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Agricultural Economics

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PARADIGM CHALLENGES:
The Writings of a Heretic

A collection of working papers challenging the accepted paradigm that market structure determines market performance of the U.S. meat packing industry.

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PREFACE

The recent paper "The New U.S. Meat Industry" by Barkema et al, provides an excellent overview of changes in the U.S. livestock market.[1] They also provide an extended bibliography of articles dealing with to the topic of "market power" and related issues in the U.S. livestock industry.

I have long been a nonbeliever in, and hence critic of, the paradigm that pervades the literature on the topic of market structure and the use of market power in the U.S. meat packing and food industry.[2] The prevailing paradigm is that concentration ratios are a measure of "market power" of firms in the industry. According to this paradigm, high concentration ratios are evidence that market power exists and is being exercised. However, no meaningful definition of "market power" is provided in the literature. Therefore, all members of the Market Power Hunters Society are licensed to conjure up any measure of market power that suits their fancy to show how the "big bad packers" are imposing social costs on American consumers and livestock producers. Society members have used this license to develop a myriad of purported measures of packer market power.

Funny thing about all the trophies bagged by these market power hunters. First, as Barkema et al, note "Most studies to date reveal little evidence of such market power at work." (p. 52). Second, the exercise of market power should result in excess profits of the market power users. Interestingly enough, members of the Market Power Hunter Society conveniently ignore the less than impressive rates of return to the meat packing industry.

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[1]Barkema, Alan, Mark Drabenstott, and Nancy Novak. "The New U.S. Meat Industry." Federal Reserve Bank of Kansas City, Economic Review, Vol. 86, No. 2, Second Quarter 2001.

[2]Bullock, J. Bruce. "Estimates of Consumer Loss Due to Monopoly in U.S. Food-Manufacturing Industries: Comment." American Journal of Agricultural Economics, Vol. 63, No. 2, May 1981, pp. 290-92.

Paradigm Challenges

Kuhn points out that paradigm challenges (new theories) are quite threatening to hard-core paradigm believers. "For these men the new theory implies a change in the rules governing the prior practice of normal science. Inevitably, therefore, it reflects upon much scientific work they have already successfully completed. That is why a new theory, however special its range of application, is seldom or never just an increment to what is already known. It's assimilation requires the reconstruction of prior theory and re-evaluation of prior fact, an intrinsically revolutionary process that is seldom completed by a single man and never over night." (p. 7).[3] Kuhn goes on to point out that paradigms can block the ability (willingness) of scientists to see facts that are inconsistent with their paradigm. Their research "seems an attempt to force nature into the preformed and relatively inflexible box that the paradigm supplies. No part of the aim of normal science is to call forth new sorts of phenomena: indeed those that do not fit in the box are often not seen at all. Nor do scientists normally aim to invent new theories and are often intolerant of those invented by others.[4]" (p. 24).

The "structure-measures-market-power" paradigm leads to quite inappropriate methodology for scientific research. Most of the studies reporting measures of market power accept the existence of high concentration ratios as "evidence" that market power exists. Few, if any, hunters test any hypotheses regarding observed industry **performance** relative to some ideal industry performance

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[3]Kuhn, Thomas S. The Structure of Scientific Revolutions, 2nd Edition, University of Chicago Press, 1970.

[4]Barber, Bernard. "Resistance by Scientists to Scientific Discovery." Science, CXXXIV (1961), 596-602.

as part of their analysis. According to the hunters, market structure is evidence that market power is being exploited. Observed performance is irrelevant.

Consequently, many (if not most) market hunters begin their analysis by *rejecting without testing* the hypothesis that observed industry performance is not different from the performance that would be generated by an ideal market. These researchers then proceed to develop measures of market power that confirm their predetermined conclusions. This approach is quite inconsistent with the research methodology we teach in the classroom.

This set of five working papers is a direct challenge to members of the Market Power Hunters Society to evaluate the **performance** of the industry rather than concluding *apriori* that acceptable performance is impossible if the industry has high CR_4 ratios. **The common theme of these five papers is that (1) the economic theory used as the basis of their paradigm is not applicable to the U.S. livestock market, and therefore (2) the research methodology used by the hunters is incorrect.** An alternative theoretical model and research methodology is then presented.

The economic theory underlying the heretical views of livestock markets is, I hope, clearly developed in each of the following papers. I welcome theoretically valid challenges to the heretical perspective presented here.

Once the appropriate economic theory is applied to the analysis of U.S. livestock markets it is clear that the **performance** of this market is quite consistent with the performance of a well functioning, "competitive" market. It is not surprising that "Most studies to date reveal little evidence of such market power at work" (Barkema et al), because market power is not being exercised by these firms even though the industry has high and rising concentration ratios.

Key Points of Pure Heresy Developed in Each Paper

Paper One

The necessary and sufficient conditions for buyer market power to exist are not present in the U.S. slaughter livestock market. Livestock producers -- not packers -- determine the number of animals slaughtered each week. Contrary to conventional wisdom, **meat packers have zero market power in spite of the small and shrinking number of packers. The number of packers has nothing to do with the existence of buyer market power in the U.S. livestock industry.**

Paper Two

The cost curve of packers is not horizontal. The short run average variable cost curve for packers is U-shaped. Consequently the derived demand curve for slaughter livestock is an inverted U. Producers -- not packers -- determine the number of animals slaughtered each week. Hence, packers have zero market power. **The derived demand for slaughter animals of an oligopsony packing industry is identical to the derived demand for livestock by a "competitive" packing industry. The price of slaughter livestock is not affected by the number of packers.**

Paper Three

Packer ownership of slaughter animals is not a determinant of slaughter animal prices. The price of slaughter livestock in time period T is determined by the total number of livestock ready for slaughter in that period. However, **the proportion of those animals owned by packers has no impact on the price of slaughter animals in period T.**

Paper Four

Geographic boundaries of packer procurement territories are not **market** boundaries. Economic theory indicates that there is probably a single market for U.S. slaughter livestock rather than the existence of multiple markets discussed in the literature. The simple test of the hypothesis that there is the single market with geographically dispersed transactions locations is yet to be conducted.

It is impossible for a geographically isolated packer to exercise "market power" and exploit its localized monopsony position as long as producers are free to select the market to which they deliver their animals.

Paper Five

Packers are forced to pay "competitive" prices for livestock even if the packing industry is a duopsony. The U-shaped cost curve of packers plus their lack of control of numbers of animals available for slaughter each week negates the type of buyer behavior that conventional wisdom postulates. This paper uses a different (from paper two) approach to again illustrate that **the number of packers does not affect the price of slaughter livestock.**

ABSTRACTS

Market Power: What is it? How is it used?

Abstract

The increased concentration of the U.S. livestock slaughter industry continues to receive considerable attention by the press, politicians, and livestock producers. The obsession of the observers and many economists with industry structure (number and size of firms) is based on the paradigm stating that as the number of firms in the industry decreases the amount of "market power" possessed by these firms increases.

Market power is a widely used but seldom defined term. Failure to define the term "market power" has given the license to market power hunters to conjure up countless "measures of market power" as evidence that market power is indeed being exercised by meat packers.

This paper develops a definition and a corresponding method of measuring market power. This definition of market power is used to define the necessary and sufficient conditions for seller market power and buyer market power to exist. The number of firms in the meat packing industry has nothing to do with whether or not market power exists in industry.

OLIGOPSONISTIC BEHAVIOR AND
THE DERIVED DEMAND FOR HOGS

Abstract

Neither oligopsonistic behavior nor farm level derived demand are topics that receive much attention in economics literature. However, these topics have recently generated volumes of newspaper and magazine articles and political rhetoric accusing the U.S. pork packing industry of using its "market power" to drive hog producers out of business.

The fray has been enjoined by economists who think that concentration ratios provide evidence of anti-social behavior by firms in a highly concentrated industry. This rhetoric makes good sound bytes. However, it is based on inappropriate application of economic theory.

This paper demonstrates that the farm level derived demand curve for hogs by an oligopsonistically structured packing industry is identical to the derived demand for hogs by a competitively structured packing industry. Prices for hogs and farm-wholesale price spreads observed over the last several years were generated by a "competitive" hog packing industry.

ECONOMIC CONSEQUENCES OF PACKER OWNERSHIP OF SLAUGHTER ANIMALS

Abstract

Widely held conventional wisdom suggests that packer ownership of slaughter animals provides packers with the capacity to alter the number of their own animals slaughtered in ways that drive the market price of slaughter animals below the price that would occur if packers did not own slaughter animals. This paper develops an economic model of the slaughter livestock market that provides the conceptual and analytical framework to answer questions regarding the economic impact of packer ownership of slaughter animals.

This model shows that there is no economic basis for concluding that packer ownership of slaughter livestock distorts the market price of slaughter livestock. The price of slaughter animals is determined by the total number of animals available for slaughter and is not affected by the proportion of livestock that is owned by packers.

Definition of Geographic Market Boundaries and Testing for Use of Spatial Market Power

Abstract

Questions regarding whether there is a single national market or a set of independent regional markets for slaughter livestock in the U.S. have received considerable attention. However, none of these studies have tested a theoretically valid hypothesis regarding the existence of multiple regional markets. Rather, the researchers have simply declared that there is a set of regional markets and proceed to show how much localized "market power" is being exercised by the increasingly concentrated livestock industry.

This paper discusses the economic theory describing the spatial dimension of perfect markets which provides the theoretical basis for a simple, direct and therefore powerful statistical test, using observed prices, to test hypotheses regarding whether there is a national market or a set of independent regional markets for slaughter livestock in the U.S. The appropriate hypothesis is identified and discussed.

PRICING PERFORMANCE OF A DUOPSONY MEAT PACKING INDUSTRY

Abstract

Conventional wisdom of economists, politicians and livestock producers is that the "market power" of meat packers increases as the number of packers (N) decreases. The smaller number of packers supposedly use their increasing market power to extract rents from both consumers and livestock producers by generating wider farm-wholesale price spreads (S) than would exist if there were a larger number of packers that would "compete" for the animals being marketed by livestock producers. This conventional wisdom states that $\sigma S/\sigma N < 0$ [i.e., the spread increases (decreases) as N decreases (increases)].

This paper explores the validity of the conventional wisdom that provides the foundation for increasing public discussion and concern about livestock prices and the structure of the meat packing industry. This paper develops the conceptual framework appropriate for specifying hypotheses about the sign of $\sigma S/\sigma N$.

THE WRITINGS OF A HERETIC

Market Power: What is it? How is it used?*

J. Bruce Bullock**

Market power is a widely used, but seldom defined term. For example, the 1996 USDA Packers and Stockyards report on concentration in the meat industry uses the term "market power" four times on the first page of the introduction section. However, the term is not defined anywhere in the report. Similarly, papers by Koontz and Garcia, Azzam and Schroeter, Hunnicut and Wessenger, Sexton, and numerous other authors propose and/or discuss development of measures of market power without defining the term.

Carlton and Perloff provide one of the few definitions of market power. They offer the following definitions: "The ability to price profitably above the competitive level is referred to as *market power*" (p. 8). And, "A firm (or group of firms acting together) has market power if it is profitably able to charge a price above that which would prevail under competition, which is usually taken to be marginal cost" (p. 802).

Throughout the literature there is a strong implication that the existence (potential use) of "market power" is inversely related to the number of firms in the industry. Carlton and Perloff note, "Whenever a firm can influence its price it receives for its product, the firm is said to have monopoly power (sometimes referred to as *market power*). The terms 'monopoly power' and 'market power' are typically used interchangeably to mean the ability to profitably set the price above competitive

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*Agricultural Economics Working Paper AEWP 2000-5, Department of Agricultural Economics, University of Missouri-Columbia. (Revised July 2001.) Working papers generally have not been reviewed by anyone other than the author. They are a part of the process of obtaining from readers comments and suggestions for the author to use in subsequent revisions of the paper and to inform colleagues of work in progress. Working papers should not be quoted or cited as a reference without approval of the author.

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levels (marginal cost)" (p. 137). They go on to note that "one could usefully distinguish the two terms by using 'monopoly power' to describe a market in which price exceeds marginal cost and profits are above competitive levels and using 'market power' for markets in which price exceeds marginal cost but profits are not above competitive levels. This distinction, however, is not commonly made" (p. 138).[1]

Carlton and Perloff provide the following definition regarding market power of buyers. (Actually they simply describe the expected outcome if buyer power is exercised.) "Analogously, monopsony power results in a lower price than a competitive market would set, which also has undesirable welfare implications" (p. 8). Presumably the undesirable welfare implications they refer to are the generation of economic rents by the buyer.

The possession of "seller market power" and/or "buyer market power" is presumably what enables firms in "noncompetitive" industries to generate economic rents.[2] As noted earlier, conventional wisdom seems to be that "market power" of firms increases as the number of firms in an industry decreases. Hence, conventional wisdom presumes that market power exists and is

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[1]If profits are not above competitive levels, why are we concerned about the use of market power? The social cost of "noncompetitive" market solutions (i.e., price exceeds marginal cost) arise because the user of market power is able to create rents (in excess of competitive returns). If economic rents (profits above competitive levels) are not generated, then there is no social cost to be concerned about. If profits are not above competitive levels then how can price be above marginal cost by enough to be of concern?

[2]Unfortunately, economists through poor choice of terms and words, have created a confusing paradox. Competition, says the dictionary, "is the act of seeking or endeavoring to gain that for which another is striving; rivalry; strive for superiority." However, according to economics literature and definitions, zero competition (using dictionary definition) exists in what economists define as "competitive" markets and competition can be quite severe in what economists define as "noncompetitive" markets. Indeed, economists use various game theory models to develop and evaluate "competitive strategies" for firms in "noncompetitive" industries.

therefore used by firms in any industry that has either a "small" number of firms or a "high" concentration ratio. Indeed, many authors seem to use the number of firms and/or concentration as a direct measure (indicator) of "market power."

Although few authors provide a definition of market power, the following statement, which explicitly defines market power (italics), appears to be consistent with both the explicit and implicit statements of most authors. The statement also provides a clear distinction between "competitive" and "noncompetitive" markets that does not refer to the number of market participants.

MARKET POWER: is the ability of a market participant (i.e., a buyer or seller) to alter the market outcome (market clearing price and quantity) that would occur if "market power" is not exercised. *Market power is the ability to generate economic rents by restricting output (purchase) of a product (input).* The existence and use of market power is what distinguishes "noncompetitive" markets from "competitive" markets. Market power (and hence economic rent) does not exist in "competitive" markets.

HOW IS MARKET POWER USED?

Use of market power of sellers (buyers) is limited to manipulation of the supply (demand) curve of the holder of the market power. That is, the holder of "seller market power" cannot alter (control) the demand curve for their product.[3] Moreover, the holder of "buyer market power" cannot alter (control) the supply curve of the commodity being purchased.

The exercise of market power (by either the buyer or the seller) will alter the market clearing outcomes relative to the "competitive" market clearing outcome. If seller market power is exercised,

[3]The seller can perhaps shift the market demand through advertising. However, shifts in market demand via advertising do not generate economic rents.

the observed market outcome results from the response of buyers to the altered supply curve of sellers. (Sellers "take advantage" of buyers by restricting quality produced/sold and thus driving up the price of the product.)

If buyer market power is exercised, the observed market outcome results from the response of sellers to the altered demand curve of buyers. (Buyers"take advantage" of sellers by reducing the price offered for the input, thus reducing the amount of the input produced/ purchased.)

Consider a "competitive" market situation where the market outcome (given market demand D_c and supply S_c) is output Q_o and market price P_o (Figure 1). This market outcome is by definition the outcome of a "competitive market" [regardless of the number of either buyers or sellers] since zero economic rents are generated. The exercise of market power by the seller (by replacing S_c with Q_s in Figure 1) results in a modified market clearing price $P_s > P_o$ and quantity $Q_s < Q_o$. The magnitude of $\Delta_s = P_s - P_o$ depends on the elasticity (price flexibility) of demand for the product at Q_o. The exercise of seller market power would generate "above normal" profits (economic rents) for the seller exercising the market power as the seller restricts output to the point that equates marginal revenue and marginal cost rather than where average revenue equals marginal cost Q_s. The firm's use of market power generates the well known dead weight social cost (ABC) and generates net economic rents (in excess of normal profits) of (P_sBCK) to the holder of seller market power.

The consequences of "buyer market power" being exercised are illustrated in Figure 2. D_c is the input buyer's derived demand for the input. The derived demand for the input is the demand curve for the processed product faced by input buyer (processor) minus the marginal cost of processing alternative quantities of the input per unit of time. (See Bullock (a) for elaboration.)

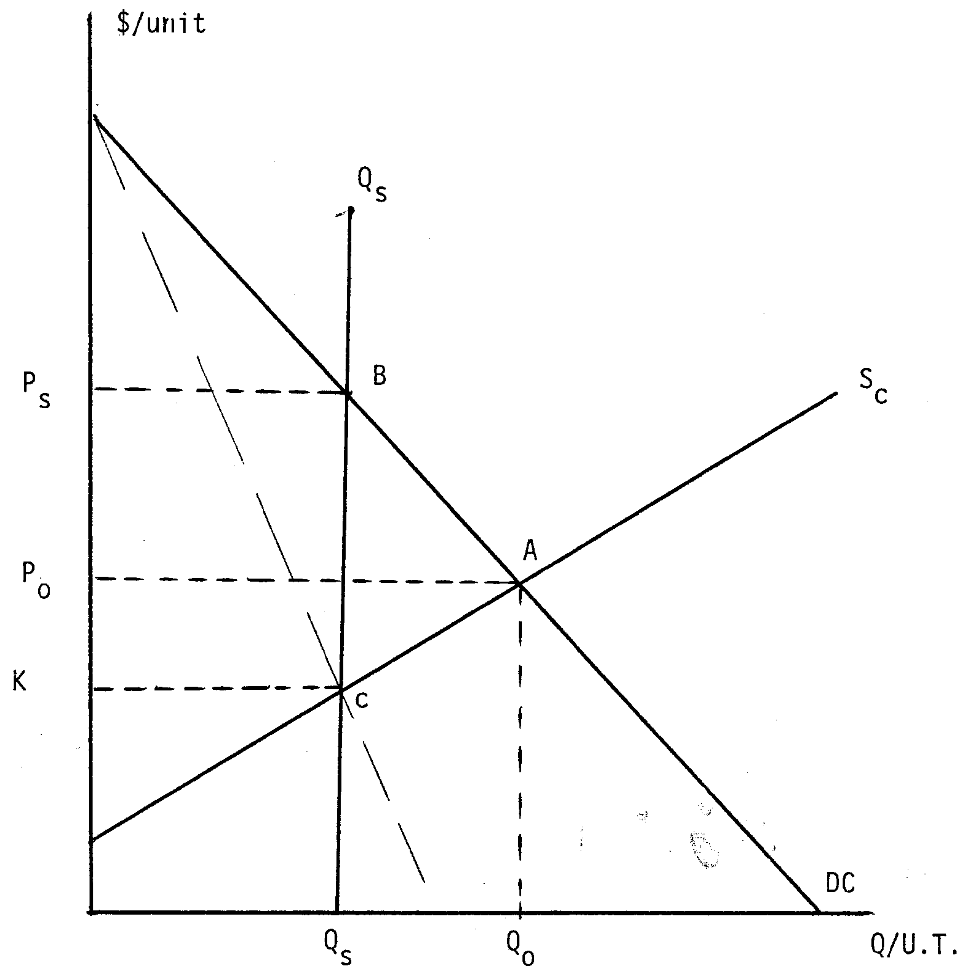

Figure 1: Economic Consequences of "Market Power" Being Exercised by Seller

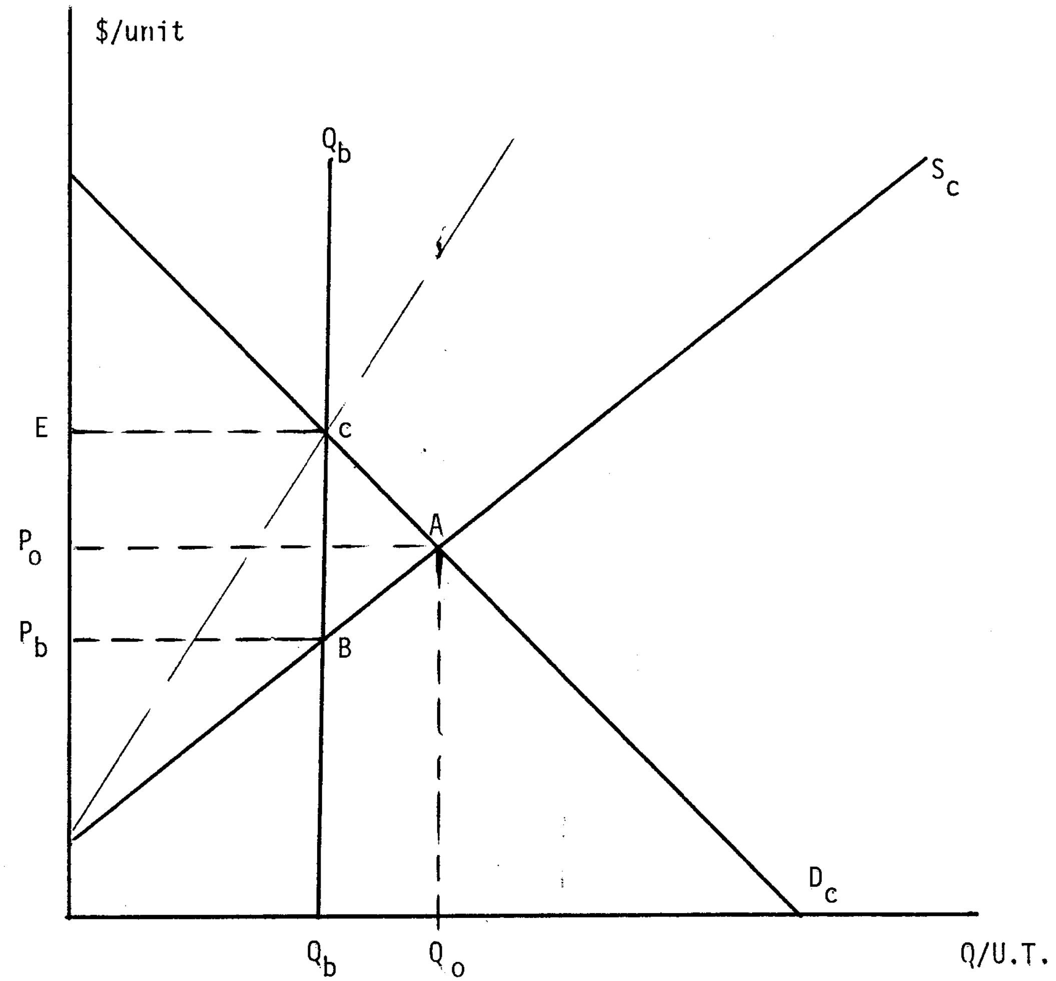

Figure 2: Economic Consequences of "Market Power" Being Exercised by Buyer

Buyer market power is exercised by replacing D_c with Q_b. This results in a modified market clearing price $P_b < P_o$ and quantity $Q_b < Q_o$. The magnitude of $\Delta_b = (P_o - P_b)$ depends on the elasticity (price flexibility) of the supply curve at Q_o. The exercise of buyer market power would generate "above normal" profits (economic rent) for commodity buyer(s) (processors) as the buyer(s) restrict purchases to their profit maximizing level of processing where the marginal value of the input equals marginal cost of purchasing the input rather than where the marginal value of the input equals average cost of the input (Q_0). The exercise of buyer market power generates a dead weight social cost of ABC and generates net economic rents of P_bECB to the holder of buyer market power.

