Testing for Market Power in Beef Packing: Where Are We and What's Next?

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Lynn Hunnicutt and Quinn Weninger[1]

Introduction

Consolidations in the U.S. beef packing industry have prompted concern within the government and interest among academics over whether packers possess and are able to exercise market power. Economists have generated numerous studies to test for and measure market power in beef packing, but the empirical studies have failed to provide definitive results on the presence of market power and whether any existing market power is being exercised. Most studies (Schroeter (1987), Bhuyan and Lopez (1997), Koontz, Garcia, and Hudson (1993), Schroeter and Azzam (1990)) conclude that some market power may exist either in the primary input market or in the consumer market, but that the degree of market power is small.

It is reasonable to expect that the numerous studies that appear in the literature would by now have resolved the issue, or at least compiled consistent evidence for or against market power in beef packing. On the contrary, neither compelling nor consistent evidence has emerged, and efforts to uncover market power in beef packing may even have increased in recent years. It therefore remains somewhat of a puzzle whether packers do indeed possess the market power that consolidation suggests they might, and if they do how they are exercising it.[2]

In this bulletin we present an assessment of techniques used to test for and measure market power, and suggest that the most commonly used measure may be seriously flawed. We also suggest alternative measures, and deal with one possible way to discover just how flaws in data measurement lead to inaccurate conclusions regarding market power.

A review of the empirical literature on market power, specifically in beef packing and more generally in agricultural markets, reveals that most studies utilize the conjectural variations approach. Conjectural variations models are reduced form models, which focus on market outcomes rather than the underlying competitive process. Specifically, the conjectural variations approach relies on reduced form models of competition which do not require that strategic variables, timing of actions, and the information structure faced by firms be fully specified (Fudenberg and Tirole (1987), hereafter F&T). We contend that the focus on market outcomes has overlooked important elements of the competitive process in the beef packing industry. For example, firms in conjectural variations models are assumed to maximize single period profits, even when it is known to all parties that competition will take place in future periods. Additionally, conjectural variations models specify that firms exercise market power only through their influence on market prices. Inasmuch as other considerations such as maintaining constant throughput rates are of interest to firms, the emphasis on price as the only measure of market power may be misleading.

Conjectural variations models generate accurate inferences only inasmuch as the data they use--consumer demand, cattle supplies and in-plant processing costs--are accurate. Data are often incomplete, which leads to reliance on (more or less useful) proxies for unobserved variables. Data are also usually sparse, forcing practitioners to use market-level or aggregated data to investigate firm-level competitive behavior. Not only problems with data, but misspecification of the functional forms of consumer demand and the cost functions underlying cattle supply can lead to incorrect conclusions regarding market power.[3]

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[2] There are several reasons to be concerned about the existence of market power. The most important are the economic welfare implications. First, in markets with price-making firms, what economists label dead weight losses arise that reduce total economic welfare. A second effect that may have important political implications, particularly in agriculture, is wealth redistribution from producers to packers that may result as beef packers exercise control over input prices.

[3] An interesting test of the sensitivity of market power estimates to data aggregation and model specification appears in Jones et al. (1996). Using simulation data, they find that estimates of market power are highly sensitive to model specification and to data aggregation techniques. In some estimated models, market power is rejected 100% of the time, even when the (simulated) data generating these estimates is created to contain evidence of such power.

The combined effects of incomplete and aggregated data, along with the additional problem of model misspecifications, may reduce the statistical power of the conjectural variations approach to the point where its conclusions about market power cannot be relied upon. This could explain the less than conclusive results generated so far by the literature on market power in beef packing.

The following section provides further details of the conjectural variations model and elaborates the shortcomings of this approach. We then discuss alternative approaches and measures of market power that may circumvent the problems that plague the conjectural variations model. Conclusions and directions for future analysis of market power in the beef packing industry follow in the final section.

