.02
	(.75)
$TRPRC_t$	-.01
	(.84)
$UTILN_t$	-.0002
	(1.00)
$DMON_{i,t}$	Base
$DTUES_{i,t}$	-.16*
	(2.92)

Model 1 - 14 Day, Plant

$DWED_{i,t}$	-.09
	(1.51)
$DTHURS_{i,t}$	.11
	(1.57)
$DFRI_{i,t}$	.08
	(.93)
$DSAT\text{-}SUN_{i,t}$	-1.04*
	(3.88)
$DJAN_{i,t}$	.13
	(1.19)
$DFEB_{i,t}$	.88*
	(7.85)
$DMAR_{i,t}$	Base
$DAPR_{i,t}$	-1.33*
	(6.83)
$DMAY_{i,t}$	-1.35*
	(6.71)
$DJUN_{i,t}$	-.77*
	(3.07)
$DJUL_{i,t}$	-1.30*

Dependent Variable = $PQMA_t$

Instrumental Variable	Coefficient
Intercept	14.52*
	(4.78)
$LCFMP_{t-1}$	-.40*
	(9.15)
$TRPRC_t$	.18*
	(8.33)
$UTILN_t$	-.003*
	(9.04)
$DMON_{i,t}$	Base
$DTUES_{i,t}$	.40*
	(4.48)
$DWED_{i,t}$	.09
	(.93)
$DTHURS_{i,t}$	1.60*
	(14.08)
$DFRI_{i,t}$	.06
	(.40)
$DSAT\text{-}SUN_{i,t}$	-2.24*
	(5.21)
$DJAN_{i,t}$	-1.33*
	(7.72)
$DFEB_{i,t}$	-.37
	(2.06)
$DMAR_{i,t}$	Base
$DAPR_{i,t}$	-2.43*
	(7.75)
$DMAY_{i,t}$	-2.03*
	(6.26)
$DJUN_{i,t}$	-2.50*
	(6.23)
$DJUL_{i,t}$	.06
	(.18)

Model 1 - 14 Day, Firm

	(5.88)
$DAUG_{i,t}$	-1.15*
	(5.66)
$DSEP_{i,t}$	-.25
	(1.36)
$DOCT_{i,t}$	.17
	(.85)
$DNOV_{i,t}$	.25
	(1.37)
$DDEC_{i,t}$	.30
	(1.87)

Dep. Mean = 1.02
Root MSE = 6.480
Adj. R^2 = .011

$DAUG_{i,t}$	-.26
	(.80)
$DSEP_{i,t}$	-.77*
	(2.59)
$DOCT_{i,t}$	-1.17*
	(3.71)
$DNOV_{i,t}$	-.87*
	(2.92)
$DDEC_{i,t}$	-2.06*
	(8.00)

Dep. Mean = 5.23
Root. MSE = 10.419
Adj. R^2 = .008

Dependent Variable = $PQMA_t$

Instrumental Variable	Coefficient
Intercept	16.36*
	(5.38)
$LCFMP_{t-1}$	-.34*
	(7.72)
$TRPRC_t$	.13*
	(5.81)
$UTILN_t$	-.003*
	(8.68)
$DMON_{i,t}$	Base
$DTUES_{i,t}$	.38*
	(4.33)
$DWED_{i,t}$	.08
	(.79)

$DTHURS_{i,t}$	1.59*	$DAUG_{i,t}$	-.56
	(13.94)		(1.72)
$DFRI_{i,t}$	.03	$DSEP_{i,t}$	.45
	(.25)		(1.52)
$DSAT\text{-}SUN_{i,t}$	-2.24*	$DOCT_{i,t}$	-1.34*
	(5.23)		(4.27)
$DJAN_{i,t}$	-1.36*	$DNOV_{i,t}$	-1.04*
	(7.88)		(3.49)
$DFEB_{i,t}$	-.30	$DDEC_{i,t}$	-2.04*
	(1.69)		(7.94)
$DMAR_{i,t}$	Base	Dep. Mean = 5.23	
		Root. MSE = 10.415	
$DAPR_{i,t}$	-2.41*	Adj. R^2 = .007	
	(7.69)		
$DMAY_{i,t}$	-2.09*		
	(6.44)		
$DJUN_{i,t}$	-2.60*		
	(6.47)		
$DJUL_{i,t}$	-.22		
	(.63)		