SOURCE OF MARKET POWER?

Seller Market Power

The necessary and sufficient conditions for "seller market power" to exist is that the seller face a downward sloping current period demand curve for the product being sold. Thus, as Carlton and Perloff note, "probably every firm in the United States has at least a tiny bit of market power" (p.802). Neither Carlton and Perloff nor other authors offer a suggestion as to how much market power is "too much."

Note that the existence of seller market power is determined by the properties of the demand curve not by the number of firms (sellers) in the industry.

Clearly a seller that is a price taker has zero market power. This seller cannot alter the market outcome by changing the quantity sold. But, does seller A facing a demand curve with a demand elasticity of -0.5 have more market power or less market power than seller B facing a demand curve with a demand elasticity of -0.25? Both seller A and seller B possess market power as defined above. Which seller has the most market power? Does either seller have "too much" market power?

Possession of "market power" provides the holder with the capacity to generate economic rents. Therefore, measures of market power should reflect the relative capacity of a firm to generate rents by using its market power. Firm A has more market power than firm B if it can generate more economic rents for each one percent reduction in output of the final product it produces than can firm B. None of the existing measures of market power provide the capability of providing this information.

Both firm A and firm B have market power. Which firm has the most market power? How can we measure relative market power?

The purpose of a seller exploiting market power is to increase profits (generate economic rents). Moreover, the creation of these rents is what makes the exercise of "market power" a socially undesirable market outcome. Differences in elasticity of demand between firm A and firm B provide a measure of their relative abilities to enhance revenues for each one percent reduction in output (Lerner).[4] However, profit is defined as total revenue minus total cost. Thus, the payoff of using market power to enhance profits depends on the elasticity of the firm's cost curve as well as the elasticity of demand for its product. Hence, the increase in profits (the amount of economic rent) generated by the seller exploiting its market power by reducing its output (from Q_o to Q_s in Figure 1) is measured by:

$$\frac{\delta \pi}{\delta Q} = \frac{\delta TR}{\delta Q} - \frac{\delta TC}{\delta Q} = MR - MC$$

[4] Lerner also discussed the relationship between elasticity of demand and profits in the unique case where "the cost curve is horizontal." He states that "In this special case we can find the degree of monopoly power via the elasticity of demand" (p. 169). But as Lerner pointed out this is true "only in this special case."

The appropriate measure of relative market power of seller A and seller B is the rate of increase in profit as output is reduced. It is possible that both seller A and seller B face demand curves for their products with identical elasticity of demand, but have different elasticities of cost (supply) and hence have quite different capacities to profit from exploiting their "market power."

We can conclude that seller A has more market power (ability to enhance profits by generating economic rents) than seller B if:

$$\frac{\delta^2 \pi_a}{\delta^2 Q_a} > \frac{\delta^2 \pi_b}{\delta^2 Q_b}$$

$$\left[\frac{\delta MR_a}{\delta Q_a} - \frac{\delta MC_a}{\delta Q_a}\right] > \left[\frac{\delta MR_b}{\delta Q_a} - \frac{\delta MC_b}{\delta Q_b}\right]$$

It is possible that the ability of a firm to enhance profits (generate rents) may be more affected by the slope of the marginal cost curve than the slope of the marginal revenue curve.

<u>Buyer Market Power</u>

The necessary and sufficient conditions for buyer market power to exist is that the buyer faces an upward sloping current period supply curve for the product being purchased.

Note that the existence of buyer market power is determined by the shape of the supply curve faced by the buyer not by the number of buyers in the market.

Clearly the buyer has zero market power in time period t if sellers are totally unresponsive to the price being offered by the seller during the time period. Thus, the buyer has zero market power if the current period supply quantity is predetermined by product suppliers (sellers) and if the entire quantity is purchased by buyers. In this case $\frac{\delta Q_t}{\delta P_t} = 0$.

The necessary and sufficient condition for the current period supply curve to be upward sloping [i.e., $\frac{\delta Q_t}{\delta P_t} > 0$] is that the length of the "current period" be long enough for the producer/ seller to alter output in response to current period product price changes. That is, the time period (represented in Figure 2) must be long enough for the producer/seller to instantaneously (within the time period) alter output.

The time dimension of production processes (and hence cost curves) is totally ignored in the existing "market power" literature. This is not a problem in the widget market where flipping switches in the widget factory instantaneously results in changes in widget production. In that case, there is no "time dimension" to the production process (and hence the current supply curve of widgets). We are dealing with an instantaneous production process.

However, ignoring the time dimension of biological production processes of agricultural products is a fatal flaw in the methodology of modeling and understanding the operation of markets for products such as slaughter livestock. The production of a 250 pound market hog or a 1,200 pound fed steer requires several months to complete once the production process is initiated. Producers cannot flip a set of switches in the hog and cattle factories on Monday morning and instantaneously change the number of animals coming off the assembly line this week in response to the price currently being offered by meat packers.

Clearly livestock (and other agricultural) markets require the development and use of different models (conceptual framework) than those used for describing and understanding the operation of widget markets. These models will be developed and discussed after we explore the widget market where the necessary and sufficient conditions for the existence of "buyer market power" might reasonably be assumed to exist.

BUYER MARKET POWER IN WIDGET MARKET

Consider a widget buyer (firm A) with $\frac{\delta Q_{ta}}{\delta P_{ta}} > 0$ where Q_{ta} equals the quantity of widgets produced (by a large number of independent widget producers) and sold to firm A, and P_{ta} is the price paid for widgets by firm A in period t. Thus, by definition, firm A has buyer market power. Firm A could use its market power to generate economic rents as illustrated in Figure 2. These rents would be generated by offering price P'_{ta} equals marginal revenue received from purchase of Q'_{ta} units of the input being purchased. In contrast, if firm A did not use its market power, it would offer a price of P''_{ta} equals marginal cost of acquiring Q''_{ta} units of the input. Since $\frac{\delta Q_{ta}}{\delta P_{ta}} > 0$ (i.e., firm A has buyer market power) producers will respond by producing (and selling to firm A) Q'_{ta} units of the product in time period t if firm A offers P'_{ta}. If firm A is to generate economic rents from use of its market power, it follows that $P''_{ta} > P'_{ta}$ and $Q''_{ta} > Q'_{ta}$.

Also consider another widget buyer (firm B) with $\frac{\delta Q_{tb}}{\delta P_{tb}} > 0$ where Q_{tb} and P_{tb} are defined analogously with Q_{ta} and P_{ta}. Both firm A and firm B have buyer market power. Which firm has the most market power? Does either firm have "too much" market power?

By definition, firm B has buyer market power and therefore has the ability to generate economic rents by paying a lower price for its input $(P'_{tb} < P''_{tb})$ and purchasing a lower quantity of the input $(Q'_{tb} < Q''_{tb})$ as did firm A. Hence, economic rents are generated by the exercise of buyer market power if $\frac{\delta \pi}{\delta Q} < 0$. That is, exercise of buyer market power generates economic rents if firm profits increase from the action of reducing the amount of the input purchased (and hence the quantity of the firm's final output).

Thus firm A will possess more buyer market power than firm B if $\left|\frac{\delta^2\pi_a}{\delta^2 Q_a}\right| > \left|\frac{\delta^2\pi_b}{\delta^2 Q_b}\right|$. That is, firm A has more buyer market power than firm B if it can achieve larger increases in profits from a one percent reduction in sales (purchases of the input of interest) than firm B.

The ability of a firm (buyer) to generate economic rents by exercising its buyer power are determined by the shape of the firm's derived demand curve for the input and the supply curve of the input.[5]

How much market power is too much? Carlson and Perloff note that "probably every firm in the United States has at least a tiny bit of market power." Where is the boundary between acceptable level of market power and "too much" or unacceptable level of market power to be established. What kind of observable performance criteria (e.g., rate of return on investment) should we use to evaluate the performance of firms/industries regarding the use of their market power. Since the magnitude of market power is not a function of the number of buyers or sellers in a market, concentration ratios are, at best, a meaningless indicator of market power.

The answer to the question of "how much market power is too much?" depends on the level of economic rents that the observer/policy maker considers to be "acceptable." Note the answer to this question requires that we examine firm/industry performance measures rather than measures and description of industry structure.

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[5]The buyer's cost of providing its services at alternative levels of output is a component of the derived demand for the input. Thus the elasticity of the buyer's cost curve is a component of the firm's profit function in the same way as for the product seller. (See Bullock (1) for elaboration of the nature of packer derived demand for livestock.)

MARKET POWER OF MEAT PACKERS

The meat packing industry is the focal point of a large portion of the "market power" literature. However, as discussed earlier, the necessary and sufficient condition for buyer market power to exist are not present in either the slaughter hog or slaughter beef market. In both of these markets $\frac{\delta Q_t}{\delta P_t} = 0$ in week t. Therefore, we have reason to suspect that meat packers are taking advantage of the perfectly inelastic short run supply of animals only if (a) the price of slaughter animals is zero and/or packers refuse to purchase a portion of animals marketed in a given time period or (b) the farm-wholesale price spread generates "excessively" high profits for meat packers. We have not observed this type of market outcome. Even during the record low levels of hog prices (and record weekly slaughter rates) packers purchased all hogs marketed at positive prices. Bullock (1 and 2) has shown that the derived demand curve for oligopsonies (even a duopsony) is identical with the derived demand that would exist in a slaughter market consisting of a large number of "competitive" packers.

Meat packers possess zero market power with respect to production of slaughter livestock for periods of up to several months. Thus, the academic literature on this topic, the political rhetoric, and the popular press coverage on this topic are all "much ado about nothing." These studies are based on inappropriate methodology and hence have no validity as estimates of the consequences of packer market power being exercised in livestock slaughter markets.

The foregoing discussion regarding the definition and measurement of market power refers to a market where production and purchase of the product (e.g., slaughter animals) takes place instantaneously at the same location. Professor Richard King,[6] North Carolina State University,

[6]Private communication.

refers to these types of models as "pin head economics" since all activity is assumed to take place instantaneously on the head of a pin.

Much of the concern and discussion of market power being exercised by meat packers stems from the observation that meat packers and livestock producers are geographically dispersed. Many (if not most) observers postulate that a packer located many miles from other packers has the capacity to exploit the "market power" provided by their local monopsony position. However, these observers fail to appropriately incorporate the spatial dimension of markets into their models. Consequently these observers have used inappropriate models to evaluate the existence and use of what they postulate to be market power.

The balance of this paper discusses the conceptual framework and research methodology appropriate for postulating and testing hypotheses regarding the ability of meat packers to extract economic rents in the time, space and form dimensions of the slaughter livestock market.

TIME, SPACE AND FORM DIMENSIONS OF MARKETS AND "MARKET POWER"

Markets for agricultural commodities and products are three dimensional.

Exercise of Market Power in the Time Dimension of Livestock Markets

Production of agricultural commodities is a biological production process. Biological production processes (unlike the production of widgets) requires passage of time between the initiation of the production process (planting of crops and breeding of animals) and the completion of the production process. Moreover, in many cases crop production is seasonal (at a given production location) in nature (e.g., grains are harvested once a year at the end of the growing season). Moreover, there are seasonal patterns in the productivity of animals (birth and growth rates) although production and hence harvest occurs throughout the year.

In contrast, consumers require continuous (daily) feeding between harvest periods. Thus, if the commodity is storable (either in raw or processed form) there is a temporal allocation (consumption) of harvest problem, and hence an optimal allocation of storage resources problem to be solved by agricultural markets. Economic theory defines the relationship between product prices at different points in time (temporal price relationships) that will exist if the temporal dimension of agricultural markets is working properly.

As noted earlier, the objective of using "market power" is to generate economic rents. If we extrapolate from (assume away) the time, space, and form dimension of agricultural markets, we are dealing with pin head economic models that have only a price variable and a quantity variable. In market situations appropriately represented by a pin head model (i.e., no time, space, or form dimension of the market): (a) seller market power is exercised by restricting the quantity produced to generate economic rents or (b) buyer market power is exercised by restricting the quantity purchased by buyers to generate economic rents. Figure 1 and Figure 2 illustrate the use of "market power" in situations where the pinhead model is applicable (i.e., nonbiological, instantaneous production situations).

Bullock (2 and 3) has shown that if we ignore (assume away) the space and form dimensions of livestock markets by using a pin head model of the livestock market, the necessary and sufficient conditions for the existence of market power do not exist for market time periods shorter than the time required for the production process to occur. Thus no buyer market power exists in cattle and hog markets that generates daily, weekly, monthly, quarterly price/quantity outcomes.

Slaughter livestock are non-storable commodities. Neither packers or livestock producers store livestock. Thus, there is no time dimension to the market for slaughter livestock. Since there is no time dimension to slaughter livestock markets, there can be no economic rents generated in the time dimension of these markets. Since slaughter livestock are non-storable commodities, time rents cannot be generated by packers via either packer ownership of livestock or ownership of "captive supplies" through contracting as is often suggested (Bullock 4).

Packers do, however, operate in the spatial and form dimensions of slaughter livestock markets. Is it possible that packers could exercise buyer market power in either the form or the spatial dimension of the slaughter livestock market? If so, how do we formulate and test hypotheses regarding the exercise of this type of market power?

Exercise of Market Power in the Form Dimension of Livestock Markets

Market power can be exercised by commodity buyers to generate economic rents in the form dimension of livestock markets by one of two methods. Method one would be to exercise their market power by generating higher selling prices (via the exercise of seller buyer power) than would occur if they did not use their market power. This would require that packers refuse to purchase (even at a zero price) some of the animals ready for slaughter in week t. This is the only way that packers can reduce current supplies of wholesale meat and hence increase the selling price side of their gross packer margin above the market clearing (competitive) price that would occur if the meat packers did not use their market power. We have not observed this type of behavior by packers and hence have no evidence to indicate, or reason to believe, that packers have used method one as a way of extracting rents from the form dimension livestock markets.

Method two would be for packers simply to pay lower prices for livestock than is economically justified (would occur in a perfectly competitive market) given the wholesale value of the animals sold by producers and the processing cost curve.[7] Presumably this can (would) occur through the development by packers of a "tacit agreement" among themselves to pay less than the competitive price for slaughter animals as postulated by Koontz and Garcia.

Economic theory regarding the form dimension of perfectly functioning markets provides the criteria for defining the perfect market relationship between prices of live animals (P^l) and the wholesale market value of the products produced from the animal (P^w). In a perfect market we would observe the wholesale-live price spread in time period t to be

$$S_t^{wl} = (P_t^w - P_t^l) = C_t$$

where C_t is the per unit marginal cost of processing the Q_t animals offered for slaughter by livestock producers in week t.[8]

Thus the researcher can use time series data to test the hypothesis.

$$H_o : \bar{\lambda}_t = 0 \text{ when } \lambda_t = (P_t^w - P_t^l) - C_t$$

Observation and measurement of C_t may not be possible by the researcher. However, a widely used assumption that C_t is constant (see for example Azzam and Schroeter and also Zhang and Sexton) is a totally inappropriate assumption. In this case λ_t would also be constant and σ_λ^2 would be zero. It does not take a rocket scientist to observe the operation of a meat packing plant

[7]This topic is addressed in more detail by Bullock (1).

[8]In general this criteria is $(P_t^w - P_t^l) \leq C_t$ if processors determine how much to process. However, in the case of slaughter livestock markets Q_t is exogenously determined and hence the equality constraint is appropriate.

to see that an assumption of constant marginal cost in a meat packing plant is simply nonsense and any data analysis based on this assumption yields totally meaningless results.[9]

In the absence of knowledge(measurement) of C_t the analyst interested in testing hypothesis is left with testing hypotheses about the deviation of observed gross margins λ_t from a "competitive level" of margin λ^*. If the observed margins are higher than the competitive level then we would expect analysis of observed data to lead us to reject the hypothesis that $\bar{\pi}_t = (\lambda_t - \lambda^*) = 0$.

If meat packers are using method 2 to generate economic rents in the form dimension of livestock markets then we would expect (a) to reject the above hypothesis given the analyst's selection (definition) of λ^*, and (b) to observe rates of return on investment by meat packing companies that are substantially higher than comparable investments in the economy. For some reason, authors of the "meat packer market power" literature have chosen to ignore this quite obvious indicator that market power is being exercised. Casual observation of meat packer profitability provides no basis for (b). When was the last time one of the meat packing companies appeared on the "hot buy" list of a stock brokerage company?

Exercise of Market Power in the Spatial Dimension of Livestock Markets

A meat packer at transaction location i located D_{ij} miles from a transaction location j where prices (P_j) are generated in a "competitive environment" could possibly exploit its market power provided by its location monopsony to generate location rents by paying producers in "its territory" prices such that $(P_j - P_i) > t_{ij}$ where t_{ij} equals transportation cost between location i and location j. In this situation, the packer at location i is generating rents (using some type of market power) by paying the livestock producers in its acquisition territory less than the net value of their product the

[9]Thus, the Lerner Index of Market Power is not applicable to livestock markets.

producer would receive simply by shipping to packers at location j rather than delivering to the packer at location i. Observed market prices at the two locations and transportation costs between the two locations provides the basis for testing the hypothesis that $\lambda = (P_j - P_i) - t_{ij} > 0$ over the time period observed. The analyst has a theoretical and empirical basis for suggesting that the packer at location i has and uses location market power only if the above hypothesis is rejected. The theory and methodology of testing hypotheses about the capacity of meat packers to extract location rents is discussed by Bullock (3).

Conclusions

Market power is not a function of the number of buyers or sellers in a market. Market power is the ability to generate economic rents by restricting output (purchase) of the product (input). Thus measures of a firm's market power require knowledge of the firm's capacity to generate economic rents by restricting output (purchase) of the product (input).

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OLIGOPSONISTIC BEHAVIOR AND THE DERIVED DEMAND FOR HOGS*

J. Bruce Bullock**

Neither oligopsonistic behavior nor farm level derived demand are topics that receive much attention in economics literature.[1] However, these topics have recently generated volumes of newspaper and magazine articles and political rhetoric accusing the U.S. pork packing industry of using its "market power" to drive hog producers (particularly family hog farms) out of business.

The fray has been enjoined by economists who think that concentration ratios provide evidence of antisocial behavior by firms in a highly concentrated industry. These individuals have long argued that a highly concentrated meat packing industry is the cause of "low" livestock prices. These observers further suggest that livestock producers would "live happily ever after" if we would just burn the witches at the stake by breaking up the large packing companies that "control" livestock markets and hence livestock prices.

This rhetoric makes good sound bites. However, it is based on inappropriate application of economic theory. The purveyors of oligopsonistic conspiracy theories conveniently choose to ignore (or do not understand) the incompatibility of their static equilibrium model of oligopsonistic behavior with the dynamic, biological, and economic realities of the slaughter hog market.

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[1]See Rogers and Sexton for further discussion of the omission of oligopsonies from the economic literature.

The classical oligopsonistic model used by the conspiracy theorists describes how oligopsonists exercise "market power" to extract oligopsony profits by restricting the quantity of the raw material purchased and hence the quantity of the final product produced and consumed.[2] Their model describes a static equilibrium solution if the oligopsonists have perfect information and if all production of both the raw material and the final product occurs instantaneously.

This model does not come close to describing the dynamic U.S. live hog market and the behavior of the hog slaughtering industry.

Clearly there is a small number of packing plants relative to the number of hog producers. No one disputes that concentration ratios in the livestock slaughter industry are high and getting higher. No harm is done by classifying the industry structure as oligopsonistic with respect to the purchase of slaughter hogs.

However, it is quite inappropriate to jump to the conclusion that simply because of high concentration ratios, the conduct of packers is accurately described by the classical static equilibrium model used by the conspiracy theorists. This line of reasoning is equivalent to observing that witches ride brooms, Ms. Jones owns three brooms, and consequently concluding that Ms. Jones must therefore be a witch.

The most obvious flaw in the conspiracy theory argument is the presumption that packers control the number of hogs slaughtered each time period (week, month, year). Packers are presumed to exercise their "market power" by restricting purchases of animals to their "oligopsonistic profit"

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[2]Market power is a freely used term in the literature. However, the term is almost never defined by the user. Bullock (a) provides a definition of market power and shows that meat packers have zero market power.

maximizing level of slaughter. According to this model, packers would refuse to purchase any animals marketed in excess of this optimal level.

This is not the type of packer behavior we observed in 1998-1999. Every hog marketed was purchased and slaughtered. Yes, the prices were shockingly low to producers. But all hogs marketed were purchased and slaughtered. This observed packer behavior is totally inconsistent with packers exercising market power as predicted (required) by the conspiracy theorists' model.

The number of hogs that will be slaughtered each of the next six weeks will not be determined by packers. Rather, the number of hogs that will be ready for slaughter during this period was determined several months ago by hog producers who bred the sows, that farrowed the pigs, that are currently being fed to slaughter weights by hog producers. Hog producers -- not hog slaughterers -- have already determined the number of hogs that will be slaughtered over the next six weeks.

Exercising the type of market power that packers are accused of using, requires that packers -- not hog producers -- determine the number of hogs slaughtered each week. That certainly is not the case. Packers do not have, and thus do not exercise, this type of "market power."[3]

Other Explanations?

Those who insist that economically unjustifiable packer behavior was the cause of $10 hogs in 1998 point out that packers are margin makers. They further point to "high" levels of packing company profits during this period as evidence that packers used their "market power" to unjustifiably widen the farm-wholesale price spread.

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[3]Packer ownership of hogs is often cited as a method that packers can use to exercise their market power by controlling the number of animals slaughtered each week. Bullock (b) has shown that packer ownership of livestock has no impact on the live price of slaughter animals.

On the surface this does not appear to be an unreasonable hypothesis. Packers are certainly few in number. Packers are indeed margin makers. Were packers able to use their "market power" to unjustifiably widen the farm-wholesale margin beyond what would have occurred if the packing industry was less concentrated and hence supposedly "more competitive?"

Evaluation of evidence that will either support or refute this hypothesis requires that we explore the nature of the farm level derived demand for hogs. Several questions must be answered. Is the derived demand for hogs by a "competitive" packing industry different from the derived demand for hogs by an oligopsonistic slaughter industry? If so, why? How would a non-competitive packing industry, that does not determine the number of hogs slaughtered each period, use its "market power" to extract excess profits (economic rents) by manipulating farm-wholesale price spreads?