Dependent Variable = $TRPRC_t$

Instrumental Variable	Coefficient		
		$DDAIRY_{i,t}$	-4.91*
			(15.77)
		$DFEDHOL_{i,t}$	-5.86*
Intercept	63.67*		(54.80)
	(28.12)	$DHFR_{i,t}$	-.92*
$PQFC14_t$	-.01		(24.17)
	(1.57)	$DMIX_{i,t}$	-.95*
$PQPF14_t$	-.25*		(11.11)
	(4.52)	$AHotWt_t$	.02*
$PQMA14_t$	-.41*		(4.29)
	(14.34)	$AHotWt_t^2$	-.000017*
$ABBCV_{t-1}$	.46*		(5.72)
	(49.34)	$NoHd_t$	.004*
$LCFMP_{t-1}$	.24*		(9.83)
	(14.17)	$NoHd^2$	-.000006*
$DSTR_{t-1}$	Base		(6.26)

Model 1 - 14 Day, Plant

PYG1-3$_t$	.05*
	(16.77)
FWD$_t$	.10*
	(17.09)
DMON$_{i,t}$	Base
DTUES$_{i,t}$	-.15*
	(3.22)
DWED$_{i,t}$	-.27*
	(5.51)
DTHURS$_{i,t}$	.53*
	(6.18)
DFRI$_{i,t}$	.19
	(2.56)
DSAT-SUN$_{i,t}$	-1.73*
	(7.85)
UTILN$_t$	.002*
	(12.24)
TRND$_i$	-6.89*
	(37.90)

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Dependent Variable = TRPRC$_t$

Instrumental Variable	Coefficient
Intercept	60.68*
	(33.90)
PQFC14$_t$	-.01
	(2.37)
PQPF14$_t$	-.30*
	(7.39)
PQMA14$_t$	-.22*
	(10.36)
ABBCV$_{t-1}$	.47*
	(67.52)
LCFMP$_{t-1}$	.26*
	(21.31)
DSTR$_{t-1}$	Base
TRND^2_i	.62*
	(34.68)
TRND^3_i	-.02*
	(27.46)
DPLT1$_{i,t}$	Base
DPLT2$_{i,t}$	-5.08*
	(9.869)
DPLT3$_{i,t}$	.09
	(1.16)
DPLT4$_{i,t}$	-2.18*
	(7.06)
DPLT5$_{i,t}$	.42
	(2.05)
DPLT6$_{i,t}$	-2.89*
	(10.88)
DPLT7$_{i,t}$	1.28*
	(3.50)

Model 1 - 14 Day, Firm

DDAIRY$_{i,t}$	-4.28*
	(17.84)
DFEDHOL$_{i,t}$	-5.99*
	(72.00)
DHFR$_{i,t}$	-.99*
	(33.83)
DMIX$_{i,t}$	-1.13*
	(16.49)
AHotWt$_t$	.02*
	(4.89)
AHotWt$_t^2$	-.000016*
	(6.75)
NoHd$_t$	.006*
	(17.82)
NoHd^2	-.000008*
	(12.43)
PYG1-3$_t$	.05*
	(24.03)
FWD$_t$	.11*
	(24.23)
DMON$_{i,t}$	Base
DTUES$_{i,t}$	-.20*
	(5.65)
DWED$_{i,t}$	-.34*
	(9.41)
DTHURS$_{i,t}$	.04
	(.63)
DFRI$_{i,t}$	-.26*
	(5.06)
DSAT-SUN$_{i,t}$	-1.05*
	(6.20)
UTILN$_t$	.001*
	(9.20)
TRND$_i$	-7.34*
	(52.90)

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DPLT8$_{i,t}$	-3.58*
	(5.85)
DPLT9$_{i,t}$	.42*
	(3.88)
DPLT10$_{i,t}$	-.41*
	(4.15)
DPLT11$_{i,t}$	.13
	(1.54)
DPLT12$_{i,t}$	2.30*
	(6.89)
DPLT13$_{i,t}$	1.21*
	(9.31)
DPLT14$_{i,t}$	-.02
	(.26)
DPLT15$_{i,t}$	-2.89*
	(10.19)
DPLT16$_{i,t}$	-3.57*
	(12.21)

$DPLT17_{i,t}$	-3.56*
	(18.67)
$DPLT18_{i,t}$	.55*
	(5.96)
$DPLT19_{i,t}$	-1.12
	(2.24)
$DPLT20_{i,t}$	-1.19*
	(8.03)
$DPLT21_{i,t}$	-3.58*
	(12.07)
$DPLT22_{i,t}$	-1.47*
	(8.22)
$DPLT23_{i,t}$	-3.27*
	(11.36)
$DPLT24_{i,t}$	-1.42*
	(9.14)
$DPLT25_{i,t}$	-4.52*
	(14.72)

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$TRND^2_i$	.67*
	(48.60)
$TRND^3_i$	-.02*
	(39.53)
$DFIRM1_{i,t}$	Base
$DFIRM2_{i,t}$	-.44*
	(2.94)
$DFIRM3_{i,t}$	-.51
	(2.49)
$DFIRM4_{i,t}$	-1.68*
	(9.61)
$DFIRM5_{i,t}$	-1.17*
	(6.34)
$DFIRM6_{i,t}$	-3.18*
	(7.98)
$DFIRM7_{i,t}$	-1.20
	(2.53)
$DFIRM8_{i,t}$	-2.70*
	(13.72)
$DFIRM9_{i,t}$	-3.17*
	(16.83)

n	=	110,623
Dep. Mean	=	121.13
Root MSE	=	3.647
Adj. R^2	=	.674

[1]Numbers in parenthesis are absolute values of calculated t statistics; * = .01 significance level.

Model 1 - 14 Day, Plant				Model 1 - 14 Day, Firm
$DPLT26_{i,t}$			-5.11*	
			(16.64)	
$DPLT27_{i,t}$			-3.95*	
			(13.06)	
$DPLT28_{i,t}$			-2.77*	
			(8.47)	
n	=	110,623		
Dep. Mean	=	121.13		
Root MSE	=	4.713		
Adj. R^2	=	.555		

[1]Number in parenthesis are absolute values of calculated t statistics; * = .01 significance level.

Table 5. Variation in Percentage Deliveries from Captive Supplies, by Inventory Period and Day of the Week.

	28-Day Inventory			14-Day Inventory		
	Forward Contract	Packer Fed	Marketing Agreement	Forward Contract	Packer Fed	Marketing Agreement
Monday	4.80	4.66	4.74	9.02	7.65	10.36
Tuesday	5.36	5.90	5.51	10.36	7.83	10.98
Wednesday	6.06	5.79	4.73	11.54	10.32	9.84
Thursday	6.88	5.94	5.97	11.79	14.56	12.09
Friday	7.50	6.75	5.46	12.77	11.78	10.45
Saturday-Sunday	3.59	4.83	3.32	8.03	14.24	6.53

Table 6. Variation in Percentage Deliveries from Captive Supplies, by Inventory Period and Month of the Year.

	28-Day Inventory			14-Day Inventory		
	Forward Contract	Packer Fed	Marketing Agreement	Forward Contract	Packer Fed	Marketing Agreement
April 1992	8.15	4.47	5.92	15.67	10.84	11.15
May	3.12	3.59	3.78	6.79	2.50	8.77
June	11.97	9.44	3.77	15.60	9.67	8.40

Model 1 - 14 Day, Plant			Model 1 - 14 Day, Firm			
July	2.70	9.70	5.64	6.88	4.25	10.95
August	10.32	2.30	4.46	14.55	6.24	9.95
September	2.15	3.90	5.31	6.78	10.66	11.57
October	3.22	5.61	5.25	7.34	11.94	10.22
November	3.56	5.22	4.59	8.44	12.45	11.14
December	8.94	5.40	4.85	14.94	8.78	10.34
January 1993	3.87	3.44	5.08	8.71	6.87	9.59
February	5.49	6.20	5.07	11.62	13.52	11.77
March	6.31	8.79	9.17	10.56	9.17	13.71

Table 7. Model 2 Regression Results, 28-Day Inventory, Plant Version.

Dependent Variable = $TRPRC_t$

Independent Variable	Coefficient[1]
Intercept	49.87*
	(35.42)
QFC_t	.0000130*
	(7.25)
QPF_t	-.0001790*
	(11.60)
QMA_t	-.0000169*
	(7.63)
$ABBCV_{t-1}$	.48*
	(99.49)
$LCFMP_{t-1}$	.36*
	(49.35)
$DSTR_{i,t}$	Base
$DDAIRY_{i,t}$	-4.78*
	(23.04)
$DFEDHOL_{i,t}$	-5.74*
	(85.90)
$DHFR_{i,t}$	-.82*
	(34.04)
$DMIX_{i,t}$	-.58*
	(7.11)
$AHotWt_t$	.022*
	(7.54)
$AHotWt_t^2$	-.000018*
	(9.45)
$NoHd_t$	.004*
	(16.90)
$NoHd^2$	-.000005*
	(10.63)
$PYG1\text{-}3_t$	.06*
	(30.18)
FWD_t	.11*
	(32.79)
$DMON_{i,t}$	Base
$DTUES_{i,t}$	-.48*
	(18.77)
$DWED_{i,t}$	.64*
	(23.01)
$DTHURS_{i,t}$	.49*
	(14.51)
$DFRI_{i,t}$	-.34*
	(7.99)
$DSAT\text{-}SUN_{i,t}$	-.40
	(2.49)
$UTILN_t$	.002*
	(16.86)
$TRND_i$	-7.63*
	(67.58)

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Table 8. Model 2 Regression Results, 28-Day Inventory, Firm Version.