Derived Demand

The packer demand for hogs is a derived demand. The farm level demand for hogs exists only because there is a retail level demand for pork cuts. Thus, the farm level demand for live hogs is derived from the consumer demand for pork cuts.

The retail demand for a product is the schedule showing the maximum prices that retail consumers are willing to pay for alternative quantities of the retail product per unit of time. Conversely, the retail demand is the schedule showing the maximum quantity that consumers will purchase per unit of time at alternative prices.

The farm level *derived* demand for hogs is the schedule showing the maximum prices that packers are willing to pay for alternative quantities of live hogs marketed per unit of time (e.g., week, month). Conversely, the farm level derived demand is the schedule showing the maximum quantity of live hogs that packers are willing to purchase per unit of time at alternative prices.

A 240 pound live hog yields a defined bundle of retail cuts purchased by retail consumers. Thus, meaningful comparisons of the market value of 100 pounds of live hog and the market value of a corresponding amount of retail pork cuts requires that the live/retail weight conversion be accounted for, and that an appropriate composite of prices of individual retail cuts be used in computing the retail value. All discussion of marketing margins in the balance of this paper refers to the prices and margins calculated by the USDA as described by Dewer.

USDA price spread data compute values (prices) of an equivalent amount of product at the retail, wholesale and retail level. Our interest here is the margin between the wholesale price (P^w) received by packers when the carcasses are sold to retailers and processors and the farm level price (P^f), paid to farmers by packers (farm-wholesale margin).

Recall that the number of hogs slaughtered this week and therefore the amount of pork purchased by consumers was determined several months ago by hog producers. Therefore, the retail value (price) of pork this week is determined by the price consumers are willing to pay for the quantity marketed (as defined by the consumer demand curve). The retail price then determines the wholesale price that retailers are willing to pay for the predetermined quantity. The wholesale price (P^w), equals the retail price minus the margin established by margin-setting retailers.

The margin-setting packing industry will then determine the farm level price as $P^f = (P^w - M_p)$ where M_p is the farm-wholesale price spread (margin).

The questions of interest are: (1) How are these margins determined? and (2) How and why we would expect the margins established by a "competitive" packing industry to be different from the margins established by an oligopsonistic packing industry?

In a competitive industry slaughtering Q_i hogs in week I, the difference between the wholesale price P_i^w and the farm price P_i^f will be equal to the cost (C_i) of transforming live hogs into the wholesale product, where all prices and costs are calculated on a per head, live hog quantity equivalent (Bressler and King). Thus, in a competitive slaughter industry we would expect the margin $M_i = (P_i^w - P_i^f) = C_i$ each week.

Suppose that the per head variable costs of slaughtering hogs (excluding animal cost) are the same whether a slaughter plant is in a competitive or oligopsonistic industry structure.[4] These costs are illustrated in Figure 1. The vertical axis of Figure 1 shows $/head cost of operating at the alternative weekly slaughter volume shown on the horizontal axis.

Hog packing plants are designed for a specific capacity (head per hour slaughter rate). The nature of the chain driven disassembly process means that the per head operating costs increase rapidly as the rate of throughput per hour increases or decreases from the designed capacity rate. Short run variations in the total number slaughtered each week are achieved by altering hours of operations.[5] Added labor costs due to overtime wage rates and possible decreases in productivity and facility utilization will add to (rather than flatten out) the steep slope of the narrow u-shaped cost curve as output is varied by changes in the weekly hours of operation to accommodate increased or decreased weekly slaughter levels.

Competitive Packing Industry

Suppose that the pork packing industry consists of N identical plants with cost curves like

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[4]This may not be the case. However, the costs are assumed to be identical in order to focus only on the question of how (if) market power is exercised by oligopsonist pork packers.

[5]French et al provides an excellent discussion of the nature of cost curves for agricultural processing plants.

the one depicted in Figure 1, where N is sufficiently large for the conspiracy theorists to classify the industry as having a "competitive" structure. In this case, each plant would process its share of industry output and hence total industry output is N times the per plant levels of processing illustrated in Figure 1.

If the collective production decisions of hog producers several months ago resulted in NQ_o hogs being marketing this week, then each plant can operate at level Q_o and will have average cost (C_A^o) equals marginal cost (C_M^o) per head. However, if the previous collective production decisions of hog producers resulted in NQ_1 total hogs being marketed this week, then each plant will operate at the less than optimal level of output Q_1 and have marginal cost of C_M^1 and average cost of C_A^1. Similarly, if past production decisions of hog producers requires the plants to operate at the above optimal level of Q_2, the packers will have average cost of C_A^2 and marginal cost of C_M^2.

Figure 2 illustrates this week's downward sloping, retail demand curve for pork (D_r). Thus, the retail prices of pork would be P_0^r, P_1^r and P_2^r at the NQ_o, NQ_1 and NQ_2 levels of industry output. The retail prices are determined by consumer demand for pork and the predetermined level of total pork production. Retail prices are not affected by the structure of the hog slaughter industry.

If the retail industry is (a) competitive and (b) has a constant marginal cost of marketing services equal to the vertical distance between D_r and D_w in Figure 2, then D_w represents the derived demand for pork carcasses faced by the packing industry.[6]

[6]There is no basis or need for assuming that the marginal cost of providing retail marketing services is constant at all levels of industry output. This is simply a convenient way to focus the discussion only on questions about the extent of competitiveness at the packer level. The assumption of constant marginal cost of retailing services is unrealistic and can easily be replaced with a more appropriate assumption when the need arises.

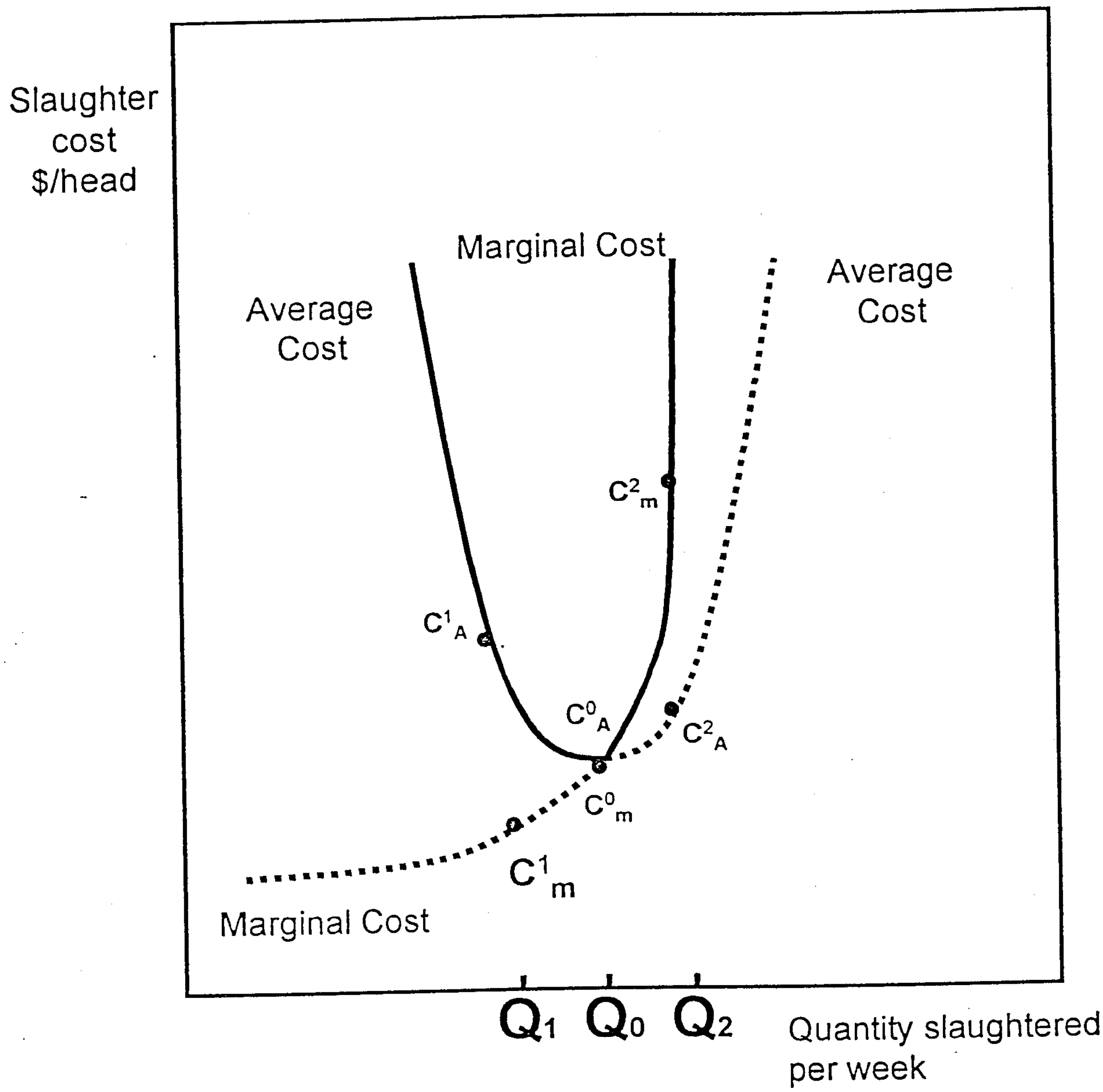

Figure 1: Illustration of slaughter plant variable cost of producing hog slaughter services at alternative levels of capacity utilization.

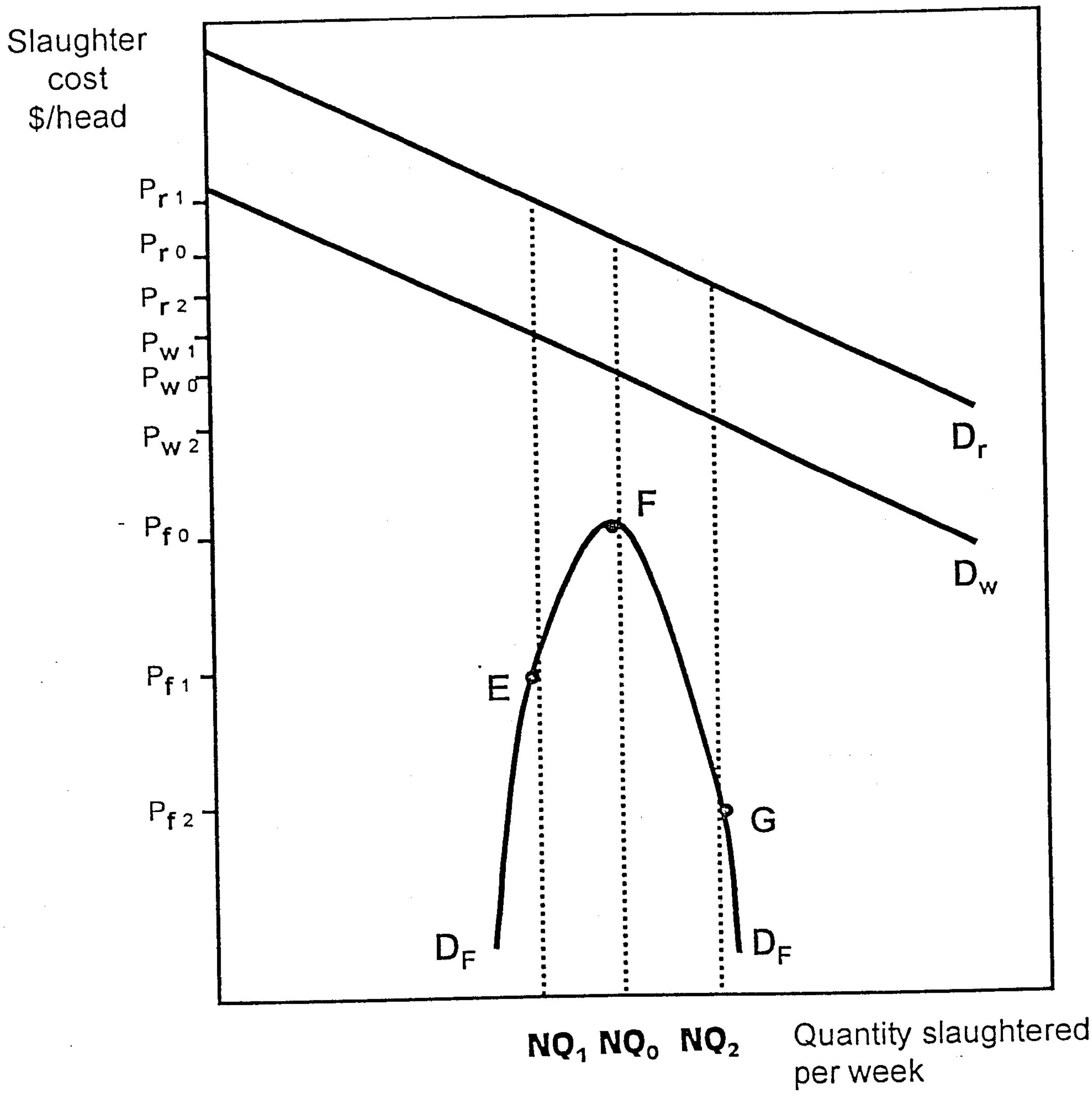

Figure 2: Farm level derived demand for hogs given demand at retail, demand at wholesale and packer slaughter costs depicted in Figure 1.

Given the wholesale demand curve for pork D_w illustrated in Figure 2 and the packing plant costs illustrated in Figure 1, we can "derive" the farm level demand for hogs that would exist for a "competitively structured" packing industry.

The derived farm level demand for hogs by a competitive slaughter industry was previously defined as the schedule showing the maximum per head price that packers would be willing to pay for alternative quantities of hogs per week, given (a) the wholesale demand for pork carcasses and (b) the per head cost of transforming live hogs into hog carcasses. The farm level price of live hogs in a competitively structured slaughter industry at industry output level Q_i is therefore $P_i^f = (P_i^w - C_i)$.

For industry output levels less than NQ_o (for example NQ_1), the relevant cost to be included in the farm level price calculation is C_A^1 (average variable cost). Since the marginal cost of processing NQ_1 animals, C_M^1, is less than the average cost of processing at output levels less than NQ_o, packers would not be able to cover out of pocket costs if they obtained only C_M^1 average revenue for services that cost them C_A^1. Even the most competitive slaughter firms would not be so generous to hog producers. Thus, the locus of points tracing out the farm level derived demand curve D_f for all levels of output less than NQ_o are calculated as the wholesale value of the carcass (P_i^w) minus the average slaughter cost at output level Q_i. For example, point E on the farm level derived demand curve (Figure 2) associated with the NQ_1 level of output is calculated as P_1^w (Figure 2) minus C_A^1 (Figure 1).

At the optimal (low cost) level of output Q_o, marginal cost of processing equals average cost of processing and point F on the farm level demand curve (Figure 2) is calculated as P_o^w (Figure 2) minus $C_A^o = C_M^o$ (Figure 1).

At output levels greater than Q_o (e.g., level Q_2) the packing industry is operating beyond its optimal (capacity) level of slaughter. At these levels of operation, the marginal cost of slaughtering each animal is above the average variable cost and the difference between marginal and average variable cost is increasing as output increases. Over this range of operations, the maximum price that packers in a competitive industry are willing to pay hog producers is the wholesale value of the pork from Q_i hogs (P_i^w) minus the marginal cost of processing Q_i hogs. Packers would not be covering their total operating cost if they paid producers the wholesale price minus the average processing cost. For example, point G on the farm level derived demand for hogs (Figure 2) is calculated as the wholesale value of a hog at the Q_1 level of production (P_1^w in Figure 2) minus the marginal cost of processing hogs at the Q_1 level of output (C_M^1 in Figure 1).

The derived farm level demand curve is represented by D_f in Figure 2. This is indeed a strange looking derived farm level demand curve. It is like nothing illustrated in any marketing or agricultural prices textbook.[7] The farm level derived demand for hogs slopes upward at quantities below industry capacity (minimum point on AVC curve) as slaughter numbers increase toward the slaughter capacity of the industry. This reflects the downward sloping average cost curve of packers over this range of operations. The farm level derived demand curve peaks at the optimal (least cost) processing level for the packing industry. The derived demand for hogs slopes sharply downward for hog numbers in excess of slaughter industry capacity. Moreover, the downward slope of this

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[7]Marketing and price analysis textbooks pay only passing attention to derived demand and graphically illustrate derived demand curves assuming constant per unit or constant percentage markups. Tomek and Robinson make reference to the possibility of crop size relative to processing industry capacity could be a determinant of the derived demand. However, they do not explore this question either graphically or mathematically.

segment of the derived demand curve is considerably steeper than the upward slope of the demand curve at hog production levels below slaughter industry capacity. Therefore D_f is not symmetric about the NQ_o level of output. This reflects the different slopes of the average and marginal cost curves over the two ranges of output.

Note that the farm-wholesale and farm-retail marketing margins widen sharply as output moves beyond NQ_o. The price flexibility of retail and wholesale demand and the price flexibility of the derived farm level demand curve at alternative levels of production are quite different. As the number of animals pushed through the competitive pork slaughter industry moves from NQ_o to NQ_2 retail and wholesale prices decrease from P_o^r to P_2^r. In contrast, farm level prices decrease from P_o^f to P_2^f. The relationship between farm level and wholesale level price flexibilities is discussed in a later section of this paper.

Also note that if industry output is at point NQ_1 and increases to NQ_o retail and wholesale pork prices decrease from P_1^r to P_o^r, and from P_1^w to P_o^w respectively, while farm prices of live hogs <u>increase</u> from P_1^f to P_o^f reflecting the processing cost decreases associated with moving from under utilization to full utilization of industry slaughter capacity.

Further note what this model of a competitive slaughter industry illustrates regarding packing industry profits at alternative levels of industry output. At hog production levels less than or equal to industry slaughter capacity, all packer industry revenues in excess of total variable costs are paid to hog producers. Thus, over this range of output, packers are not accruing producer surplus and have no incentives to change industry capacity. However, at output levels in excess of industry capacity, packers accrue producer surplus since not all revenues in excess of variable operating costs are paid to farmers for purchase of hogs. However, packers are paying producers the "competitive" price for hogs. These producer surpluses (profits) provide incentives for the industry to increase slaughter capacity if and only if packers are convinced that producers will continue to produce at output levels that exceed current industry capacity for a long enough time to justify new investments in hog slaughter facilities.

The above model of a perfectly competitive pork slaughter industry explains the changes in prices, packer margin and packer profit situations observed in late 1998. Pork producers marketed record numbers of hogs that exceeded industry slaughter capacity. The retail demand for pork was strong enough to absorb the increased pork supplies with rather modest declines in retail price. However, the farm-wholesale margin increased sharply and hence farm prices fell sharply reflecting the higher operating costs of packers as they accommodated (at considerable increase in their operating cost) the expanded output of the hog industry in excess of the slaughter industry capacity. Moreover, these margins have narrowed as hog numbers have been reduced.

There is nothing about the observed hog prices, packer margins, and packer profits during this time period that are inconsistent with the hypothesis that the U.S. hog packing industry is competitive. Everything we observed in the winter of 1998 was the predictable and understandable consequences of a pork industry producing more hogs than the slaughter capacity of a "competitive" packing industry was designed to handle.

<u>Oligopsonistic Structured Packing Industry</u>

The above reasoning is undoubtedly not convincing to the conspiracy theorists who have "known" for a long time that the highly concentrated pork packing industry is busy using its "market power" to take advantage of hog producers.

Is it possible that the margins and hog price movements observed last year were exacerbated by use of oligopsonistic market power that forced hog prices even lower than what we would have expected to observe in a competitive packing industry?

The theory of a perfectly competitive hog slaughter market states that in a competitive market the margin (M) between the wholesale value of pork obtained from a carcass (P^w) and the market price of the live animal (P^f) should be equal to the competitive industry cost of transforming the live animal into a wholesale carcass (C). That is, in a competitive market $M = (P^w - P^f) = C$.

If, however, the packing industry is noncompetitive and the firms in that industry are able to use their "market power" to extract non-competitive profit levels, presumably we would observe higher than competitive margins, $M = (P^w - P^f) = (C + \Delta)$, where $\Delta > 0$ indicating that packers are extracting oligopsony profits, assuming that the slaughter cost is the same in the competitive and noncompetitive industries.

The validity (acceptability) of the assumption that an oligopolisitically structured packing industry can extract higher than competitive rates of returns requires that we demonstrate that the margin generated by this market structure will indeed contain a value $\Delta > 0$.

Return to Figure 1. Let this cost curve now represent the identical cost curves of N_1 identical firms where N_1 is small enough to meet conspiracy theorists' definition of an oligopsonistic industry structure.

Compare the price that an oligopsonist would be willing to pay for hogs at industry output level NQ_1 with the competitive market farm level price derived previously. The noncompetitive packer would first subtract average processing costs (C_A^1) from the wholesale value (P_1^w) for the same reason that competitive packers did. The noncompetitive packer would supposedly then subtract an additional amount Δ from the wholesale price to determine the price he is willing to pay for Q_1 hogs.

The nature of the packer's operating cost curve provides each packer with a strong incentive (reward) to increase its offer price above the $(P^w - C_A^1) - \Delta = P^f$ level to acquire a larger market share and thereby move down a steeply sloped average cost curve toward its optimal (least cost) level of operating. This competitive pressure for market share among the oligopsonists would compete away the positive value of Δ. Therefore, at industry production levels less than or equal to NQ_o, the derived demand curve of an oligopsonist packing industry will be no different from the derived demand curve that would exist with a competitively structured packing industry.

At production levels greater than NQ_o, (for example NQ_2) the oligopsonistic packers would subtract the marginal processing cost (C_M^2) from the wholesale price (P_2^w) for the same reasons that competitive packers discussed earlier did. They supposedly would then try to subtract an additional amount Δ in order to increase profits. However, recall that the derived demand in this range of output is based on marginal slaughter costs rather than average slaughter costs. This results in accumulation of producer surplus over this range of outputs even in a competitively structured slaughter industry. Thus, there is an incentive for each oligopsonistic firm to reduce the magnitude of Δ and thereby capture a larger market share and hence higher profits. Even (perhaps especially) oligopsonists are not likely to stand idly by and let a competitor profit by increasing market share. Thus the value of Δ will be competed away over this range of output as well.[8]

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[8]The discussion here assumes that all packers have identical cost curves. We know this is an unrealistic assumption. The above conclusions about packers "competing" for market share is even more appropriate when there are cost differences between packers. See Bullock (c) for further development of this point.

The farm level derived demand for hogs if the packing industry has an oligopsonistic structure is exactly the same as the derived demand for hogs if the packing industry has a competitive market structure. The bottom line to the entire analysis is that packers do not control either retail price or the number of hogs slaughtered. Without this control packers have no "market power" that they can use to extract oligopsonistic profits.