Dependent Variable = $TRPRC_t$

Independent Variable	Coefficient[1]
Intercept	50.00*
	(35.12)
QFC_t	.0000066*
	(5.99)
QPF_t	-.0001680*
	(14.64)

Model 1 - 14 Day, Plant

QMA_t	-.0000088*
	(10.63)
$ABBCV_{t-1}$	.49*
	(100.20)
$LCFMP_{t-1}$	.36*
	(49.99)
$DSTR_{i,t}$	Base
$DDAIRY_{i,t}$	-4.63*
	(22.04)
$DFEDHOL_{i,t}$	-5.81*
	(86.09)
$DHFR_{i,t}$	-.84*
	(35.13)
$DMIX_{i,t}$	-.51*
	(6.18)
$AHotWt_t$	.020*
	(6.82)
$AHotWt_t^2$	-.000017*
	(8.76)
$NoHd_t$	.004*
	(17.39)
$NoHd^2$	-.000006*
$TRND^2_i$	.70*
	(63.42)
$TRND^3_i$	-.02*
	(54.36)
$DPLT1_{i,t}$	Base
$DPLT2_{i,t}$	-3.66*
	(27.42)
$DPLT3_{i,t}$	-.28*
	(3.67)
$DPLT4_{i,t}$	-.79*
	(7.60)
$DPLT5_{i,t}$	1.29*
	(10.52)
$DPLT6_{i,t}$	-.24*
	(2.72)
$DPLT7_{i,t}$	.02
	(.15)
$DPLT8_{i,t}$	-.78*
	(3.72)
$DPLT9_{i,t}$	.32*
	(3.23)
$DPLT10_{i,t}$	-.10
	(1.68)
$DPLT11_{i,t}$	-.03
	(.57)
$DPLT12_{i,t}$	-.03
	(.37)
$DPLT13_{i,t}$	-.52*
	(5.04)
$DPLT14_{i,t}$	-.34*
	(4.80)
$DPLT15_{i,t}$	----[2]

Model 1 - 14 Day, Firm

	(10.61)
$PYG1\text{-}3_t$	.06*
	(30.73)
FWD_t	.11*
	(31.62)
$DMON_{i,t}$	Base
$DTUES_{i,t}$	-.40*
	(15.64)
$DWED_{i,t}$	.63*
	(22.37)
$DTHURS_{i,t}$	-.60*
	(17.59)
$DFRI_{i,t}$	-.57*
	(13.66)
$DSAT\text{-}SUN_{i,t}$	-.26
	(1.62)
$UTILN_t$	.001*
	(11.09)
$TRND_i$	-7.60*
	(67.71)

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$DPLT16_{i,t}$	-----
$DPLT17_{i,t}$	-2.15*
	(21.90)
$DPLT18_{i,t}$	.50*
	(8.67)
$DPLT19_{i,t}$	.30
	(2.09)
$DPLT20_{i,t}$	-.32*
	(2.94)
$DPLT21_{i,t}$	-.49*
	(3.73)
$DPLT22_{i,t}$	-.27
	(1.69)
$DPLT23_{i,t}$	-----
$DPLT24_{i,t}$	-1.37*
	(16.32)
$DPLT25_{i,t}$	-----
$DPLT26_{i,t}$	-----

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$TRND^2_i$	.70*
	(62.95)
$TRND^3_i$	-.02*
	(53.53)
$DFIRM1_{i,t}$	Base
$DFIRM2_{i,t}$	-.01
	(.22)
$DFIRM3_{i,t}$	-.65*
	(10.24)
$DFIRM4_{i,t}$	-----[2]

$DFIRM5_{i,t}$		-----
$DFIRM6_{i,t}$		-3.52*
		(35.92)
$DFIRM7_{i,t}$		-.69*
		(4.18)
$DFIRM8_{i,t}$		-----
$DFIRM9_{i,t}$		-----

n	=	53,005
Dep. Mean	=	120.39
Root. MSE	=	2.127
Adj. R^2	=	.819

[1]Numbers in parenthesis are absolute values of calculated t statistics; * = .01 significance level.

[2] Did not have captive supplies

$DPLT27_{i,t}$	-----
$DPLT28_{i,t}$	.33
	(1.60)

[2] Did not have captive supplies.

n	=	53,005
Dep. Mean	=	120.39
Root MSE	=	2.085
Adj. R^2	=	.826

[1]Numbers in parenthesis are absolute values of calculated t statistics; * = .01 significance level.

Model 2 - 28 Day, Plant

Table 9. Model 2 Regression Results, 14-Day Inventory, Plant Version.

Dependent Variable = $TRPRC_t$

Independent Variable	Coefficient[1]
Intercept	58.79*
	(53.57)
$QFC14_t$	.0000042
	(1.64)
$QPF14_t$	.0000673*
	(3.39)
$QMA14_t$	-.0000410*
	(12.74)
$ABBCV_{t-1}$	.43*
	(107.47)
$LCFMP_{t-1}$	.41*
	(67.02)
$DSTR_{i,t}$	Base
$DDAIRY_{i,t}$	-4.72*
	(34.25)
$DFEDHOL_{i,t}$	-5.81*
	(118.95)
$DHFR_{i,t}$	-.82*
	(43.51)
$DMIX_{i,t}$	-.75*
	(11.61)
$AHotWt_t$	.019*
	(8.47)
$AHotWt_t^2$	-.0000162*
	(10.82)
$NoHd_t$	.004*
	(21.75)
$NoHd^2$	-.0000061*
	(14.75)
$PYG1\text{-}3_t$	.05*
	(35.98)
FWD_t	.09*
	(35.20)
$DMON_{i,t}$	Base
$DTUES_{i,t}$	-.40*
	(20.12)
$DWED_{i,t}$	-.52*
	(23.33)
$DTHURS_{i,t}$	-.44*
	(16.96)
$DFRI_{i,t}$	-.29*
	(9.39)
$DSAT\text{-}SUN_{i,t}$	-.42*
	(4.51)
$UTILN_t$	.002*
	(18.82)
$TRND_i$	-8.99*
	(91.00)

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Table 10. Model 2 Regression Results, 14-Day Inventory, Firm Version.

Dependent Variable = $TRPRC_t$

Independent Variable	Coefficient[1]
Intercept	57.28*
	(51.54)
$QFC14_t$	.0000199*
	(11.35)
$QPF14_t$	.0000154
	(.96)
$QMA14_t$	-.0000219*
	(17.39)
$ABBCV_{t-1}$	.43*
	(108.65)
$LCFMP_{t-1}$	.43*
	(69.13)
$DSTR_{i,t}$	Base
$DDAIRY_{i,t}$	-4.76*
	(34.08)
$DFEDHOL_{i,t}$	-5.85*
	(119.06)
$DHFR_{i,t}$	-.81*
	(43.10)
$DMIX_{i,t}$	-.47*
	(7.24)
$AHotWt_t$	.018*
	(8.05)
$AHotWt_t^2$	-.000016*
	(10.22)
$NoHd_t$	.004*
	(21.44)
$NoHd^2$	-.000006*
	(14.77)
$PYG1\text{-}3_t$	.05*
	(35.16)
FWD_t	.09*
	(34.92)
$DMON_{i,t}$	Base
$DTUES_{i,t}$	-.30*
	(14.81)
$DWED_{i,t}$	-.48*
	(21.17)
$DTHURS_{i,t}$	-.50*
	(19.27)
$DFRI_{i,t}$	-.47*
	(15.03)
$DSAT\text{-}SUN_{i,t}$	-.36*
	(3.83)
$UTILN_t$	.001*
	(16.68)
$TRND_i$	-8.95*
	(90.96)

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$TRND^2_i$	.82*
	(88.00)
$TRND^3_i$	-.02*
	(78.40)
$DPLT1_{i,t}$	Base
$DPLT2_{i,t}$	-5.12*
	(50.40)
$DPLT3_{i,t}$	-.38*
	(6.32)
$DPLT4_{i,t}$	-1.12*
	(16.62)
$DPLT5_{i,t}$	.61*
	(6.60)
$DPLT6_{i,t}$	-.03
	(.45)
$DPLT7_{i,t}$	.44*
	(6.82)
$DPLT8_{i,t}$	-3.10*
	(18.72)
$DPLT9_{i,t}$	-.006
	(.09)
$DPLT10_{i,t}$	-.20*
	(3.94)
$DPLT11_{i,t}$	.01
	(.13)
$DPLT12_{i,t}$	-.29*
	(4.42)
$DPLT13_{i,t}$	-.36*
	(4.76)
$DPLT14_{i,t}$	-.30*
	(5.18)
$DPLT15_{i,t}$	----[2]
$DPLT16_{i,t}$	-----
$DPLT17_{i,t}$	-2.07*
	(28.87)
$DPLT18_{i,t}$	.41*
	(8.35)
$DPLT19_{i,t}$	-.06
	(.62)
$DPLT20_{i,t}$	-.75*
	(10.86)
$DPLT21_{i,t}$	-.19
	(2.49)
$DPLT22_{i,t}$	-.35*
	(4.94)
$DPLT23_{i,t}$	-----
$DPLT24_{i,t}$	-1.24*
	(19.55)
$DPLT25_{i,t}$	-----