There is a small number of packers. Concentration ratios are increasing. However, as long as hog producers -- not pork packers -- control industry output, packers are not able to extract rents from the hog/pork market for their slaughter services.

Consequences of Invalid Assumptions about the Shape of the Slaughter Cost Curve

Many existing studies purporting to measure the magnitude of "market power" being extracted by meat packers have used conveniently specified models that guarantee their predetermined, desired results. Unfortunately these models have zero economic validity and hence produce nonsensical results.

For example, in developing their analytical model, Zhang and Sexton state, "It will be convenient to assume constant marginal cost and thus $c(q) = cq$." Convenient? Yes. A valid assumption? Absolutely not! Azzam and Shroeter and numerous other authors also assume that processing costs are constant. This assumption removes from their models any economic justification for packer margins changing as the rate of slaughter per unit of time changes and guarantees that their analysis will generate positive measures of what they claim to be abuse of "market power" by packers.

The drastic contrast with the conceptual and analytical framework presented here and the widely used assumption of constant slaughter cost is illustrated with use of the empirical example described below. The example represents the monthly markets for pork and hogs.

Wholesale level demand curve for pork:

$$P_w = 1888.091Q^{-1.42359}$$

where P_w = month average wholesale price of pork (cents/cwt)

Q = number of hogs slaughtered during the month (million head)

Average variable cost of slaughter/wholesaling activities:

$$AVC = 1275.68 - 333.8565Q + 22.2726Q^2$$

where AVC = average variable cost of performing slaughter/wholesaling services (cents/cwt)

Q = number of hogs slaughtered during the month (million head)

The minimum point of the AVC occurs at $Q = 7.4936$

Marginal variable cost of slaughter/wholesaling activities:

$$MVC = 1275.68 - 667.7130Q + 66.8286Q^2$$

where MVC = marginal cost of performing slaughter/wholesaling activities (cents/ cwt)

Derived farm level demand:

$$\begin{aligned} FV^a &= P_w - AVC \quad \text{for} \quad Q \leq Q^* = 7.4936 \\ &= [188.091Q^{1.42359}] - [1275.68 - 333.8565Q + 22.2726Q^2] \quad \text{and,} \end{aligned}$$

$$\begin{aligned} FV^b &= P_w - MVC \quad \text{for} \quad Q > Q^* = 7.4936 \\ &= [188.091Q^{1.42359}] - [1275.68 - 667.7130Q + 66.8286Q^2]. \end{aligned}$$

The values of these variables for alternative slaughter levels are presented in Table 1.

Once we recognize that packer costs are not constant we can explain and understand observed price relationships and price spreads as a result of competitive market forces rather than conjuring up measures of market power with invalid models. Table 1 illustrates the outcome of a competitive packing industry operating with u-shaped cost curves and consequently with short run finite slaughter capacity constraints. Observed performance of the hog slaughter market over the past decade, including 1998-1999, are quite consistent with the results presented in Table 1.

Note that even in a perfectly competitive market the farm value of hogs is driven to zero if industry capacity is stressed too much. Moreover, the increase in packer profits (accumulation of producer surplus) is not an indication of market power. These profits simply reflect competitive pricing of packers and would provide an incentive for expansion of industry capacity if slaughter numbers can be expected to be sustained at these levels. However, expansion of industry slaughter capacity is not warranted if further hog marketings are expected to be below Q^* most of the time.

Contrast the results in Table 1 with the purported "measures of market power" generated by a methodology that incorrectly assumes that processing costs are constant. Results of this methodology are presented in Table 2. The "excess margin" calculations in the last column of Table 2 are not measures of market power. Rather, these are meaningless numbers defined by an inappropriately specified, economic model.

Comparison of Wholesale and Farm Level Price Flexibility

The nature of the farm level derived demand for slaughter animals produces a much different relationship between the wholesale and farm level price flexibility coefficients than has been

Table 1. Farm and Wholesale Values, Slaughter Costs and Competitive Farm-Wholesale Margins at Alternative Levels of Monthly Slaughter

Number of Head Slaughtered	Wholesale[1] Value	Average[1] Variable Cost	Marginal[1] Variable Cost	Farm[2] Value	Farm-Wholesale[3] Spread
(mil hd)	--- (cents/cwt) ---				
6.1	143.89	68.05	-310.68	75.84	68.05
6.2	140.60	62.07	-295.25	78.53	62.07
6.3	137.43	56.53	-278.48	80.91	56.53
6.4	134.39	51.43	-260.38	82.95	51.43
6.7	125.90	38.82	-198.06	87.08	38.82
7.0	118.29	30.22	-123.71	88.07	30.22
7.3	111.43	25.63	-37.33	85.80	25.63
7.49357	107.36	24.79	24.79	82.56	24.79
7.6	105.22	25.04	61.08	44.14	61.08
7.9	99.58	28.47	171.52	-71.94	171.52
8.2	94.43	35.91	293.99	-199.55	293.99
8.5	89.72	47.36	428.49	-338.76	428.49
8.8	85.40	62.81	575.01	-489.61	575.01
9.2	80.16	89.66	789.09	-708.93	789.09

[1]Calculated using the respective equations specified above.

[2]Calculated as wholesale value minus AVC for $Q_i \leq Q^*$ and as wholesale value minus MVC for $Q_i > Q^*$.

[3]Calculated wholesale value minus farm value.

Table 2: Calculations of "Excess Margins" Attributed to the Use of Market Power by Assuming that Slaughter Costs are Constant

Number of Head Slaughtered	Wholesale[1] Value	Assumed Constant AVC=MV	Assumed[2] "Correct" Farm Value	Presumed[3] "Correct" Margin	Observed[4] Margin	"Excess" Margin[5] Attributed to Market Power
(mil hd)	--- (cents/cwt) ---					
6.1	143.89	24.79	119.10	24.79	68.05	43.26
6.2	140.60	24.79	115.81	24.79	62.07	37.28
6.3	137.43	24.79	112.64	24.79	56.53	31.74
6.4	134.39	24.79	109.60	24.79	51.43	26.64
6.7	125.90	24.79	101.11	24.79	38.82	14.03
7.0	118.29	24.79	93.50	24.79	30.22	5.43
7.3	111.43	24.79	86.64	24.79	25.63	0.84
7.49357	107.36	24.79	82.57	24.79	24.79	0.00
7.6	105.22	24.79	80.43	24.79	61.08	36.29
7.9	99.58	24.79	74.79	24.79	171.52	146.73
8.2	94.43	24.79	69.64	24.79	293.99	269.20
8.5	89.72	24.79	64.93	24.79	428.49	403.70
8.8	85.40	24.79	60.61	24.79	575.01	550.22
9.2	80.16	24.79	55.37	24.79	789.09	764.30

[1]Calculated using the specified wholesale level demand curve.

[2]Calculated by subtracting the assumed constant processing cost from the computed wholesale value.

[3]Set equal to the assumed constant processing cost where MC = AC.

[4]Calculated as the wholesale value minus the processing cost that competitive packers would pay for hogs as discussed previously. (Same calculation as the Farm-Wholesale Spread in Table 1.)

[5]Calculated as difference between observed margin and presumed correct margin.

previously recognized. The existing paradigm regarding farm level derived demand assumes that the farm wholesale price spread is either constant or a fixed percentage of the wholesale price.

The farm level derived demand curve is by definition the wholesale level demand curve minus the cost of providing slaughter/wholesaling services. The farm level derived demand curve consists of two segments that share a common point at slaughter level (Q^*) which identifies the minimum point on the slaughter/wholesaling average variable cost. Hence:

$P_a^f = P^w - AVC$ for values of $Q \leq Q^*$, and

$P_b^f = P^w - MVC$ for values of $Q > Q^*$

Consequently

$$\frac{\delta P^f}{\delta Q} = \frac{\delta P^w}{\delta Q} - \frac{\delta(AVC)}{\delta Q} \quad \text{for values of } Q \leq Q^*, \text{ and}$$

$$\frac{\delta P^f}{\delta Q} = \frac{\delta P^w}{\delta Q} - \frac{\delta(MVC)}{\delta Q} \quad \text{for values of } Q > Q^*.$$

If the AVC is a quadratic function of Q as suggested above, then the farm level price flexibility coefficients (F_f) are defined as

$$F_f = [\frac{\delta P^f}{\delta Q}] \cdot [\frac{P^f}{Q}] = [\frac{\delta P^w}{\delta Q} - \frac{\delta(AVC)}{\delta Q}] \cdot [\frac{P^f}{Q}] \quad \text{for} \quad Q \leq Q^*, \text{ and}$$

$$F_f = [\frac{\delta P^f}{\delta Q}] \cdot [\frac{P_f}{Q}] = [\frac{\delta P^w}{\delta Q} - \frac{\delta(MVC)}{\delta Q}] \cdot [\frac{P^f}{Q}] \quad \text{for } Q > Q^*.$$

For values of $Q \leq Q^*$ the negative slope of the AVC curve exceeds in absolute value the slope of the wholesale level demand curve. Hence over this range of slaughter levels the farm level derived demand curve slopes upward with respect to Q and therefore $F_f > 0$.

For values of $Q > Q^*$ the slope of the MVC curve is positive and increases exponentially with Q. Hence $F_f < 0$ over this range of Q and the flexibility coefficient increases exponentially relative to the wholesale level price flexibility coefficient (F_w). The values of the respective price flexibility coefficients for the empirical example being considered are shown in Table 3.

Table 3 also shows the flexibility calculations for a linear wholesale level demand curve and the same cost curves.

At slaughter levels $Q < Q^*$ the farm level price flexibility coefficient is positive even though the wholesale level price flexibility is negative over the entire range of the wholesale demand curve. The absolute value of the two price flexibility coefficients approach equality as Q increased toward Q^*. However, note that as soon as Q exceeds Q^* (Industry slaughter capacity is reached) both flexibilities are negative but the farm level price flexibility becomes a large multiple of the wholesale level price flexibility. In this example the farm value becomes 0 somewhere between 7.6 and 7.9 million hogs and the farm level price flexibility calculations beyond that level are of no interest.

The calculations in Table 3 clearly illustrate that efforts to empirically estimate farm level price flexibility coefficients for slaughter livestock requires the estimation of the farm level derived demand curve as the first step. The shape of the wholesale level demand curve and the shape of the slaughtering/ wholesaling cost curves define the farm level derived demand curve and hence the relationship between the farm level and wholesale level price flexibility coefficients.

Clearly farm level prices are much more sensitive to changes in slaughter level than are wholesale prices at values of $Q > Q^*$. Hence we will observe that when livestock producers are generating slaughter levels $Q > Q^*$ that wholesale prices may decline modestly in response to increases in Q while farm level prices decline quite sharply and can be driven to zero even though the meat from these animals has considerable positive value at the wholesale level.

Table 3. Calculated Wholesale and Farm Level Price Flexibility Values with Both a Log Linear and a Linear Wholesale Level Demand Curve

Quantity Slaughtered	Log Linear Equation				Linear Demand Equation[1]			
	Wholesale Value	Wholesale Price Flexibility	Farm Value	Farm Price Flexibility	Wholesale Value	Wholesale Price Flexibility	Farm Value	Farm Price Flexibility
6.1	143.89	-1.424	75.84	2.293	140.06	-0.912	72.01	3.49
6.2	140.60	-1.424	78.53	2.001	137.97	-0.941	75.90	3.00
6.3	137.43	-1.424	80.91	1.723	135.88	-0.971	79.35	2.56
6.4	134.39	-1.424	82.95	1.453	133.78	-1.002	82.35	2.16
6.7	125.90	-1.424	87.08	0.662	127.50	-1.100	88.68	1.09
7.0	118.29	-1.424	88.07	-0.164	121.22	-1.209	91.00	0.08
7.3	111.43	-1.424	85.80	-1.115	114.94	-1.330	89.31	-1.01
7.5	107.36	-1.424	82.56	-1.851	110.89	-1.415	86.09	-1.82
7.6	105.22	-1.424	44.14	-63.325	108.66	-1.464	47.58	-58.95
7.9	99.58	-1.424	-71.94	44.597	102.38	-1.616	-69.14	46.74
8.2	94.43	-1.424	-199.55	18.272	96.10	-1.787	-197.89	18.61
8.5	89.72	-1.424	-338.76	12.129	89.81	-1.981	-338.67	12.28
8.8	85.40	-1.424	-489.61	9.387	83.53	-2.206	-491.48	9.48
9.2	80.16	-1.424	-708.93	7.453	75.16	-2.563	-713.93	7.51

[1]These calculations are based on a linear wholesale level demand function FV = 267.7787 - 20.937Q for purposes of illustrating the relationship between the farm and wholesale level price flexibilities for a situation with a nonconstant wholesale level price flexibility coefficient.

The key point illustrated here is that the relationship between farm level and wholesale level prices is not the result of market power being exercised by packers. This relationship simply reflects the u-shaped cost curve of packers.

Observations

Livestock slaughter plants are capital intensive investments with modest rates of return on investment. These modest rates of return require that the slaughter facility be operated for multiple years in order to recoup investment expenditures. Packer management is always competing for market share. Moreover, they are positioning themselves today for market share several weeks, months, and even years in advance. Meat packing plants operate with a multi-year planning horizon in a dynamic world with imperfect information.

The steep slopes on both sides of the slaughter plant cost curve (Figure 1) place a high premium on obtaining and maintaining a market share that enables the plant to operate as closely as possible to its optimal (least cost) level of processing. Even if a packer could do so, it is not in its best interest to extract short run, non-competitive rents and ignore the impacts of their actions on future market share. The static long run equilibrium model of oligopsonistic behavior used by conspiracy theorists is not an appropriate representation of the livestock slaughter industry. Even with a smaller number of firms, meat packers simply cannot extract non-competitive rents and "live happily ever after" at the expense of hog producers.

Neither economic theory nor real world observations of rates of return in the packing industry support the conspiracy theorists allegation of non-competitive rents being generated by a highly concentrated meat packing industry. However, the conspiracy theorists simply ignore the relatively low profit levels of meat packers.

Question: when was the last time that one of the major meat packing companies was listed one of the "hot buys" of a stock brokerage company? The rhetoric of the conspiracy theorists implies that the meat packing industry must be extremely profitable given all the market power these firms supposedly exercise. Observed data on packer profits simply are not consistent with this rhetoric. Perhaps that is why the conspiracy theorists conveniently ignore these data.

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ECONOMIC CONSEQUENCES OF PACKER OWNERSHIP OF SLAUGHTER ANIMALS*

J. Bruce Bullock**

Widely held conventional wisdom suggests that packer ownership of slaughter animals provides packers with the capacity to alter the number of their own animals slaughtered in ways that drive the market price of slaughter animals below the price that would occur if packers did not own slaughter animals. The purpose of this paper is to develop an economic model of the slaughter livestock market that provides the conceptual and analytical framework to answer questions regarding the economic impact of packer ownership of slaughter animals.

This paper addresses two questions:

(1) How can packers use ownership of animals to distort (drive down) prices of slaughter animals in time period T?

(2) How can packers use contracted animals to distort (drive down) prices of slaughter animals in time period T?

Production of slaughter cattle or slaughter hogs is a biological production process that requires the passage of time between the initiation and completion of the feeding process. The production of slaughter animals is not an instantaneous production process. Hence, the number (Q_T) of animals ready for slaughter at some point in time (T) was predetermined by producer decisions made prior to period T. During period T, slaughter animal producers cannot alter the number of

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animals ready (available) for slaughter in period T in response to the price of slaughter animals in period T. In economic jargon, the supply of animals available for slaughter in period T is perfectly inelastic with respect to price in period T at the quantity Q_T.[1]

Consider the slaughter animal price impacts of packer ownership of animals in period T. Let $0 \leq \lambda \leq 1$ be the proportion of all slaughter animals owned by packers. Thus, $Q_T = \lambda Q_T + (1-\lambda)Q_T$ where λQ_T animals are owned by packers and $(1-\lambda)Q_T$ animals are owned by non-packer producers in period T.

The farm level demand for slaughter animals in period T is derived from the wholesale demand for carcass meat sold by packers. The farm level demand is the wholesale value of the animal minus the non-animal cost of providing slaughtering services (see Bullock for elaboration). Let $WV_T = \alpha^T Q_T^{\beta}$ represent the wholesale demand curve for the slaughter animals where WV_T is the wholesale value (\$/hd) of the carcass produced from each animal slaughtered in period T, and Q_T is the number of animals slaughtered in period T.[2]

The non-animal cost of providing slaughter services are represented as follows

$$
\begin{aligned}
AVC^T &= a - b_1 Q_T + b_2 Q_T^2 \\
MVC_T &= a - (2b_1)Q_T + (3b_2)Q_T^2
\end{aligned}
$$

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[1]The validity of this statement depends on the length of time period being examined. The possibility of price responsive marketing decisions by slaughter animal producers in sub-intervals of time period T is examined later in this paper.

[2]The wholesale demand equation for meat is of the general form $WV_T = \alpha Q_{bT}^{\beta_1} Q_{pT}^{\beta_2} Q_{cT}^{\beta_3} I_T^{\beta_4}$ where Q_{bT}, Q_{pT}, Q_{cT} and I_T are the number of beef, pork and poultry slaughtered during period T respectively and I_T is per capita income in period T. The value of α^T above is the expression of the wholesale level demand curve for the meat of interest with the magnitude of production of the competing meats and per capita income held constant at some specified level.

where AVC_T = average variable cost ($/hd) of slaughtering Q_T animals in period T

MVC_T = marginal variable cost ($/hd) of slaughtering Q_T animals in period T

Q_T = number of animals slaughtered in period T

Bullock has shown that regardless of the number of firms in the packing industry, the derived demand curves for slaughter animals are:

(1) $FV_T = WV_T - AVC_T$ **for** $\mathbf{Q_T \leq Q^*}$

and

(2) $FV_T = WV_T - MVC_T$ **for** $\mathbf{Q_T > Q^*}$

where Q^* = the level of slaughter during time interval T that minimizes the AVC_T of slaughtering the animals

FV_T = farm value of Q_T animals that are slaughtered during time interval T ($/hd)

WV_T, AVC_T, MVC_T, Q_T are as defined above.

Thus the farm level derived demand curves are

(3) $FV_T = \alpha^T Q_G^\beta - [a - b_1 Q_T + b_2 Q_T^2]$ **for** $\mathbf{Q_T \leq Q^*}$

and

(4) $FV_T = \alpha^T Q_T^\beta - [a - (2b_1)Q_T + (3b_2)Q_T^2]$ **for** $\mathbf{Q_T \leq Q^*}$

The extent of packer ownership of slaughter animals can be introduced into the farm level derived demand equations by substituting $Q_T = [\lambda Q_T + (1-\lambda)Q_T]$ into the above two equations.

$$FV_T = \alpha^T[\lambda Q_T + (1-\lambda)Q_T]^\beta - \{a - b_1[\lambda Q_T + (1-\lambda)Q_T] + b_2[\lambda Q_T + (1-\lambda)Q_T]^2\} \quad \textbf{for } \mathbf{Q_T \leq Q^*}$$

and

$$FV_T = \alpha^T[\lambda Q_T + (1-\lambda)Q_T]^\beta - \{a - (2b_1)[\lambda Q_T + (-\lambda)Q_T] + (3b_2)[\lambda Q_T + (1-\lambda)Q_T]^2\} \quad \textbf{for } \mathbf{Q_T > Q^*}$$

Since $\lambda + (1-\lambda) = 1$ the derived demand curves reduce to

$$(5) \qquad FV_T = \alpha^T Q_T^\beta - (a - b_1 Q_T + b_2 Q_T^2) \quad \textbf{for } \mathbf{Q_T \leq Q^*}$$

and

$$(6) \qquad FV_T = \alpha^T - Q_T^\beta - [a - (2b_1)Q_T + (3b_2)Q_T^2] \quad \textbf{for } \mathbf{Q_T > Q^*}$$

It is clear from above that (a) the wholesale value of the meat produced in period T, (b) the average per head slaughter costs in period T, (c) the per head marginal slaughter costs in period T and therefore (d) the farm value of slaughter animals are totally determined by Q_T and are not affected by the value of λ or the number of packing firms in the industry. Hence packer ownership of animals has zero impact on prices at the wholesale and farm levels in period T since the number of animals sold/slaughtered in time period T does not change in response to prices offered by packers.

However, the time interval T can be partitioned into K sub-time periods. Owners of slaughter animals can (in response to the market price offered by packers during sub-interval k) decide to sell their animals during any of the K sub-intervals with zero additional transaction cost, subject to the constraint that $\sum_{k=1}^{K} Q_{kT} \leq Q_T$ [non-packer owners might refuse to sell some animals during time period T if the farm value (price) is negative].[3]

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[3]We know slaughter animals are growing animals that change in size daily and for which positive cost of gain are incurred. In other words the transaction costs of delaying the marketing sub-period from t_o to t_k within time period T are not zero. The assumption of zero transaction cost biases the model toward more reallocation of animals between sub-intervals of period T than would occur if transaction costs are greater than zero. That is, with zero transaction costs packers and slaughter animal producers are allowed to ignore the transaction costs. Hence, the model is biased in favor of packers shifting animals between sub-intervals in order to manipulate prices of slaughter animals.

The impact of λ on the price pattern over the K sub-intervals during period T is examined by:

(a) setting $\lambda = 0$ and identifying the optimal distribution of marketing by non-packer livestock owners across the k sub-intervals of time period T, and

(b) setting $\lambda > 0$ and assuming that packers follow a strategy within one or more of the sub-intervals of slaughtering their own animals first and then purchasing the balance of the animals in the open market. Marketing decisions of non-packer feeders in each of the sub-periods are determined by the sub-interval-k price offered by packers given the decisions of packers regarding the slaughter of the animals they own.

Suppose $\lambda = 0$

The derived demand curve (farm value) of slaughter animals in time period T can be viewed as the summation of K identical derived demand curves in each of the K sub-intervals of time period T. These derived demand curves for slaughter animals are revealed to livestock sellers by the posted offer prices of alternative quantities (inverse derived demand curve) by packers in each sub-interval.

The objective of non-packer livestock owners is to allocate the Q_T animals available in time period T among the K sub-intervals so that the total market value of the Q_T animals is maximized given the packer derived demand for slaughter animals. Since there is assumed to be zero transactions cost of transferring animals between the sub-intervals of time period T, the revenue maximizing allocation of animals by non-packer feeders is to market $\left(\frac{1}{K}\right)Q_T$ animals in each sub-interval generating a price P_T in each period. Where P_T is the market clearing price for the period, given Q_T and the farm level derived demand for slaughter animals.[4] Moreover, this revenue

[4]If the market price of slaughter animals in one sub-interval exceeds the price in another sub-interval, livestock owners would respond by transferring animals from the lower price sub-

maximizing allocation strategy holds for all values of $Q_T \gtreqless Q^*$ given that $\lambda = 0$ (where Q^* is as previously defined).