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$DPLT26_{i,t}$	-----

$TRND^2_i$	.81*
	(87.82)
$TRND^3_i$	-.02*
	(78.10)
$DFIRM1_{i,t}$	Base
$DFIRM2_{i,t}$	-.17*
	(7.08)
$DFIRM3_{i,t}$	.23*
	(7.30)
$DFIRM4_{i,t}$	-----[2]
$DFIRM5_{i,t}$	-----
$DFIRM6_{i,t}$	-4.60*
	(56.85)
$DFIRM7_{i,t}$	-2.44*
	(16.72)
$DFIRM8_{i,t}$	-----
$DFIRM9_{i,t}$	-----

n	=	86,956
Dep. Mean	=	121.14
Root. MSE	=	2.144
Adj. R^2	=	.859

[1]Numbers in parenthesis are absolute values of calculated t statistics; * = .01 significance levels.

[2]Did not have captive supplies.

$DPLT27_{i,t}$	-----
$DPLT28_{i,t}$	-.51* (6.78)

n	=	86,956
Dep. Mean	=	121.14
Root MSE	=	2.098
Adj. R^2	=	.865

[1]Numbers in parenthesis are absolute values of calculated t statistics; * = .01 significance levels.

[2] Did not have captive supplies.

Table 11. Total Captive Supply Inventory Coefficients for Model 2, Plant Version, Full Year and Quarters.

	Coefficient[1]	
	$QTOT_t28$	$QTOT_t14$
Full Year	-.0000015	-.0000123*
	(1.06)	(6.01)
Qtr2 AMJ 1992	.0000401*	.0000126
	(10.47)	(2.37)
Qtr3 JAS 1992	-.0000298*	-.0000258*
	(10.07)	(6.79)
Qtr4 OND 1992	.0000407*	.0000146
	(9.58)	(2.42)
Qtr1 JFM 1993	-.0000374*	-.0000618*
	(7.06)	(11.66)

[1]Numbers in parenthesis are absolute values of calculated t statistics; * = .01 significance levels.

Table 12. Total Captive Supply Inventory Coefficients for Model 2, Firm Version, Full Year and Quarters.

	Coefficient[1]	
	$QTOT_t28$	$QTOT_t14$
Full Year	-.0000035*	-.0000074*
	(5.27)	(7.38)
Qtr2 AMJ 1992	-.0000068*	-.0000034
	(15.37)	(1.62)
Qtr3 JAS 1992	-.0000081*	-.0000074*
	(8.27)	(5.18)
Qtr4 OND 1992	.0000223*	.0000246*
	(14.14)	(11.02)
Qtr1 JFM 1993	-.0000198*	-.0000449*
	(10.32)	(18.98)

[1]Numbers in parenthesis are absolute values of calculated t statistics; * = .01 significance levels.

Table 13. Captive Supply Inventory Coefficients for Model 2, Plant Version, by Quarters.

	Coefficient[1]					
	QFCt28	QPFt28	QMAt28	QFCt14	QPFt14	QMAt14
Qtr2 AMJ 1992	.000061*	-.00025*	-.000043*	.000049*	-.00031*	-.00012*
	(15.30)	(4.96)	(6.93)	(8.64)	(3.67)	(14.28)
Qtr3 JAS 1992	-.000037*	-.000014	-.000020*	.000029*	.00012*	-.000017*
	(10.05)	(.30)	(4.97)	(6.23)	(2.86)	(3.10)
Qtr4 OND 1992	.000090*	-.00069*	.000028*	.000050*	-.00017*	-.000007
	(14.21)	(15.37)	(5.80)	(5.91)	(3.45)	(.95)
Qtr1 JFM 1993	-.000089*	.000009	-.000007	-.000071*	.000064	-.000060*
	(9.75)	(.24)	(.99)	(9.46)	(2.00)	(7.80)

[1]Numbers in parenthesis are absolute values of calculated t statistics; * = .01 significance levels.