Suppose $\lambda > 0$

In this case packers own λQ_T animals while non-packers own $(1-\lambda)Q_T$ animals. As above, the derived farm value of live animals in time period T can be viewed as the summation of K identical farm value relationships in each of the K sub-intervals of time period T. However, if $\lambda > 0$ packers have the option of slaughtering some or all of their own animals in one or more sub-interval and hence restricting their purchase of animals in the market in those sub-intervals. Thus, the packer derived demand curve in a sub-interval in which some of their own animals are slaughtered is simply the excess demand curve in that sub-interval given that Q_o of packer owned own animals are slaughtered before packers purchase animals from non-packer livestock owners. This situation is depicted in Figure 1.

The line DD' in Figure 1 represents the farm level derived demand curve for slaughter animals and is identical for each of the K sub-intervals of time period T. If Q_o packer owned animals are slaughtered in one of the sub-intervals, then the packer excess derived demand curve for that sub-interval is represented by the AD' segment of DD'. This then is the packer demand for slaughter animals facing non-packer sellers in the sub-interval where Q_o packer owned animals are being slaughtered.

We noted that if $\lambda = 0$ (i.e., packers own no animals) the optimal pattern of marketings in each sub-interval would be $\left(\frac{1}{K}\right)Q_T$ which would generate a price P_T in each sub-interval. If

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interval to the higher price sub-interval. Transfer opportunities will have been exhausted when the price in all sub-intervals equals P_T which is the market clearing price in time period T given Q_T.

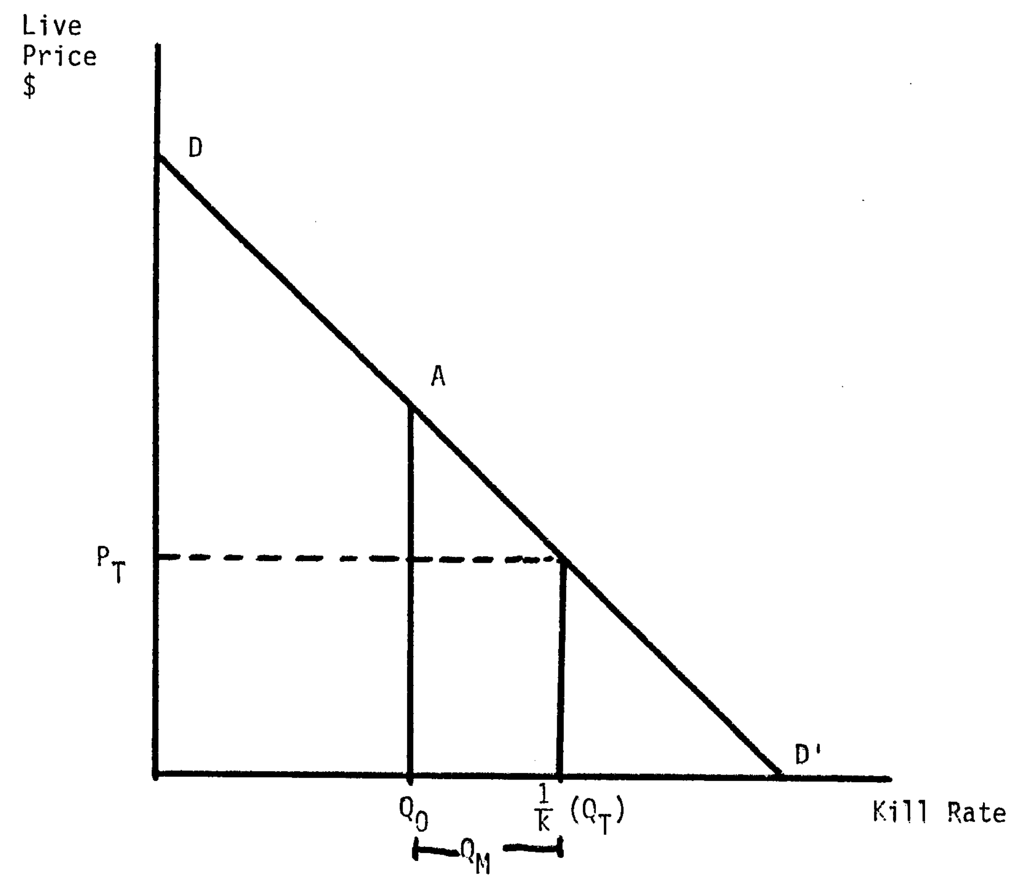

Figure 1: Packer Excess Demand Given the Slaughter of Q_0 Packer Owned Cattle in Sub-interval k

$Q_o < \left(\frac{1}{K}\right) Q_t$ as illustrated in Figure 1, then non-packer sellers would respond by selling $Q_m = [\left(\frac{1}{K}\right) Q_T - Q_o]$ animals in the sub-interval resulting in an animal price in that sub-interval of P_T. Hence, the revenue generated from the sale of these Q_n animals by non-packer owners is exactly the same as would be the case if $\lambda = 0$. This will hold true for all values of $Q_o \leq \left(\frac{1}{K}\right) Q_T$ in any sub-interval in which packer owned animals are slaughtered and hence causing Q_n to be less than $\left(\frac{1}{K}\right) Q_T$. Thus, if $Q_o < \left(\frac{1}{K}\right) Q_T$ in each period that packers slaughter their own animals and all Q_T animals are slaughtered during time period T, packer ownership of slaughter animals has no impact on the total value of the $(1-\lambda)Q_T$ animals owned/sold by non-packers during time period T.

Suppose $Q_o^{'} > \left(\frac{1}{K}\right) Q_T$ in one sub-interval as illustrated in Figure 2. This would reduce the farm value of animals in this sub-interval to $P_o^{'} < P_T$ and non-packer owners would choose to sell none of their $(1-\lambda)Q_T$ animals during this sub-interval. They would wait for a price $\hat{P} = P_T > P_o^{'}$ in one or more of the remaining sub-intervals of period T. Since $Q_o^{'} > \left(\frac{1}{K}\right) Q_T$ we know that slaughter in one or more of the remaining sub-intervals must be less than $\left(\frac{1}{K}\right) Q_T$ and hence the price in that interval will exceed P_T. In this case, packers will end up paying more for the $(1-\lambda)Q_T$ animals purchased from non-packer owners than if they had made sure that $Q_o \leq \left(\frac{1}{K}\right) Q_T$ in each sub-period.

Thus, if $\lambda > 0$ and non-packer owners are free to allocate their animals across K sub-intervals of time period T, we see that packers can cause the price of slaughter animals in one or more of the sub-intervals to be less than the "competitive" market clearing price for period T (i.e., P_T). However, only packer owned animals are slaughtered at these prices. Consequently the average price paid for the $(1-\lambda)Q_T$ animals purchased by packers from non-packers exceeds the price that packers would have paid if they had caused $\left(\frac{1}{K}\right) Q_T$ animals to be slaughtered in each sub-interval. Non-packer slaughter animal owners would welcome this type of marketing strategy by

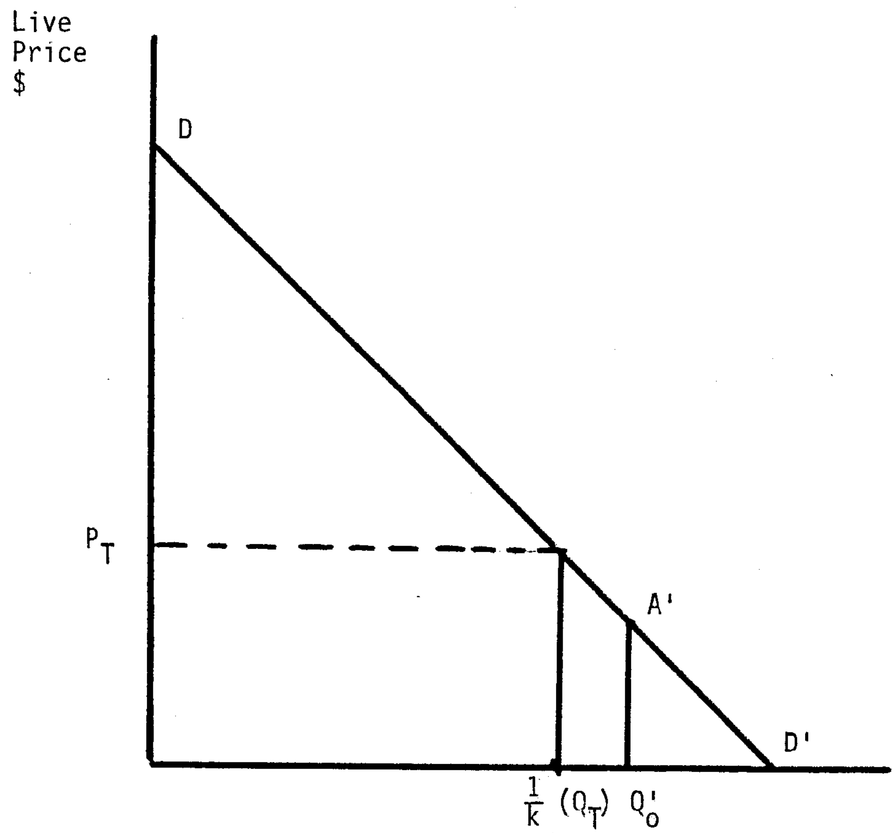

Figure 2: Packer Excess Demand Given the Slaughter of Q_o' Packer Owned Cattle in Sub-interval k

packers. However, packers certainly have no incentive to behave in this manner. Clearly packers would prefer to pay no more than the "competitive" market clearing price (i.e., P_T) for the $(1-\lambda)Q_T$ animals owned by non-packers.

The discussion above shows that packer ownership of slaughter livestock has no impact on the live price of slaughter livestock provided that non-packer owners are free to market their $(1-\lambda)Q_T$ animals in the sub-interval of their choice in response to the posted derived packer demand for slaughter animals in each sub-interval of time period T. Given packer derived demand for slaughter animals, the factor determining the live prices of slaughter animals in period T (and all K sub-intervals of period T) is the total number of animals (Q_T) available in time period T not the proportion of these animals owned by packers.

Packer ownership of slaughter animals does not negatively impact farm level prices of slaughter animals. But what about packers acquisition of "captive supplies" via contracting for slaughter animals that will be delivered in time period T? In this case, packers do not actually "own" the animals and would therefore not incur the negative price impacts if the number of animals slaughtered during one of the K sub-intervals of time period T exceeds $\left(\frac{1}{K}\right)Q_T$. Therefore, it is possible that packers could use contracts to generate "captive supplies" in time period T and then use these contracts to distribute the Q_T animals available in period T across the sub-intervals of time period T in a way that enables packers to purchase the Q_T animals at a lower total cost than would be the case if $\left(\frac{1}{K}\right)Q_T$ animals are purchased/slaughtered in each sub-interval.

Obviously the contracts we are talking about here are contracts that have a delivery date in time period T but do not specify the exact price to be paid for the animals at delivery. Moreover, within the contract, the packer has the ability to identify the specific sub-interval of time period T in which the contracted animals are to be delivered/slaughtered. The contract also specifies that the price paid for the animals will be the prevailing market price during the sub-interval in which the animals are delivered.

The question regarding whether packers could use contracting as a method of purchasing cattle more cheaply than would occur if no contracting is done is best addressed by examining the following empirical example.

Empirical Example of Theoretical Model

This example can be viewed as the simulated behavior of either a single firm or as the behavior of a packing industry where all packers agree to work as a unit to achieve the stated objective of distorting (driving down) the price of slaughter animals.

Suppose that $K = 7$. That is, the Q_T animals to be slaughtered in time interval T can be marketed in any one of the 7 sub-intervals at the discretion of the owners of the slaughter animals. The wholesale demand curve and the packer cost function for each of the seven sub-intervals are:

wholesale demand for meat: $WF_k = 58104.59Q_k^{-.71}$

packer cost curves:

$$AVC_k = 2197 - 8.4Q_k + .0084Q_k^2$$
$$MVC_k = 2197 - 16.8Q_k + .0252Q_k^2$$

where all variables are as previously defined.

The minimum point of AVC_k is $Q^* = 500$, hence the rate of slaughter that minimizes AVC in each sub-interval is 500 units/period. Substituting the above expressions into equations (3) and (4) specifies the farm level derived demand curves for this example.

$$FV_k = [58104.59Q_k^{-.71}] - [2197 - 8.4Q_k + .0084Q_k^2] \qquad \textbf{for } \mathbf{Q_k \leq 500}$$

and

$$FV_k = [58104.59Q_k^{-.71}] - [2197 - 16.8Q_k + .0252Q_k^2] \quad \textbf{for } \mathbf{Q_k > 500}$$

where: FV_k denotes farm value at slaughter rate Q_k.

Table I shows the values of the above equations at alternative kill rates per sub interval of time period T. The column labeled total surplus is the magnitude of producer surplus (profit) accruing to packers at alternative kill rates per sub-interval. At kill rates $Q_k \leq Q^* = 500$ the value (price paid) for live animals is $FV_k = WV_k - AVC_k$. Hence, zero producer surplus accrues to packers at these kill rates. At kill rates $Q_k > Q^* = 500$ the price of live animals is $FV_k = WV_k - MVC_k$ and the amount of producer surplus accruing to packers is $MVC_k - AVC_k$ per head.

Note in Table I that the farm value of the slaughter animals increases over the 360 to 420 kill rates even though the wholesale value of the animals declines over this range. Thus the farm to wholesale price spread declines over the 360 to 420 kill rates. Note also that over the 420 to 500 head kill rate that the farm wholesale price spread continues to decline. However, at $Q_K = 500$ the derived demand (farm value) falls off sharply as packers begin charging the marginal cost of slaughter rather than the average variable cost for their slaughter services.[5]

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[5]Note also that the price, cost and margin data over the 520 to 556 kill rate represent the type of price relationships observed in the hog market in 1998-99. Over this range wholesale values decline only slightly as meat production per period increases. However, the farm value of the animals fall sharply reflecting the sharp increases in *MVC* over these ranges. Indeed, the farm value is quite low relative to wholesale prices and actually becomes negative in this example at the 557 kill rate.

The pork market in 1998-99 was obviously stressing the capacity of the pork slaughter identity and was operating in the equivalent 520 to 556 range of this example. Moreover, the low farm prices relative to wholesale prices in this example (and in the 1998-99 hog market) are the result of competitive market pricing of both wholesale meat and live animals. The wide margins and low animal prices are not the result of "non-competitive" behavior of packers.

Table I: Simulated Packer Costs and Revenues, Farm Value, Wholesale Value and F-W Spread

KILL RATE 1000 hd.	WHSE VALUE $/hd	AVG. V. COST $/hd	MARG. COST $/hd.	FARM VALUE $/hd.	PACKER SURPLUS $/hd	F-W MARGIN $/hd.	TOTAL REV. $	TOTAL COST $	TOT. ANI. COST $	TOTAL SURPLUS $
360	889.68	261.64	-585.08	628.04	0	261.64	320286	94190	226096	0
380	856.18	217.96	-548.12	638.22	0	217.96	325348	82825	242523	0
400	825.56	181.00	-491.00	644.56	0	181	330223	72400	257823	0
420	797.45	150.76	-413.72	646.69	0	150.76	334929	63319	271610	0
440	771.54	127.24	-316.28	644.30	0	127.24	339478	55986	283492	0
460	747.57	110.44	-198.68	637.13	0	110.44	343883	50802	293080	0
480	725.32	100.36	-60.92	624.96	0	100.36	348153	48173	299980	0
500	704.60	97.00	97.00	607.60	0	97	352299	48500	303799	0
520	685.25	100.36	275.08	410.17	174.72	275.08	356329	52187	213288	90854
540	667.13	110.44	473.32	193.81	362.88	473.32	360251	59638	104658	195955
550	658.50	118.00	580.00	78.50	462	580	362173	64900	43173	254100
556	653.44	123.34	646.43	7.02	523.0848	646.4272	363314	68578	3900	290835
557	652.61	124.29	657.67	-5.07	533.3832	657.6748	363503	69230	-2821	297094
560	650.13	127.24	691.72	-41.59	564.48	691.72	364070	71254	-23293	316109
580	634.13	150.76	930.28	-296.15	779.52	930.28	367794	87441	-171768	452122

Three cases are examined within the example.

Case 1 $Q_T < Q^*$

Case 2 $Q_T = Q^*$

Case 3 $Q_T > Q^*$

Three packer strategies for scheduling of contract animals are considered within each of these cases.

option a: packers slaughter $\left(\frac{1}{k}\right)Q_T$ animals each sub-period

option b: packers slaughter only contract animals in one sub-period in order to restrict slaughter to less than $\left(\frac{1}{k}\right)Q_T$ animals in one sub-interval

option c: packers slaughter only contract animals in one sub-interval and schedule more than $\left(\frac{1}{k}\right)Q_T$ contract animals in one of the sub-intervals.

Table II shows the simulation results for Case 1 where $Q_T < Q^*$. In Situation 1.b packers can reduce the total purchase price of the Q_T animals by causing less than $\left(\frac{1}{k}\right)Q_T$ animals to be slaughtered in one of the sub-intervals. However, the animal cost savings is largely offset by lower packer total revenues and higher packer costs. Packers accrue zero producer surplus in both Situation 1.a and Situation 1.b and have no incentive to select option b over option a. However, by following option c, packers can generate producer surplus by scheduling more than $\left(\frac{1}{k}\right)Q_T$ animals in one sub-interval provided the number slaughtered in that sub-interval exceeds Q^* (recall that packers accrue zero producer surplus at kill rates less than Q^* per period). However, the 36 percent reduction in the farm value (price paid) in that time interval (i.e., \$410.17 vs. \$641.33 in the other periods) would be quite obvious to non-packer contract participants and they would refuse to contract in subsequent time periods. Moreover, this game reduces total packer costs of purchasing Q_T

Table II: Simulated Outcomes Case 1 [Qt = 3220]

	KILL RATE 1000 hd.	WHSE VALUE $/hd	AVG. V. COST $/hd	MARG. COST $/hd.	FARM VALUE $/hd.	PACKER SURPLUS $/hd	TOTAL REV. $	TOTAL COST $	TOT. ANI. COST $	TOTAL SURPLUS $
					Situation 1.a					
	460	747.57	110.44	-198.68	637.13	0	343883	50802	293080	0
	460	747.57	110.44	-198.68	637.13	0	343883	50802	293080	0
	460	747.57	110.44	-198.68	637.13	0	343883	50802	293080	0
	460	747.57	110.44	-198.68	637.13	0	343883	50802	293080	0
	460	747.57	110.44	-198.68	637.13	0	343883	50802	293080	0
	460	747.57	110.44	-198.68	637.13	0	343883	50802	293080	0
	460	747.57	110.44	-198.68	637.13	0	343883	50802	293080	0
total	3220						2407178	355617	2051561	0
					Situation 1.b					
	340	926.53	312.04	-601.88	614.49	0	315021	106094	208927	0
	480	725.32	100.36	-60.92	624.96	0	348153	48173	299980	0
	480	725.32	100.36	-60.92	624.96	0	348153	48173	299980	0
	480	725.32	100.36	-60.92	624.96	0	348153	48173	299980	0
	480	725.32	100.36	-60.92	624.96	0	348153	48173	299980	0
	480	725.32	100.36	-60.92	624.96	0	348153	48173	299980	0
	480	725.32	100.36	-60.92	624.96	0	348153	48173	299980	0
total	3220						2403940	395130	2008810	0
					Situation 1.c					
	520	685.25	100.36	275.08	410.17	174.72	356329	52187	213288	90854
	450	759.33	118	-260	641.33	0	341698	53100	288598	0
	450	759.33	118	-260	641.33	0	341698	53100	288598	0
	450	759.33	118	-260	641.33	0	341698	53100	288598	0
	450	759.33	118	-260	641.33	0	341698	53100	288598	0
	450	759.33	118	-260	641.33	0	341698	53100	288598	0
	450	759.33	118	-260	641.33	0	341698	53100	288598	0
total	3220						2406515	370787	1944874	90854

animals by only 5 percent while revenues are reduced very slightly and slaughter costs are increased by over 4 percent relative to option a.

Table III shows the simulation results when $Q_T = Q^*$. In this case by slaughtering less than $\left(\frac{1}{k}\right)Q_T$ animals in one sub-interval, packers can generate producer surplus in the subsequent time intervals (Situation 2.b). Note, however, that packer revenues are decreased and total packer non-animal costs are increased in both Situation 2.b and Situation 2.c relative to Situation 2.a. Packers can generate producer surplus in both Situation 2.b and Situation 2.c. However, the wide fluctuation in farm value and the reduced animal costs (market value of available animals) generated by this packer strategy provides non-packer owners an incentive to not contract in subsequent periods, hence removing these strategies from packers in subsequent time periods.

Table IV shows the simulation results when $Q_T > Q^*$. In this case packers earn producer surplus in all sub-intervals because slaughter exceeds $\left(\frac{1}{k}\right)Q^*$. The small gain in total producer surplus in Situation 3.b and Situation 3.c relative to Situation 3.a is probably not worth the ire of contract producers that would be caused by the wide fluctuations in prices (farm value) between sub-intervals caused by packers following this strategy of altering kill rate by scheduling contract cattle at levels not equal to $\left(\frac{1}{k}\right)Q_T$ in one or more periods. Again, the wide range in prices would cause contract producers to not contract in subsequent time periods.

Thus, it appears that by scheduling animal slaughter to be not equal to $\left(\frac{1}{k}\right)Q_T$ when $Q_T \geq Q^*$ packers could enhance their producer surplus accumulation. However, the clear message sent to non-packer animal owners is that contracts result in lower prices than would occur if no contracts existed. Contracting would not last long if packers followed these types of strategies.

Table III: Simulated outcomes Case 2 [Qt = 3500]

	KILL RATE 1000 hd.	WHSE VALUE $/hd	AVG. V. COST $/hd	MARG. COST $/hd.	FARM VALUE $/hd.	PACKER URPLU $/hd	TOTAL REV. $	TOTAL COST $	TOT. ANI. COST $	TOTAL URPLUS $
					Situation 2.a					
	500	704.60	97	97	607.60	0	352299	48500	303799	0.00
	500	704.60	97	97	607.60	0	352299	48500	303799	0.00
	500	704.60	97	97	607.60	0	352299	48500	303799	0.00
	500	704.60	97	97	607.60	0	352299	48500	303799	0.00
	500	704.60	97	97	607.60	0	352299	48500	303799	0.00
	500	704.60	97	97	607.60	0	352299	48500	303799	0.00
	500	704.60	97	97	607.60	0	352299	48500	303799	0.00
total	3500						2466095	339500	2126595	0.00
					Situation 2.b					
	440	771.54	127.24	-316.28	644.30	0	339478	55986	283492	0
	510	694.76	97.84	183.52	511.24	85.68	354328	49898	260733	43697
	510	694.76	97.84	183.52	511.24	85.68	354328	49898	260733	43697
	510	694.76	97.84	183.52	511.24	85.68	354328	49898	260733	43697
	510	694.76	97.84	183.52	511.24	85.68	354328	49898	260733	43697
	510	694.76	97.84	183.52	511.24	85.68	354328	49898	260733	43697
	510	694.76	97.84	183.52	511.24	85.68	354328	49898	260733	43697
total	3500						2465448	355376	1847891	262181
					Situation 2.c					
	530	676.04	104.56	371.68	304.36	267.12	358303	55417	161313	141574
	495	709.64	97.21	55.63	612.43	0	351274	48119	303155	0
	495	709.64	97.21	55.63	612.43	0	351274	48119	303155	0
	495	709.64	97.21	55.63	612.43	0	351274	48119	303155	0
	495	709.64	97.21	55.63	612.43	0	351274	48119	303155	0
	495	709.64	97.21	55.63	612.43	0	351274	48119	303155	0
	495	709.64	97.21	55.63	612.43	0	351274	48119	303155	0
total	3500						2465947	344131	1980243	141574

Table IV: Simulated Outcomes Case 3 [Qt = 3745]

	KILL RATE 1000 hd.	WHSE VALUE $/hd	AVG. V. COST $/hd	MARG. COST $/hd.	FARM VALUE $/hd.	PACKER SURPLUS $/hd	TOTAL REV. $	TOTAL COST $	TOT. ANI. COST $	TOTAL SURPLUS $
					Situation 3.a					
	535	671.55	107.29	421.87	249.68	314.58	359280	57400	133580	168300
	535	671.55	107.29	421.87	249.68	314.58	359280	57400	133580	168300
	535	671.55	107.29	421.87	249.68	314.58	359280	57400	133580	168300
	535	671.55	107.29	421.87	249.68	314.58	359280	57400	133580	168300
	535	671.55	107.29	421.87	249.68	314.58	359280	57400	133580	168300
	535	671.55	107.29	421.87	249.68	314.58	359280	57400	133580	168300
	535	671.55	107.29	421.87	249.68	314.58	359280	57400	133580	168300
total	3745						2514960	401801	935057	1178102
					Situation 3.b					
	505	699.64	97.21	139.63	560.01	42.42	353317	49091	282804	21422
	540	667.13	110.44	473.32	193.81	362.88	360251	59638	104658	195955
	540	667.13	110.44	473.32	193.81	362.88	360251	59638	104658	195955
	540	667.13	110.44	473.32	193.81	362.88	360251	59638	104658	195955
	540	667.13	110.44	473.32	193.81	362.88	360251	59638	104658	195955
	540	667.13	110.44	473.32	193.81	362.88	360251	59638	104658	195955
	540	667.13	110.44	473.32	193.81	362.88	360251	59638	104658	195955
total	3745						2514821	406917	910751	1197153
					Situation 3.c					
	547	661.06	115.5556	547.47	113.59	431.91	361599	63209	62134	236255
	533	673.34	106.1476	401.64	271.70	295.50	358890	56577	144814	157499
	533	673.34	106.1476	401.64	271.70	295.50	358890	56577	144814	157499
	533	673.34	106.1476	401.64	271.70	295.50	358890	56577	144814	157499
	533	673.34	106.1476	401.64	271.70	295.50	358890	56577	144814	157499
	533	673.34	106.1476	401.64	271.70	295.50	358890	56577	144814	157499
	533	673.34	106.1476	401.64	271.70	295.50	358890	56577	144814	157499
total	3745						2514938	402669	931020	1181249

Summary and Conclusions

The price of slaughter animals in time period t is established by the intersection of the packer derived demand for animals in period t and the quantity of animals ready for slaughter in period T (i.e., Q_T). The market clearing price P_T in period T is not affected by the proportion $0 \leq \lambda \leq 1$ of cattle owned by packers.

If $\lambda > 0$ and time period T is decomposed into a set of $K \geq 2$ identical sub-intervals, we observe the following. Packers can cause the price of slaughter animals in one or more of the sub-intervals to be less than the "competitive" market clearing price for period T. However, only packer owned animals will be slaughtered at these prices. Consequently, the average price paid by packers for $(1 - \lambda)Q_T$ animals exceeds the price that would have caused $\left(\frac{1}{k}\right)Q_T$ animals to be slaughtered in each sub-interval. Non-packer owners of slaughter animals would welcome this type of slaughter scheduling by packers.

We also conclude that acquisition of "captive" supplies of slaughter animals via contracting rather than ownership of slaughter animals probably is not an effective way to "drive down" the price of slaughter animals. Non-packer animal owners quickly observe that it is not in their interest to contract if packers contract solely for the purpose of "distorting" slaughter animal prices. Moreover, economic gains to packers of following this strategy are not large.

Conclusion: There is no economic reason to fear or restrict packer ownership of slaughter animals. Moreover, non-packer owners are smart enough to prevent packers from contracting for the sole purpose of scheduling slaughtering over the K sub-intervals of time period T in ways that alter animal prices to the detriment of contract producers.

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Definition of Geographic Market Boundaries and Testing for Use of Spatial Market Power*

J. Bruce Bullock**

Consider a set of N geographically separated transaction locations. A homogeneous product X is bought and sold at each of the locations. Let P_i denote the price of this product in time period t at location i where i = 1, 2, -- N.

Question: Do these geographically separated transaction locations constitute;

A. N geographically separated, independent markets,

B. a set of M < N geographically separated, independent markets where each of the M markets consists of a subset of one or more of the N transaction locations, or

C. a single market with N geographically separated transaction locations?

Economic theory describing the spatial dimension of perfect markets provides the theoretical basis for a simple, direct and therefore powerful statistical test, using observed prices, to determine which of the above situations is the most appropriate description of the spatial nature of the market for product X.

A market with N geographically dispersed transaction points contains a set of geographically separated sellers and/or buyers. The objective of profit seeking sellers is to sell their supplies of X at the highest available net price f.o.b. their location. The objective of profit seeking buyers is to purchase the product at the lowest possible price f.o.b. at their location (Fetter). The theory of a

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perfect market consisting of N geographically separated transaction locations states that if buyers and sellers have knowledge of,

a. current price at each transaction location, and

b. the cost of transporting (and other transaction cost) the product from location i to location j, (t_{ij}),

then a perfectly functioning market will generate a geographically dispersed set of N prices for the product in time period t such that $(P_i - P_j) \leq t_{ij}$ for all possible combinations of i and j.[1]

The condition describing the relationship of prices between geographically separated transaction locations then provides the idealized standard by which to evaluate the spatial pricing performance of real world markets.[2] It also provides a clear definition of the geographic boundary of a market described by situation C above.

The question posed earlier can be translated into three alternative hypotheses regarding the spatial dimension of the market (or markets) that generated the observed price data.

H_c: The set of geographically dispersed prices was generated by the operation of a single market with N geographically separated transaction locations. The N locations are bound together into a single market by actual or potential arbitrage.

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[1]See Bressler and King for derivations of this conclusion. This model applies to either situations with geographically concentrated buyers and dispersed sellers or situations with geographically concentrated sellers and dispersed buyers. Fetter points out that the movement of goods is centripetal from buying transaction locations and is centrifical relative to selling transaction locations.

[2]The operative word here is "performance." Performance is what matters. Market structure is an economic issue only if performance of the market is less than desirable. Performance is, by definition, ideal in a perfect market. Hence, the performance of a perfect market becomes the utopian standard by which to evaluate the performance of real world markets.

H_b: The set of geographically dispersed prices was generated by the simultaneous operation of M < N markets. Each of the M regional markets contains $1 \leq m < N$ of the geographic locations. The locations *within* each of the M markets are bound together by actual or potential arbitrage. Arbitrage does not occur between the M markets.

H_a: The set of geographically dispersed prices was generated by the simultaneous operation of N independent markets which are not bound together by actual or potential arbitrage.

The perfect market outcome (performance) conditions provide the basis for testing the consistency of the observed data with hypothesis H_c. If hypothesis H_c is valid and the market is performing ideally then we would observe that in our data, $(P_i - P_j) \leq t_{ij}$ and hence $z_{ij} = (P_i - P_j) - t_{ij} \leq 0$ for all values of i and j.

Therefore, by testing the null hypothesis H_o: $\bar{z}_{ij} \leq 0$, we are testing for the consistency of the observed data with H_c. If H_o is rejected by this test, we can also reject H_c. However, if H_o is not rejected then we have no reason to reject H_c on the basis of our test of spatial price relationships using observed data. One could perform this test over multiple time periods to test the validity of H_c over the time interval examined.

Note that by testing H_o we have imposed a harsh test regarding the acceptability of H_c. It is possible that by using this approach we would reject H_o and, hence H_c, even though H_c is true but market participants do not have perfect information and hence the spatial price relationships do not comply with H_o.

Failure to reject H_o and therefore H_c is a rigorous test of whether the N geographic locations constitute a single market in which spatial price differences are fully explained by transportation costs between transactions locations. Testing H_o with observed data does not assume or require the existence of perfect information by market participants. The process simply asks (and tests) whether the observed performance of the market, as reflected by observed spatial price relationships, is different from the performance that would be generated by a perfect market.

Efforts to define the geographic boundaries of markets are often part of an effort to provide evidence of spatial market power being exercised by meat packers. Exercise of market power generates economic rents to the holder/user of market power (Bullock, a). Therefore, the use of market power will result in price differences between geographic locations that are wider than would exist in a perfect market. That is, if market power is being exercised at location A then $(P_a - P_b) > t_{ab}$ where location B is part of a separate "competitive" market where market power cannot be exercised because transaction location B is tied together by actual or potential arbitrage with other locations within the market containing location B. One has a theoretical and empirical basis for postulating that market power is being exercised at location A only if we observe that $(P_a - P_b) > t_{ab}$ on a regular and prolonged basis. This would cause us to reject H_o regarding location A and location B and to conclude that location A and B are in different markets.

If H_o is not rejected there is absolutely no theoretical justification for suggesting that the functioning of the market being examined is distorted by a group of participants (meat packers for example) exercising some type of "localized market power" at one or more of the transaction locations. A perfect market with spatially separated transactions points generates a set of prices where $(P_i - P_j) \leq t_{ij}$ not a situation where $(P_i - P_j) = 0$.

Numerous studies (e.g., Koontz and Garcia and Quail et al.) incorrectly assume that all price differences between geographic locations are generated by meat packers exercising "market power." That is, these studies postulate that $(P_i - P_j) = 0$ in a "competitive" market. This performance expectation is appropriate only if transport costs between all pairs of transaction locations are zero. These researchers (on the basis of observing the presence of only 1 to 3 packers in several of the N locations) have rejected H_o (and hence H_c) without testing the consistency of the observed data with the performance criteria defined by the theory of a spatially dispersed perfect market. This is a serious, indeed fatal, flaw in their research methodology. These studies have no theoretical (and hence no empirical) basis of validity.

The analysis conducted by these types of studies are meaningful only if the analyst first tests and rejects H_o as described above, and then uses $z_{ij} = (P_i - P_j) - t_{ij}$ as the portion (component) of price differences between locations that is not explained by the fact that point i and point j are geographically separated. In a perfectly functioning market, we expect the price differences between the two locations to be totally explained by transportation costs between the two locations. There is a basis for postulating that some type of "market power" is being exercised by some group of participants only if H_o can be rejected. If H_o is not rejected, there is nothing left to explain about locational price differences since the expected value of z_{ij} is zero.

Researchers that fail to reject H_o as their first step and proceed to use $\Delta_{ij} = (P_i - P_j) = (z_{ij} + t_{ij})$ as their variable of analyses are quite inappropriately and illogically assuming that $t_{ij} = 0$ and therefore any price differences between geographically separated markets is the result of "market power" being exercised. No meaningful interpretation of their results exist regardless of the statistical properties of their resulting models. Unless researchers first test and reject H_o there is no theoretical basis for suggesting that there is any "market power" being exercised or any other type of "market imperfection" to be explained by concentration ratios, conjectural variation models, game theory strategies or some other complex, sophisticated, and mathematically elegant model formulated. Without a theoretical basis to provide the framework for interpretation of results, their analyses simply have no meaning.

Rejection of H_o does not provide evidence that market power is being exercised. This means only that there are M independent markets that are not tied together by arbitrage and it is therefore possible that "market power" could be exercised in any or all of these markets. The researcher must first show evidence of multiple markets and then use the observed data to test hypotheses regarding the exercise of market power in one or more of these markets.

There are no legal barriers to interstate trade (arbitrage) in the U.S. Consequently there is no *apriori* reason to assume that the slaughter animal markets in the U.S. are anything other than a single national market. Hence, researchers intent on measuring "how much" market power is being exercised would be well advised to test for the existence of multiple markets prior to attributing price differences between transaction locations as evidence of "market power."

It is worth noting that the perfect market performance criteria are not dependent on the number of buyers or sellers at any or all of the transaction locations. Concentration ratios are not a variable in the model since the performance criteria are derived from a perfectly competitive market.

Return to the question of defining geographical boundaries of markets based on a set of observed prices at geographically separated transaction locations.

Neither H_b nor H_a can be valid if H_c cannot be rejected. Hence, it is appropriate to test H_c first in the process of trying to answer the question posed on page 1.

If H_o (and hence H_c) cannot be rejected then we effectively reject H_b and H_a and can proceed to treat the data as if we have observations from a single market with geographically separated transaction points. Moreover, as stated several times above, if H_o is not rejected then we have no theoretical basis for postulating that the operation of the spatial dimension of this market is being distorted by use of "market power" by some market participant(s) during the period observed.

Suppose H_o is Rejected

The hypotheses H_o will be rejected if we observe that $(P_i - P_j)$ is consistently greater than t_{ij} for at least one pair of transaction locations. If H_o is rejected then there is both a theoretical and empirical basis for proceeding to test H_b.

H_b: The set of geographically dispersed prices was generated by the simultaneous operation of M markets. Each of these geographically dispersed markets contains $1 \leq m < N$ of the geographical locations present in the available data.

If H_b is true then the observed price data across the geographically separated transaction points can be partitioned into M sets of observations such that within each set one cannot reject H_o, but H_o must be rejected when any two or more of the M groups are combined. Let this two stage hypothesis be represented as H_1.

There is no ideal or optimal way to search for the "correct" combination of locations that defines the magnitude of M for purposes of testing H_1. However, the researcher will likely have preconceived ideas about the magnitude of M and the appropriate grouping of m locations that constitute "separate" markets. These *apriori* assumptions/hypotheses can provide the basis for initial groupings of locations for the sequential formation and testing of market boundary definitions. Each proposed grouping must be tested for consistency with H_b.

Given that H_c has previously been rejected, failure to reject H_1 for some grouping of observations into M markets means that we cannot reject H_b for the defined set of M markets.

Failure to reject H_1 and hence H_b for the defined set of markets indicates that the data provide a basis for postulating that the M markets are not tied together by spatial arbitrage which provides the opportunity for "market power" to be exercised within these market boundaries. In this case, the researcher has a theoretical foundation and empirical evidence to proceed with testing various hypotheses about the existence and exercise of market power within the separate markets.

Suppose That H_c and H_b Are Both Rejected

In this case, the researcher has established both the theoretical and empirical basis for suggesting that the observed data reflect the operation of N independent markets and may provide evidence that some type of market power is being exercised at some (or all) of the independent locations/markets. The researcher can proceed to use the individual transaction point price data to test hypotheses (regarding various types of market power being exercised) that are suggested by the theoretical framework (model) being proposed by the researcher.

Observations Regarding Other Methods of Identifying/Defining Geographic Boundaries of Markets

Correlation Coefficients Calculated Using Time Series Observations of P_i and P_j

The presumption of this method is that if location i and location j are part of the same market then the prices in the two markets should be highly positively correlated random variables. In contrast, one might expect a lower correlation coefficient between the two price series if the two locations are not included in the same market and hence prices might move more independently than if the locations were in the same market (Stigler and Sherwin).

This reasoning is intuitively appealing. However, the perfect market performance criteria $(P_i - P_j) \leq t_{ij}$ imposes no constraints on the correlation between P_i and P_j over time. If locations i and j are contained in the same market then over a set of T time periods we expect to observe that the average observed price difference $(P_i - P_j)$ to not be significantly different from the average transport cost between the two points over the same time period. But that does not mean that P_i and P_j must/will be highly positively correlated over time.

Indeed, it is quite possible that location i and location j are contained in the same perfectly functioning market and have zero or even negative correlations between their respective prices over time. This is particularly true if there is a substantial distance between the two points and thus t_{ij} is relatively high. The perfect market performance criteria requires only that price differences between the two locations meet inequality (as opposed to strict equality) constraints. This constraint can be met over time with zero, negative or positive correlation between P_i and P_j even if location i and location j are in the same markets. Moreover, zero, negative or positive correlations between P_i and P_j can also exist if P_i and P_j are in two different markets. Also note that if $(P_i - P_j)$ equals a constant amount $C > t_{ij}$ over k periods, then P_i and P_j will be perfectly correlated even though location i and j are in separate markets since $C > t_{ij}$ and the two locations are obviously not tied together by arbitrage. Consequently, economic theory provides no basis for drawing conclusions about whether or not locations i and j are in the same market based on the sign or magnitude of the correlation coefficient between prices at the two transaction locations.

Observed Arbitrage and Calculated Probabilities of Arbitrage as Indicators of Market Boundaries

Note in the specification of H_c the statement "the N locations are bound together by actual or potential arbitrage." This means that geographically separated transaction location A and location B could be part of the same market even though direct movement of the product between these locations never occurs or would be expected to occur (be observed). Therefore, the observation of arbitrage or the creation of a calculated positive "probability of observing arbitrage" between a pair of transaction locations (USDA) provide no information about geographic boundaries of markets.

Clearly, if $(P_i - P_j) = t_{ij}$ we can presume that arbitrage has tied the two locations together into the same market. However, contrary to the conclusions of Spiller and Huang and many authors, it is not correct to presume that location i and j are in different markets simply because $(P_i - P_j) \neq t_{ij}$. It is true that location i and location j are in different markets if $(P_i - P_j) > t_{ij}$ since the locations have not been tied together by arbitrage activity. Observation that $(P_i - P_j) > t_{ij}$ is *apriori* evidence that the two locations are in different markets. However, it is quite incorrect to conclude that location i and location j are in different markets if we observe $(P_i - P_j) < t_{ij}$. Surely, no one is willing to conclude that Wichita and Salina, Kansas are in different geographic markets for hard red winter wheat simply because we observe that price differences between the two locations is always less than transport cost between the two locations. It is likewise no more reasonable to conclude that North Carolina, Nebraska, and California are not three transaction locations in a single national slaughter hog market simply because price differences between any pair of the locations are always less than transportation costs and we never observe direct arbitrage between North Carolina and California.

The requirement that $(P_i - P_j) = t_{ij}$ is a sufficient condition to conclude that i and j are contained in the same market. However this is not a necessary condition for location i and location j to be contained in the same regional or national market. It is quite possible, indeed quite likely, that in an input market with geographically distributed production locations and a much smaller number of transaction locations (e.g., the slaughter livestock market) we will never observe (or expect to observe) actual movement of the product between any pair of transaction locations even though all N locations are part of a perfectly functioning market with geographically separated transaction locations.

For example consider a situation where production of a homogeneous product is uniformly distributed across the entire production plane.[3] All buyers in this production plane are located at one of the four transaction locations A, C, D and E. Production is delivered by producers to the transaction point which yields the highest f.o.b. production site price at each of the transaction points (Fetter). The cost of transporting the product from location i to location j in the production plane is defined by $t_{ij} = a + \lambda D_{ij}$ where t_{ij} is the per unit cost of transport noted earlier and D_{ij} is the distance between locations i and j.[4] The site-price surface of this single market with multi-transaction locations is defined by the respective transaction point price minus the transport cost from the production point to the transaction location (Bressler and King, p. 125).

The resulting market price at each location and the acquisition territory boundary for each transaction location, are illustrated by the site price graph illustrated in Figure 1. The horizontal axis of Figure 1 is measured in distance and the vertical axis is measured in dollars. B_w is the west boundary of the production plane and B_e is the eastern boundary of the production plane.

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[3]This assumption of uniform geographic distribution is made for purposes of simplification. It is not a necessary condition to generate the conclusions of the reasoning process.

[4]A linear transport cost function is illustrated for simplicity. The actual mathematical form of this function is not restricted by the theory.

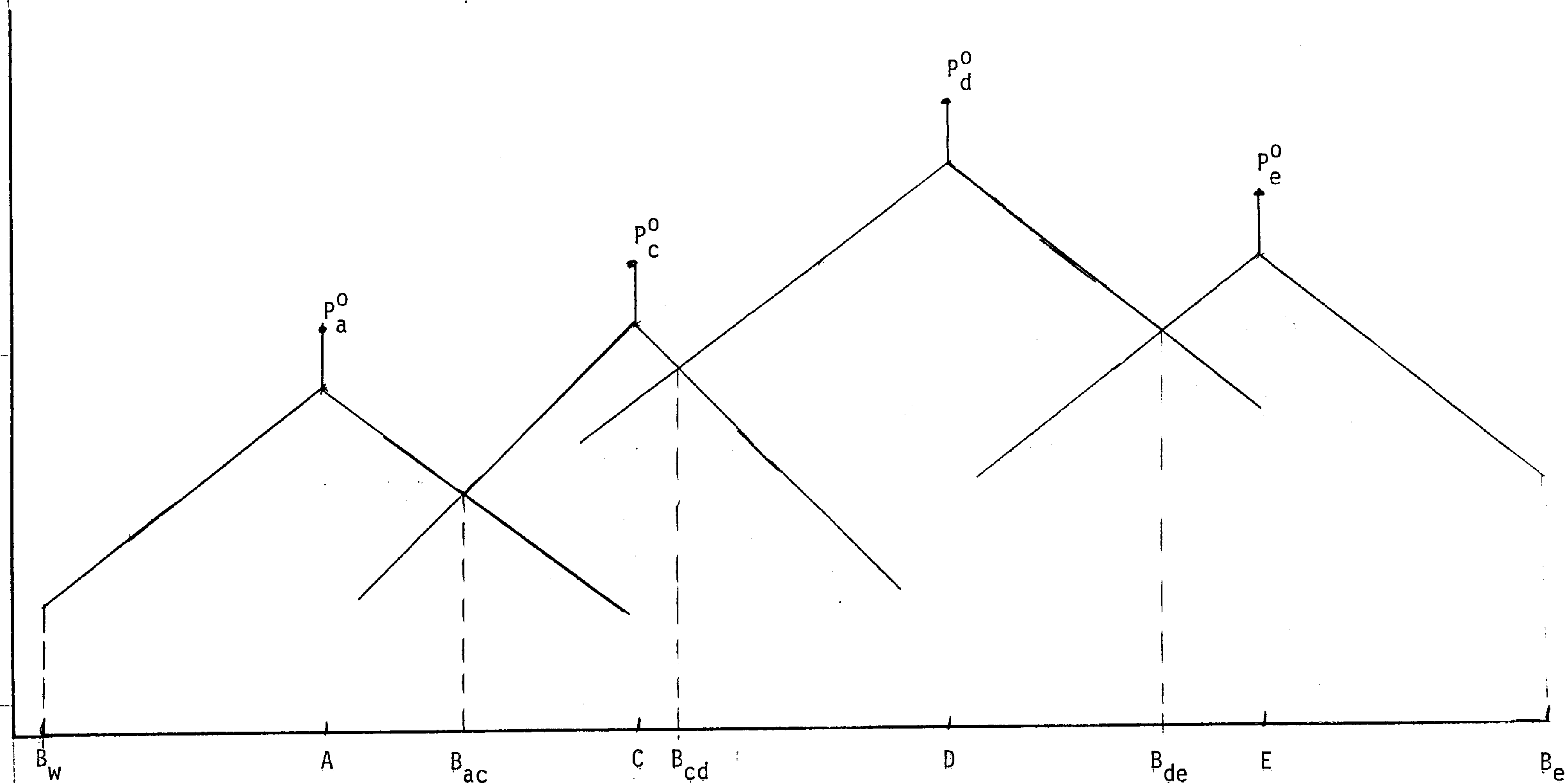

Figure 1. Period Zero Site Price Surface of a Market With Four Geographically Separated Transaction Locations in a Homogeneous Production Plane

Given the total available supply (geographically dispersed) and the market demand for the product geographically distributed across the four transaction locations in time period t, a geographic market clearing set of prices will be generated where each producer has delivered its supplies to the transaction location that yields the highest f.o.b. price at its production location. The market average price of the product within the market area is defined as $P_M^t = \Phi_a P_a^t + \Phi_c P_c^t + \Phi_d P_d^t + \Phi_e P_e^t$ where Φ_k represents the market share of total sales volume delivered to location k. P_M^t is the market clearing price in time period t given the total market demand and the total supply produced in period t. We also know that between the transaction locations, $(P_i - P_j) \leq t_{ij}$ since if this condition does not hold, reallocation of the product between transaction locations would occur. Figure 1 thus represents the perfect market solution of a single market with four geographically separated transaction locations.