Table 14. Captive Supply Inventory Coefficients for Model 2, Firm Version, by Quarters.

	Coefficient[1]					
	QFCt28	QPFt28	QMAt28	QFCt14	QPFt14	QMAt14
Qtr2 AMJ 1992	.000017*	-.00015*	-.000025*	.000057*	-.00028*	-.000043*
	(8.09)	(7.39)	(15.59)	(16.13)	(3.90)	(15.80)
Qtr3 JAS 1992	-.000016*	-.000089*	-.000005*	-.000017*	.000044	-.0000043*
	(8.69)	(3.56)	(4.72)	(5.51)	(1.22)	(2.68)
Qtr4 OND 1992	.000036*	-.00025*	.000019*	.000036*	-.00015*	.000017*
	(14.02)	(7.44)	(9.84)	(10.38)	(3.76)	(5.84)
Qtr1 JFM 1993	.000008	-.000025	-.000028*	.000011	.000012	-.000074*
	(1.81)	(.93)	(12.60)	(2.48)	(.52)	(24.62)

[1]Numbers in parenthesis are absolute vales of calculated t statistics; * = .01 significance levels.

Table 15. Model 3 Regression Results, Plant Version.

Dependent Variable = $PPRC_t$

Independent Variable	Coefficient[1]
Intercept	34.24*
	(36.72)
$DFWDCON_t$	-3.16*
	(67.99)
$DPKRFED_t$	.01
	(.16)
$DMKTAGREE_t$	.10*
	(3.82)
$ABBCV_{t-1}$	.59*
	(196.58)
$LCFMP_{t-1}$	.27*
	(53.85)
$DSTR_{i,t}$	Base
$DDAIRY_{i,t}$	-.85*
	(13.42)
$DFEDHOL_{i,t}$	-5.98*
	(127.29)
$DHFR_{i,t}$	-1.10*
	(60.18)
$DMIX_{i,t}$	-1.20*
	(27.11)
$AHotWt_t$	.007*
	(3.27)
$AHotWt_t^2$	-.000010*
	(6.61)
$NoHd_t$	.005*
	(24.60)
$NoHd^2$	-.000008*
	(19.19)
$PYG1\text{-}3_t$	.04*
	(31.01)
$FWDALL_t$	-.008*
	(16.69)
$DMON_{i,t}$	Base
$DTUES_{i,t}$	-.23*
	(11.63)
$DWED_{i,t}$	-.39*
	(18.36)
$DTHURS_{i,t}$	-.36*
	(15.10)
$DFRI_{i,t}$	-.28*
	(10.32)
$DSAT\text{-}SUN_{i,t}$	.16*
	(2.81)
$UTILN_t$	.001*
	(19.18)
$TRND_i$	-2.31*
	(53.95)

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Table 16. Model 3 Regression Results, Firm Version.

Dependent Variable = $PPRC_t$

Independent Variable	Coefficient[1]
Intercept	33.17*
	(35.24)
$DFWDCON_t$	-3.02*
	(64.70)
$DPKRFED_t$	-.08
	(.90)
$DMKTAGREE_t$	.07*
	(2.86)
$ABBCV_{t-1}$	.59*
	(196.87)
$LCFMP_{t-1}$	.28*
	(54.44)
$DSTR_{i,t}$	Base
$DDAIRY_{i,t}$	-.90*
	(14.74)
$DFEDHOL_{i,t}$	-5.96*
	(127.27)
$DHFR_{i,t}$	-1.04*
	(57.18)
$DMIX_{i,t}$	-1.07*
	(24.03)
$AHotWt_t$	.007*
	(3.32)
$AHotWt_t^2$	-.000009*
	(6.24)
$NoHd_t$	.005*
	(26.16)
$NoHd^2$	-.000008*
	(20.29)
$PYG1\text{-}3_t$	.04*
	(32.33)
$FWDALL_t$	-.007*
	(15.92)
$DMON_{i,t}$	Base
$DTUES_{i,t}$	-.14*
	(7.21)
$DWED_{i,t}$	-.38*
	(17.56)
$DTHURS_{i,t}$	-.42*
	(17.08)
$DFRI_{i,t}$	-.40*
	(14.87)
$DSAT\text{-}SUN_{i,t}$	.12
	(2.07)
$UTILN_t$	.009*
	(14.42)
$TRND_i$	-2.31*
	(53.40)