For the market outcome illustrated in Figure 1, it is impossible for a single unit of the production at location k to be reallocated to a different transaction location without reducing the f.o.b. selling price (and hence the income) of producer k. Producers at all points are receiving the highest f.o.b. price possible given period t total market conditions.[5] The boundaries of procurement areas for the respective pairs of markets in time period zero are B_{ac}^o, B_{cd}^o and B_{de}^o.[6] There is no need for actual movement of the product (observed arbitrage) between any pair of transaction locations to achieve this perfect market solution in time period zero. The competition for market share between each pair of transaction locations (i.e., the allocation of available supplies between the

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[5]Producers are free to deliver their product to the location yielding the highest net f.o.b. price at their location. The producer will ship to location i only if $(P_i - t_{ai}) \geq (P_j - t_{aj})$ for all i other delivery points..

[6]These boundaries are depicted as a point in the one dimensional graph of Figure 1. A view of the two dimensional production plane taken from directly above the AE axis of Figure 1 would reveal hyperbolic shaped acquisition territories (see Fetter and Bressler and King).

transaction locations) occurs at these procurement area boundaries. Moreover, since the net price received at each geographic location is greater than or equal to the producer's next best alternative given the spatial realities of the market, zero market power is being exercised at all transactions points -- regardless of the number of buyers at each location.

Note that boundaries of acquisition territory do not define market boundaries. In the above example the single national market consists for four juxtaposed acquisition territories. Moreover, the "competitiveness" of the pricing process at each transaction location is <u>not affected</u> by the distance from the transaction location (slaughter plant) to the boundary of the location's acquisition territory relative to the distance between the two closest transaction locations. Furthermore, the "competitiveness" of the pricing process at location i is <u>not affected</u> by the number of buyers located at the transaction location. Every producer in the production plane is receiving the highest possible f.o.b. price for his product or he would simply transfer delivery to the higher f.o.b. price location. Even if meat packer Z has a complete monopsony position at location i, the packer will be forced to pay all producers that deliver (sell) to the plant, a price that meets or exceeds the seller's next best alternative. That is all that is expected in a perfectly functioning market with geographically separated transaction locations.

Contrary to conventional wisdom (and numerous published analyses) the number of firms located at transaction i does not affect the price f.o.b. received by producers as long as producers have the alternative to deliver to an alternative location j. Seller arbitrage is equally as effective as buyer arbitrage in generating the socially optimal geographical array of prices. The combination of these two arbitrage forces guarantees that the pricing performance of geographically dispersed transactions will comply with the ideal performance standards.

Now suppose that as we move from time period zero discussed above to time period 1. In period 1 the demand for the product at location E increases while the supply density across the entire production plane and product demand at the other three points remain unchanged from period 0.

Clearly the price at location E will increase (i.e., $P_e^1 > P_e^o$) *ceteris paribus* (Figure 2). This raises the production site price surface emanating out of transaction location E. As a result the acquisition territory of location E spreads out (from east to west) and producers between B_{de}^o and B_{de}^1 who previously shipped to location D in time period zero will now ship to location E in response to the price increase at location E. This will result in an increase in market share for location E and a decrease in market share for location D unless the price at location D is increased in an effort to maintain market share. Thus the increase in demand at location E is an increase in total market demand and increases the average market price.

The willingness of buyers at location D and other locations to pay higher prices in an effort to retain market share depends on the price flexibility of the derived demand for the product at those locations.[7] The increase in demand at transaction location E will thus increase product prices at all locations in the market unless the price flexibility of demand at one of the transaction locations is zero.

Whatever the details of the outcome, the product will effectively move from west to east in response to the demand increase at location E. However, there will be no direct movement (observed arbitrage) of the product observed or expected between any of the transaction locations. Relocation of acquisition territory boundaries is where arbitrage occurs between the locations and

[7]Locational differences (between transaction locations) in these flexibilities are likely to exist because of locational differences in the price flexibility at the local retail level and/or the slope of the product transformation cost curve at each transaction location.

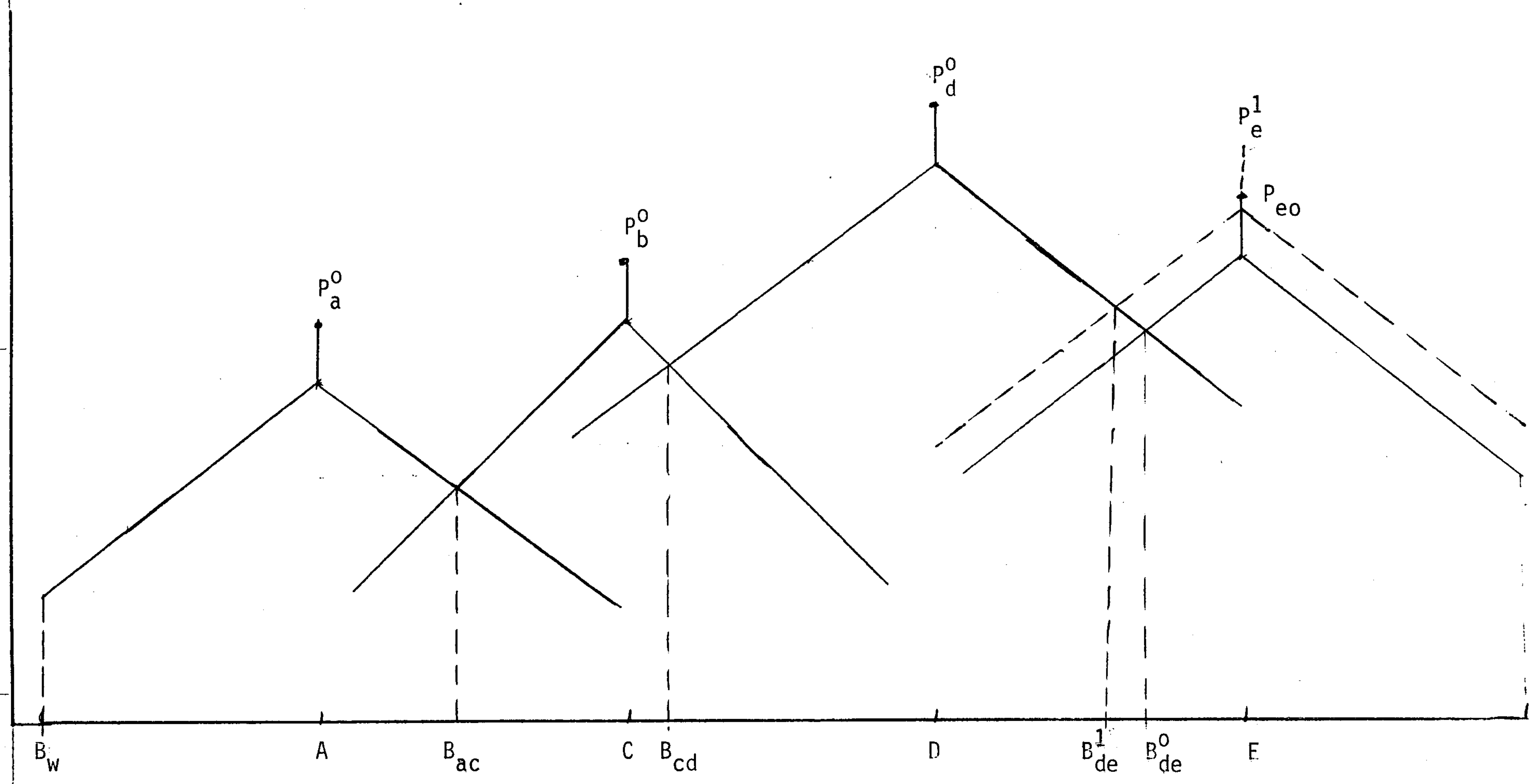

Figure 2. Period One Initial Site Price Surface of a Market With Four Geographically Separated Transaction Locations in a Homogeneous Production Plane

ties all four locations together into a single market. Therefore attempts to define market boundaries on the basis of observed arbitrage between two transaction (or some concept of the probability of arbitrage) locations (as suggested by Koontz, Sexton, et al, and Spiller and Huang) is not a valid process in defining market boundaries.

Suppose that in period one we have the increase in demand at location E discussed above and we also have a simultaneous decrease in demand at location A with no change in demand at locations C and D and no change in production density across the production plane. The possible combinations of changes in acquisition territories are numerous in this case and we will have prices moving up in one or more territories and prices moving downward in one or more territories (i.e., possibility of negative correlation between prices at two locations within the same market) depending on the relative magnitudes of the demand decrease at location A and the demand increase at location E. Whatever the details, all four locations will be tied together into a single market by this arbitrage process. Moreover, we will observe zero product movement (direct arbitrage) between the transaction locations. Price relationships will satisfy the perfect market performance criteria as profit maximizing product sellers ship to the location generating the highest f.o.b. production locations.

In this example, transaction locations A, C, D and E are tied together into a single market with four geographically separated transaction points. In this case the net f.o.b. price lines of each transaction location intersect the price line of each of the neighboring transaction locations at a non-zero price. Thus, producers at the boundary of the juxtaposed acquisition territories between two transaction points have a choice of which of two transaction points they deliver to. Figure 2 thus illustrates the market outcome consistent with H_c. Since all markets are tied together by selling (delivery location) decisions of producers, no market power (generation of rents) will occur at any of the transaction locations.

Juxtaposition of acquisition territories is however, not a necessary condition for two transaction locations to be contained in the same market. Figure 3 illustrates a situation where transaction locations A and C share acquisition territories while locations D and E also share acquisition territory boundaries. However, the acquisition territories of location C and D are not shared. Hence, there is no production of the product in the geographic territory between B_{ec} and B_{wd}.

However, all four transaction locations are bound together into a single market if $(P_c - P_d) \leq t_{cd}$. In this case, P_a and P_c will move together in response to supply/demand at either of their respective locations. The same will be true of P_d and P_c. However, P_c and P_d will move independently of each other subject to the constraint that $(P_c - P_d) \leq t_{cd}$. If $(P_c - P_d) > t_{cd}$ then arbitrage between location C and D will be brought back into compliance with the $(P_c - P_d) \leq t_{cd}$ condition. Buyers, in neither of the two combined territories [i.e., (A+C) and (D+E)] will be able to extract economic rents since the threat of arbitrage will enforce the market performance criteria. Note in particular that economic rents are not being extracted from producers located at either B_{ec} and B_{wd} even if there is a single buyer at either/both of the transaction location since the producer is receiving an f.o.b. price at their location that is greater than or equal to their next best alternative.

If, however, there is some type of transaction constraint that prevents arbitrage between location C and location D from occurring then $(P_c - P_d)$ may exceed t_{cd} and we would have two separate markets consisting of two transactions each. This is the type of situation consistent with hypothesis H_b.

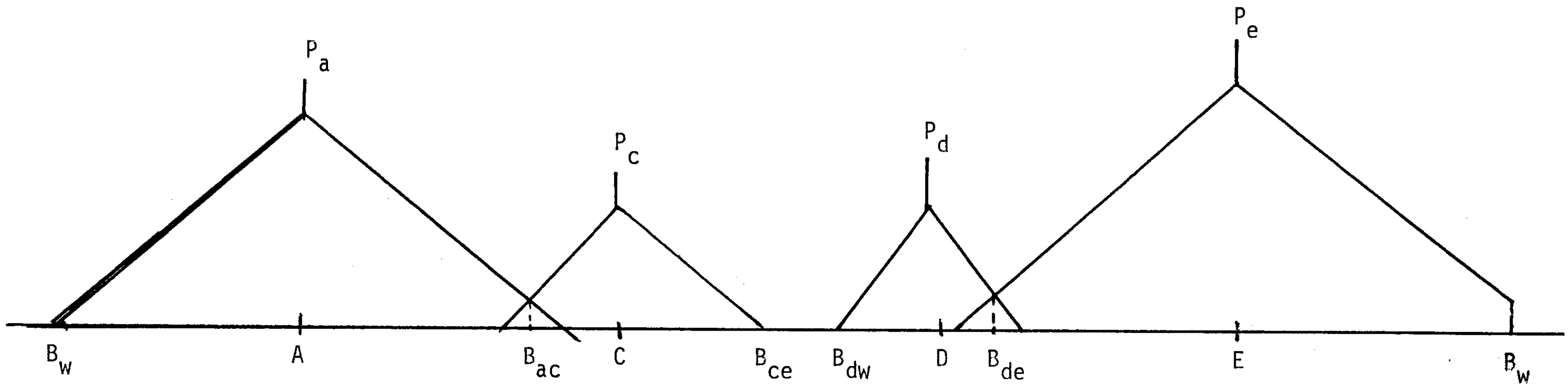

Figure 3: Site Price Surface for a Market With Four Transaction Locations in Which Acquisition Territory Boundaries Are Not Shared Between Two Transaction Locations

Comments Regarding the Concept of "Arbitrage Probability"

The concept of calculating the probability of "probability" of arbitrage as a technique for defining market boundaries proposed by Spiller and Huang, and later by Sexton et al., and by Koontz has no theoretical foundation once we recognize that testing H_o is the appropriate methodology for defining geographic boundaries of markets. Since $(P_i - P_j) = t_{ij}$ is not a necessary condition for location i and location j to be located in the same market, the calculation of the probability that the magnitude of $(P_i - P_j)$ will equal or exceed t_{ij} and trigger actual arbitrage has no meaning.

The probability that the price difference between any pair of locations in the single market depicted in Figure 1 will exceed t_{ij} is zero. Choice of delivery location by sellers will keep this from occurring. That does not mean that the locations are in separate markets.

The probability that live hogs will be transported from (arbitrated between) North Carolina and California must be zero. However, the likelihood that the equivalent east to west arbitrage within the national U.S. slaughter hog market is certain to occur if the demand for slaughter hogs increases in California *ceteris paribus*. The arbitrage will occur as simultaneous movements westward in the acquisition territory boundaries between North Carolina and Ohio, Ohio and Iowa, Iowa and Texas, and between Texas and California packers. The reverse movement of these boundaries will also occur if the demand curve for slaughter hogs decreases in California, *ceteris paribus*.

Casual observation indicates that California and North Carolina, and all transaction locations in between, are part of a single national market for hogs since there are no legal barriers to shipments of live hogs anywhere in the U.S. Testing H_o can provide the empirical test for the consistency of this statement with observed market outcomes. There are no non-market barriers to interstate movement of hogs in the U.S. Moreover, there are no non-market barriers to movement of hogs between the U.S. and Canada and we observe extensive movements of slaughter hogs from Canada to U.S. slaughter plants. Consequently, there is most likely a single North American market for slaughter hogs. Arguments to the contrary will have to show that $(P_i - P_j) > t_{ij}$ between a selected pair of transaction locations and hence the rejection of H_o discussed in this paper.

Conclusions

The theory of perfect markets provides a simple, and hence, powerful test for evaluating the pricing performance of a geographically dispersed market. This theory identifies the ideal price relationships between geographic locations. The theory of spatial price relationships in a perfect market also provides the theoretical basis for defining the geographic boundaries of geographically separated transaction locations.

Use of price relationships defined by the theory of perfect markets to formulate and test hypotheses about the performance of real world markets does not presume (or test for) the existence of a perfect market. We know that observed industry structure and the absence of perfect information do not comply with the characteristics (assumptions) of a perfect market. However, the social welfare implications of the outcome of a perfect market are indeed the ideal performance characteristics (outcomes) of a market. The outcomes of a perfect market define the socially optimal price relationships. The bottom line is that industry structure is irrelevant if observed performance of (outcomes generated by) the existing market structure are not significantly different from the ideal performance of a perfectly functioning market. There is cause for concern about the structure of the market and conduct of the participants only if the observed outcomes are significantly different from the socially optimal outcomes that would be generated by a perfect market.

The literature regarding the slaughter livestock market is dominated by research based on the presumption of socially undesirable performance by firms in the industry because of high concentration ratios (Azzam and Schroeter and also Hunnicut and Weniger). Researchers have basically rejected without testing the hypothesis that the performance of the market is not significantly different from the ideal performance of a perfect market (i.e. H_o). Consequently much of this literature uses inappropriate methodology designed to show how market power is being exercised by market participants rather than testing hypotheses about whether we have reason to suspect that market power is being exercised.

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PRICING PERFORMANCE OF A DUOPSONY MEAT PACKING INDUSTRY*

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Conventional wisdom of economists, politicians and livestock producers is that the "market power" of meat packers increases as the number of packers (N) decreases. The smaller number of packers supposedly use their increasing market power to extract rents from both consumers and livestock producers by generating wider farm-wholesale price spreads (S) than would exist if there were a larger number of packers that would "compete" for the animals being marketed by livestock producers.[1] This conventional wisdom states that $\sigma S/\sigma N < 0$ [i.e., the spread increases (decreases) as N decreases (increases)].

The purpose of this paper is to explore the validity of this conventional wisdom that provides the foundation for increasing public discussion and concern about livestock prices and the structure of the meat packing industry. This paper develops the conceptual framework appropriate for specifying hypotheses about the sign of $\sigma S/\sigma N$.

The Farm Level Market for Livestock

Meat packers apparently make key decisions regarding kill rate and hence prices they are willing to pay for live animals on a weekly basis. Thus, the relevant unit of time for packer decisions

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[1]Market power is a widely used term that is almost never defined by authors. See Bullock (2) for a discussion (definition) of the term "market power."

and for envisioning packing plant cost curves and derived demand curves for live animals is one week. All discussion and graphs that follow use one week as the unit of time.

The slaughter animal market clears each week with a quantity Q_t marketed/slaughtered in week t at an average price P_f^t. The magnitude of Q_t is determined by producers. The price offered by packers, P_f^t, is determined by the wholesale demand curve for meat and the cost of providing slaughter/wholesaling services at the weekly slaughter rate Q_t.

Consider the case of a duopsony (two firm) packing industry purchasing hogs from a large number of hog producers.

The average variable cost (excluding animal cost) curves for Firm A and Firm B are denoted as AVC_a and AVC_b respectively in Figure 1. MC_a and MC_b represent the upward sloping portion of the associated marginal cost curves. Q_*^a and Q_*^b are the least cost per head operating levels (weekly slaughter rates) for the two firms. Firm B benefits from economies of scale relative to Firm A as indicated by the relative magnitude of average cost in the vicinity of their respective least cost levels of weekly operation.

Both slaughter firms sell identical products into the wholesale market and produce the same yield of wholesale product per live animal at all levels of plant operation (i.e., wholesale products are obtained in fixed proportions from live animals).

The wholesale demand curve for the products produced from alternative levels of hog slaughter is represented by:

$$P_t^w = \alpha Q_t^\beta$$

where: $P_t^w =$ the per head value of wholesale pork products marketed during week t.

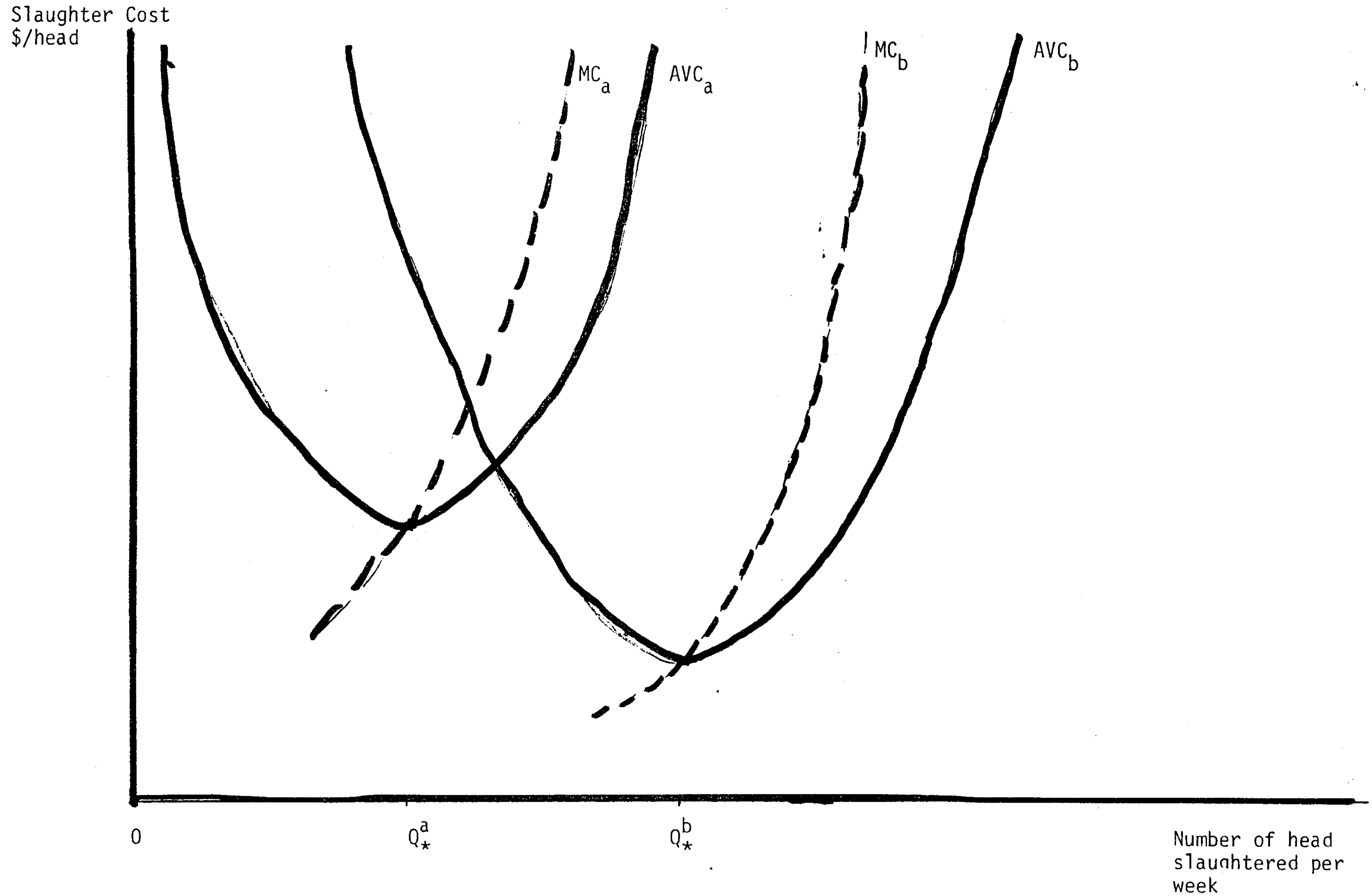

Figure 1: Average variable cost and marginal cost of slaughter (non animal costs) for Firm A and Firm B

Q_t = the total number of hogs slaughtered during week t. Q_t is the sum of the quantity slaughtered by Firm A and by Firm B, i.e., $Q_t = Q_t^a + Q_t^b$.