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$TRND^2_i$	.22*
	(48.30)
$TRND^3_i$	-.005*
	(31.86)
$DPLT1_{i,t}$	Base
$DPLT2_{i,t}$	-4.19*
	(58.17)
$DPLT3_{i,t}$	-.26*
	(6.54)
$DPLT4_{i,t}$	-.85*
	(18.93)
$DPLT5_{i,t}$	1.11*
	(13.80)
$DPLT6_{i,t}$	.64*
	(15.44)
$DPLT7_{i,t}$	-.33*
	(7.07)
$DPLT8_{i,t}$	-2.44*
	(24.16)
$DPLT9_{i,t}$	.59*
	(12.31)
$DPLT10_{i,t}$	-.28*
	(6.93)
$DPLT11_{i,t}$	.09
	(2.35)
$DPLT12_{i,t}$	.31*
	(6.25)
$DPLT13_{i,t}$	.35*
	(8.10)
$DPLT14_{i,t}$	.08
	(1.79)
$DPLT15_{i,t}$	.60*
	(13.78)
$DPLT16_{i,t}$	-.06
	(1.16)
$DPLT17_{i,t}$	-1.35*
	(24.75)
$DPLT18_{i,t}$	.35*
	(8.73)
$DPLT19_{i,t}$	.43*
	(6.78)
$DPLT20_{i,t}$	-.34*
	(7.07)
$DPLT21_{i,t}$	.11
	(1.91)
$DPLT22_{i,t}$	.15*
	(3.08)
$DPLT23_{i,t}$	.33*
	(7.09)
$DPLT24_{i,t}$	-.88*
	(15.78)
$DPLT25_{i,t}$	-1.11*
	(15.66)

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$TRND^2_i$	.22*
	(47.65)
$TRND^3_i$	-.005*
	(31.34)
$DFIRM1_{i,t}$	Base
$DFIRM2_{i,t}$	.14*
	(7.34)
$DFIRM3_{i,t}$	.39*
	(12.75)
$DFIRM4_{i,t}$	.08*
	(2.81)
$DFIRM5_{i,t}$	.69*
	(20.13)
$DFIRM6_{i,t}$	-4.06*
	(60.55)
$DFIRM7_{i,t}$	-2.24*
	(22.88)
$DFIRM8_{i,t}$	-1.06*
	(16.01)
$DFIRM9_{i,t}$	-2.31*
	(36.42)

n	=	139,189
Dep. Mean	=	121.10
Root MSE	=	2.566
Adj. R^2	=	.816

Model 3 - Plant

Model 3 - Firm

[1]Numbers in parenthesis are absolute values of calculated t statistics; * = .01 significance level.

$DPLT26_{i,t}$	-2.35*
	(33.88)
$DPLT27_{i,t}$	-.49*
	(7.53)
$DPLT28_{i,t}$	.09
	(1.46)

n	=	139,189
Dep. Mean	=	121.10
Root MSE	=	2.534
Adj. R^2	=	.820

[1] Numbers in parenthesis are absolute values of calculated t statistics; * = .01 significance level.

Table 17. Price Difference Coefficients for Model 3, Plant Version, by Quarters.

	Coefficient[1]		
	$DFWDCON_{i,t}$	$DPKRFED_{i,t}$	$DMKTAGREE_{i,t}$
Qtr2 AMJ 1992	-3.57*	-.51*	-.24*
	(43.55)	(2.59)	(4.48)
Qtr3 JAS 1992	-1.73*	-.66*	.16*
	(23.12)	(4.27)	(4.49)
Qtr4 OND 1992	-4.00*	-.18	.62*
	(41.47)	(1.24)	(14.02)
Qtr1 JFM 1993	-6.92*	-.25	.26*
	(51.52)	(1.49)	(5.10)

[1]Numbers in parenthesis are absolute values of calculated t statistics; * = .01 significance levels.0

Table 18. Price Difference Coefficients for Model 3, Firm Version, by Quarters.

	Coefficient[1]		
	$DFWDCON_{i,t}$	$DPKRFED_{i,t}$	$DMKTAGREE_{i,t}$
Qtr2 AMJ 1992	-3.38*	-.76*	-.30*
	(41.32)	(3.82)	(5.83)
Qtr3 JAS 1992	-1.69*	-.56*	.12*
	(22.31)	(3.55)	(3.61)
Qtr4 OND 1992	-4.05*	-.24	.76*
	(41.75)	(1.60)	(17.68)
Qtr1 JFM 1993	-6.94*	-.14	.18*
	(50.00)	(.84)	(3.66)

[1]Numbers in parentheses are absolue values of calculated t statistics; * = .01 significance levels.

Model 3 - Plant

Model 3 - Firm