The biological nature of swine production means that the number of hogs reaching slaughter weight in week t was determined several months ago by hog producers who bred the sows that farrowed the pigs that were fed to slaughter weight in week t by the hog producers. Slaughter weight hogs, are for all practical purposes, a non-storable commodity. Thus, the number of slaughter weight hogs marketed by producers in week t is highly (almost perfectly) inelastic with respect to the market price of hogs being offered by packers in week t.

The wholesale price of pork produced in week t is defined by the willingness of wholesale buyers to purchase the pork products obtained from the predetermined number of hogs marketed in week t. The wholesale price of pork in week t (P_t^w) is independent of decisions and actions of pork packers. The number of hogs slaughtered each week is determined by production/ marketing decisions of producers. The wholesale price is the market clearing price for the quantity of pork placed in the market by producers.

The classical static equilibrium economic model used by IO economists to illustrate how oligopsonsists exercise "market power" assumes that (a) producers determine production in time period t as a function of the price offered by buyers in period t (i.e., there is an instantaneous production process), and (b) therefore the buyers determine industry output in time period t by setting the price they are willing to pay for the raw material.

Neither of these assumptions is a valid description of the market for slaughter hogs in week t. Even during the weeks of record low hog prices (and record high weekly slaughter rates) in 1998 and 1999, pork packers purchased all hogs placed in the market each week. Pork packers do not generate economic rents by restricting the number of hogs slaughtered each week as is postulated (assumed) by the economic model offered by conspiracy theorists.

The farm level price of hogs paid by packers is, however, directly determined by packer decisions regarding the price they are willing to pay for alternative quantities of animals placed in the market during week t. Packers are margin makers. They determine the price they are willing to pay for live hogs in week t (without regard to hog producer production costs), given (a) the wholesale level demand for pork products, (b) the total number of hogs marketed in week t, and (c) the per head slaughter costs at Q_t level of operation.

The farm level demand curve for live hogs is thus derived (by packers) from the wholesale demand for pork products. By definition, the producer level derived demand for hogs is the schedule showing the maximum price that packers are willing to pay for Q_t hogs during week t. In a competitive market, this price is the wholesale value of the products produced from the animal minus the cost of the slaughtering process at the weekly Q_t slaughter rate [(i.e., $P_t^f = (P_t^w - C_t)$)].

Bullock (1) has shown that the derived demand for hogs by an oligopsonist packing industry is identical to the derived demand curve for hogs by a competitively structured packing industry provided the cost curves of the firms in the two industries are identical. Thus, in that case the number of packers is not a factor in determining the farm level price of hogs in week t.

The questions of interest in this paper are:

1. How will the duopsony firms described above (i.e., non-identical cost curves) distribute available supplies between themselves?
2. What will be the price of live hogs in this situation?

3. Does the resulting price of hogs accurately reflect the "true" value of hogs marketed in week t as would be the case with a "competitively structured" packing industry?

Given the wholesale demand for pork products and the processing cost curves of the two packing plants illustrated in Figure 1, the derived weekly demand curve for hogs by Firm A (DD_a) and Firm B (DD_b) are depicted in Figure 2. [See Bullock (1) for a discussion of the derivation process.]

It is clear from Figure 2 that for sustained levels of industry output less than Q_k, Firm A can outbid Firm B for 100 percent of available supplies. Ongoing industry output levels $Q_L < Q_t < Q_k$ are large enough to sustain only Firm A. In this situation, Firm A would be a natural monopsonist.

At industry output levels $Q_k < Q_t < (Q_*^b + Q_s)$ Firm B can outbid Firm A for 100 percent of available supplies. Continued industry output levels in this range are large enough to sustain only Firm B. In this case Firm B would be a natural monopsonist.

The two plants can co-exist over a period of W weeks only if the average number of hogs marketed each week $Q_t \geq (Q_*^b + Q_s)$.

The derived demand curve for hogs in the duopsony packing industry is depicted in Figure 3. Over the range of sustained weekly hog production in the range $Q_L \leq Q_t \leq Q_k$ the market derived demand curve is the derived demand for hogs of Firm A. Over the range of sustained weekly hog production $Q_k < Q_t \leq (Q_*^b + Q_s)$ the market level derived demand for hogs is the corresponding segment of the Firm B derived demand curve for hogs. At weekly hog production levels $(Q_*^b + Q_s) \leq Q_t \leq (Q_m + Q_*^a)$, the derived demand for live hogs is the upward sloping segment of the Firm A derived demand curve for hogs over the Q_s *to* Q_*^a range. At weekly hog production levels $(Q_m + Q_*^a) < Q_t < (Q_g + Q_h)$ the market demand for live hogs is the horizontal summation of the

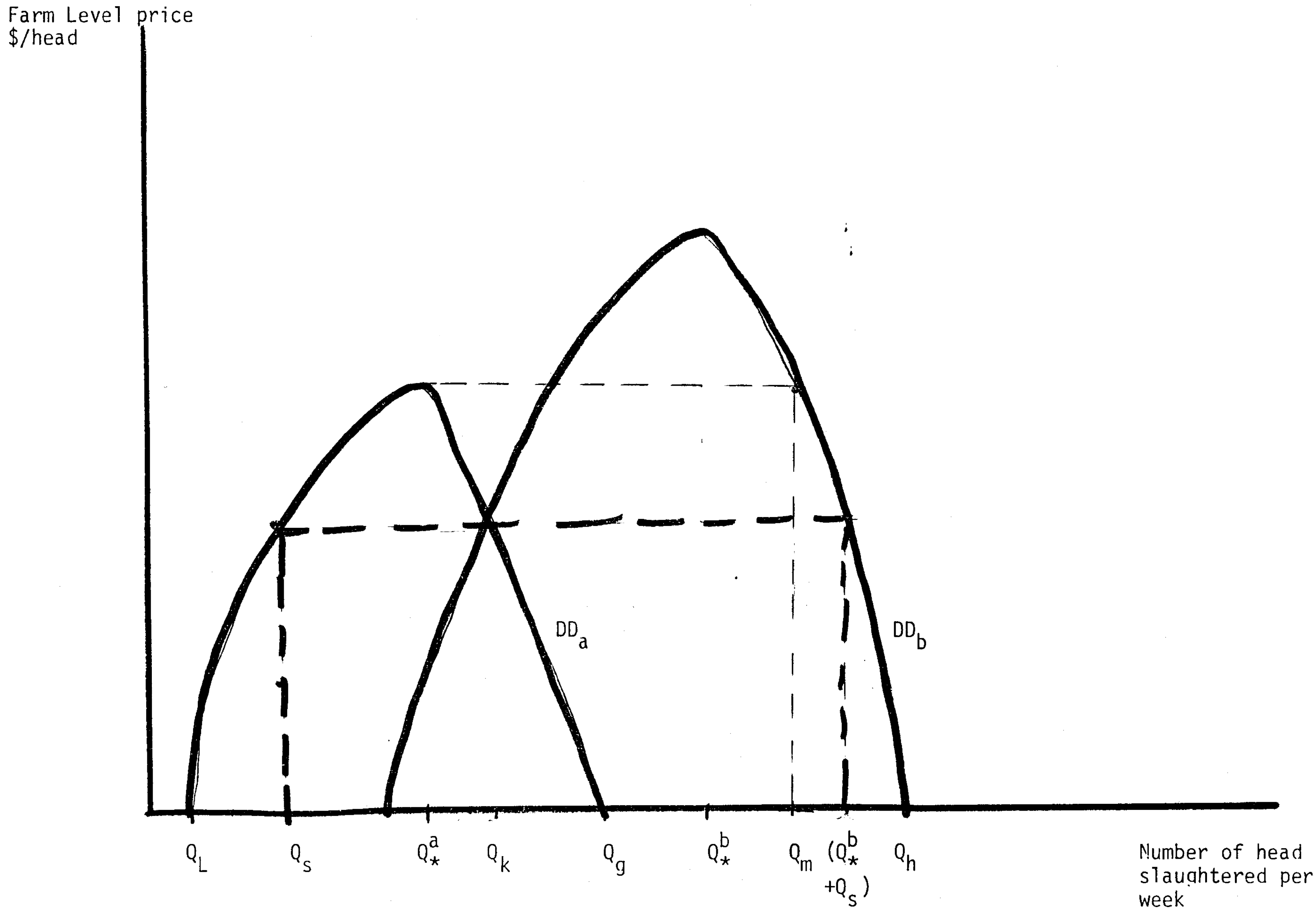

Figure 2: Derived demand for hogs by slaughter Firm A and slaughter Firm B

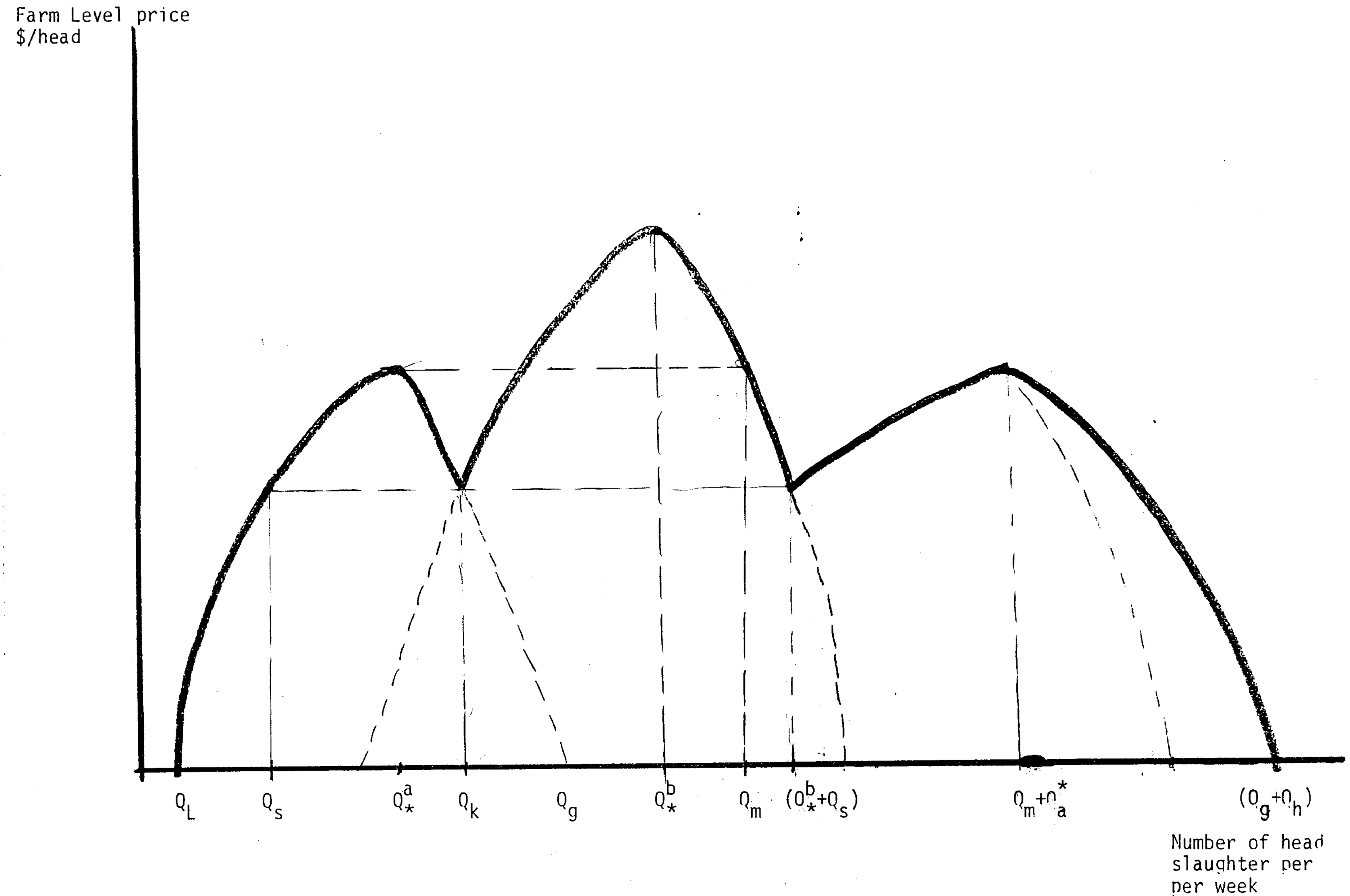

Figure 3: Market derived demand for hogs with Duopsony packing industry

derived demand for hogs by Firm A (over the range $Q_*^a \; to \; Q_g$) and the derived demand for hogs by Firm B (over the range $(Q_m + Q_s)$ to Q_h. The market derived demand for hogs crosses the quantity axis at $Q_t = (Q_g + Q_h)$ given the existing capacity of the slaughter plants owned by the two firms.

At hog slaughter levels $(Q_*^b + Q_s) \le Q_t \le (Q_m + Q_*^a)$ both firms can exist and will compete for hogs. Over this range of industry output Firm A can outbid Firm B for its hogs and thus gain entry into the market. Firm A will gain market share over this range of production but will always have a smaller share than Firm B. As industry output increases from $(Q_*^b + Q_s)$ to $(Q_m + Q_*^a)$ Firm A will reduce weekly slaughter from $(Q_*^b + Q_s)$ to Q_m, while Firm B expands slaughter from zero to Q_*^a.

At hog production levels $(Q_m + Q_*^a) \le Q_t < (Q_g + Q_h)$ both firms will be operating on the upward sloping portion of their respective marginal cost curves and will hence have downward sloping derived demand curves for hogs. The two firms will compete for all production in this interval of industry output. Changes in market share over this interval will be determined by the relative slopes of the two firms' marginal processing cost curves over the $Q_*^a \; to \; Q_g$ range for Firm A and over the $Q_m \; to \; Q_h$ range for Firm B.

The firm having the steepest sloping marginal cost curve will lose market share as industry output expands beyond $(Q_m + Q_*^a)$. Given that at these levels of processing $\frac{Q_a}{Q_*^a} < \frac{Q_b}{Q_*^b}$ it is likely that Firm A will gain market share as industry production expands beyond $(Q_m + Q_*^a)$ since $\frac{\sigma C_a^m}{\sigma Q_a} < \frac{\sigma C_b^m}{\sigma Q_b}$ over this range.

In order to maintain both Firm A and Firm B in operation, total weekly slaughter must average more than $(Q_*^b + Q_s)$ and not exceed $(Q_g + Q_h)$ if hog prices are to be above zero.

A couple of observations can be derived from this exercise.

First, and most significant, since meat packers possess zero buyer market power, even with only two packing plants. Therefore, hog producers will receive the competitive value for their hogs $P_t^f = (P_t^w - C_t)$ where C_t is the cost of slaughtering the Q_tth hog in week t. Rivalry between the two packers for market share to insure that the rival does not buy hogs at "bargain prices," generates the same farm prices that would exist if there were "large numbers" of packer buyers.

The cost of slaughter in week t (i.e., C_t) is the marginal cost of slaughter for Firm B and is the average cost of slaughter for Firm A. Note that as industry output level increases from $(Q_*^b + Q_s)$ to $(Q_m + Q_a^*)$ that Firm A gains market share by expanding production along the downward sloping portion of its AVC curve and offering farm level prices of $P_a^f = (P_w - AVC_a)$. At the same time Firm B loses market share by moving to the left along its MVC curve and paying the farm level price of $P_t^f = (P_w - MVC_b)$. Since both firms sell at the same price P_w and purchase slaughter animals at the same price $P_a^f = P_b^f$ it follows that at the respective slaughter rates in period t $MVC_t^b = AVC_t^a = C_t$ thus, Firm A is not accruing producer surplus as it expands from Q_s to Q_*^a level of slaughter. However, Firm B is accruing producer surplus on all animals slaughtered although its market share and operating profits are reduced by the participation of Firm B as industry output expands beyond $(Q_*^b + Q_s)$. Both firms accrue producer surplus only when industry output exceeds $(Q_m + Q_a^*)$.

It is theoretically possible that Firm A and Firm B will decide to collude and simply agree to widen the spread $S - (P_w - P_f)$ beyond the "competitive" levels discussed above. Evidence of this non-competitive behavior by the packers would appear as above normal profit levels for the industry. Proponents of such a conspiracy theory are welcome to pursue this model. However, observed rates of profit on either sales or investment in the packing industry are not consistent with the collusion theory. To the contrary, observed profit rates of meat packers is quite consistent with the model described above.

Second, we know that the number of animals marketed/slaughtered per week fluctuates substantially during the year. Given the ongoing existence of more than one packer, we can conclude that the average value of Q_t in recent years has been greater than $(Q_*^b + Q_s)$ and has ranged between $(Q_*^b + Q_s)$ and $(Q_g + Q_h)$ since no packer has temporarily closed because of short supplies and then reopened when supplies increased. Moreover, we can conclude that in late 1998 and early 1999, Q_t was quite close to $(Q_g + Q_h)$.

The packing industry model depicted here can, with no loss of generality, be viewed as either a duopsony or as an industry with N_1 identical smaller firms and N_2 identical larger firms where the larger firms benefit from economies of scale. Suppose that we change the problem setting so that AVC_a represents the aggregate of N_1 identical firms and AVC_b represents the aggregate of N_2 identical firms. In this case numerous "small" firms confront numerous "large" firms in the process of buying hogs and selling wholesale pork products. The market outcome is not dependent on the number of firms in either category.

Thus, given the existing slaughter capacity of the $N_1 + N_2$ firms, the market level derived demand curve is simply a scaled up version of the market derived demand curve depicted in Figure 3. Given industry slaughter capacity of the two groups of firms, the weekly market demand curve for hogs has three upward sloping sections and three downward sloping segments over the output range $Q_L \leq Q_t \leq (Q_g + Q_h)$.

Since the current industry consists of more than one packing firm and these firms are not of identical size, we can conclude that in recent years hog production (slaughter) has exceeded

$(Q_*^b + Q_s)$ in all periods. Thus this segment of the market derived demand curve for hogs is relevant for purposes of our discussion here.

Variation in Market Share and Farm-Wholesale Price Spreads

Select two levels of industry output Q_i and Q_j such that

$$(Q_*^b + Q_s) < Q_i < Q_j < (Q_g + Q_h).$$

Three possible situations exist depending on the magnitudes of Q_i and Q_j.

I. $(Q_*^b + Q_s) < Q_i < Q_j < (Q_m + Q_*^a)$

In this situation, as output increases from Q_i to Q_j the wholesale price of pork decreases but the farm price of hogs increases and therefore the farm-wholesale price spread decreases.

II. $(Q_m + Q_a^*) < Q_i < Q_j \leq (Q_g + Q_h)$

In this situation as output increases from Q_i to Q_j, both the wholesale price of pork and the farm price of hogs decrease and the farm-wholesale price spread widens reflecting the rising marginal slaughter cost of both packers (groups of packers).

III. $Q_i < (Q_m + Q_*^a) < Q_j < (Q_g + Q_h)$

In this case the wholesale price of pork decreases as output increases from Q_i to Q_j. However, at the farm, level $P_i^f \gtreqless P_j^f$ depending on the relative magnitude of $[Q_j - (Q_m + Q_*^a)]$ and $[(Q_m + Q_*^a) - Q_i]$, therefore the farm-wholesale spread may increase, decrease, or remain unchanged as retail prices decline in response to an increase in the number of animals marketed/slaughtered over this interval of total number of hogs marketed/slaughtered.

These situations and the resulting conclusions are not dependent on the magnitude of N_1 or N_2 (provided $N_1 \geq 1$ and $N_2 \geq 1$ since industry output exceeds the levels where natural monopsonies would exist. Moreover the conclusions are not changed if the model is expanded to accommodate M > 2 groups of firms.

Clearly $\sigma S/\sigma N = 0$ and there is no theoretical basis for arguing that meat packer spreads will increase as the number of packers decreases. The relevant variable explaining changes in the farm-wholesale price spread is the magnitude of Q_t relative to the existing weekly slaughter capacity of the packing industry.

Note that the only assumptions of this model are:

1. The wholesale demand for pork is downward sloping with respect to the number of animals marketed each week.
2. That the number of animals marketed each week exceeds the number required for the existence of a natural monopsony.
3. That one firm (group of firms) enjoy economies of scale relative to the other firm (group).
4. The number of animals marketed/slaughtered in week t was predetermined several months ago by the collective decisions of hog producers.
5. Packers purchase and slaughter all hogs marketed in week t as long as $Q_t < (Q_g + Q_h)$.
6. Packers are margin makers and act in their own best interest in determining the farm level price of hogs each week.

Bottom Line: The wholesale price of pork, the farm price of hogs, and hence the farm-wholesale price spread for hogs is not a function of the number of pork packers. Therefore calculation of, and references to, packer concentration ratios is an irrelevant and useless activity in trying to understand and explain changes in the price of hogs and the farm-wholesale price spreads. More importantly, the focus of market observers and policy markers on industry structure (concentration ratios) leads to the wrong conclusions about the existence and use of packing industry "market power." Government policies and programs based on the inappropriate conclusions from the calculations of concentration ratios can lead to inappropriate allocation of resources and prevent the development of public understanding of the complex livestock market.

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