The Conjectural Variations Approach

Conjectural variations (CV) models assume that firms base output decisions on the response they expect to get from competitors. Limited market response to a change in firm output suggests that the market is competitive, while an extensive market response suggests the presence of market power. Tests using the CV framework explicitly permit the decision process of a single firm to be affected by the behavior of rival firms. Assuming the model accurately describes underlying conditions, this allows direct predictions of firm beliefs (conjectures) regarding rival actions, and therefore of firm behavior. The CV model does not require that the conjectures be specified *ex ante*, but instead allows empirical data to provide information about the nature of the conjectures. These reasons, along with relative ease of estimation, makes CV a popular choice for measuring and estimating market power.

A typical CV model uses the single firm's profit maximization condition to derive a profit-maximizing output response condition. The output response depends on the price elasticity of cattle supply and boxed beef demand (net of processing costs), and on the firm's "conjecture" about industry response to a change in its own production level. The response function is arranged such that a single parameter, the conjectural elasticity, measures the difference between the cattle input price and the firm's marginal valuation of output (called the price-cost margin, or Lerner index). Data on input and output prices and marginal packing cost are used to estimate the conjectural elasticity, and thus determine whether market power (power to raise price above marginal costs) exists.[4]

Problems with the Conjectural Variations Approach

We discuss three potential shortcomings of the CV approach. First, CV models are static (single period only), while competition is dynamic (extends over several periods). The assumption that firms maximize current period profits only may overly simplify the competitive process in beef packing. For example, packers may be more interested in maintaining a steady flow of input supply or output demand than in selecting the single period low input or high output price. It is not clear that single-period profit maximization is an optimal choice when competition extends over several periods.[5]

Second, the CV model's emphasis on price as the only measure of market power may be misleading. There is some evidence that assuring a steady supply of inputs is important to beef packers, especially as plants become larger (Azzam (1998), Schroeter and Azzam (1990)). If firms use market power to assure a steady supply of inputs, prices may make the market appear competitive when in fact it is not. These first two problems can be restated as a condition where the implicit assumptions of the CV approach do not coincide with the strategic setting under which competition actually takes place in beef packing.

The third shortcoming is empirical. As suggested above, the CV methodology relies crucially on accurate estimates of the underlying market and technological conditions. In order to obtain estimates of

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[4]For clear expositions of the conjectural variations approach, see Schroeter (1987), or Bhuyan and Lopez (1997).

[5]There is an extensive literature regarding repeated games which demonstrates that players may not maximize current period payoff if such action leads to punishment by other players in future periods. See, for example, Kreps, Milgrom, Roberts, and Wilson (1982), Abreu et al. (1986), Rotemberg and Saloner (1986). Empirical support for this idea can be found in Driscoll et al. (1997), who find firm level beef packing data to be inconsistent with single-period profit maximization.

firm conjectures, the researcher must provide estimates of the price elasticity of demand, and/or the wage elasticity of supply, or estimate them concurrently with firm conjectures. Correct specification of output demand, input supply and packing costs is necessary for estimates of market power to be accurate. If any of the estimated supply/demand or cost functions is incorrect, conclusions regarding firm conjectures may also be incorrect.

The Dynamic Nature of Competition In Beef Packing

The CV model depends crucially on individual firms' profit maximization during each period of competition (Driscoll, Kambhampaty, and Purcell (1997)). As noted above, there is a very large literature regarding repeated games that suggests firms may not maximize single period profits. That is, the static nature of the CV model may not correctly describe the dynamic nature of competition in beef packing. This problem is familiar to many authors using the CV approach. For example, Schroeter and Azzam (1990) used a CV model to test for market power in beef and pork production, and note that "...we have approximated an inherently dynamic problem with a static model..." (page 1374). Given that ranchers/feeders cannot easily relocate their operations and that beef packing plants are fixed in geographic space, each side should recognize that they will engage in future dealings. If either side has the ability to punish the other in future dealings, maximizing current period payoffs may not be in a party's best interest. Instead, packers likely maximize a discounted sum of future expected profits, knowing that their actions in the current period will affect rancher/feeder supply decisions in future periods. Additionally, since there are relatively few large beef packers in the industry, each of them can reasonably expect to be competing with the same firms year in and year out. Not only do packers play a dynamic game with input suppliers, they must also account for the effect their current period actions have on future choices their competitors may make.

In addition to the repeated nature of competition, the technological constraints on live cattle supplies suggest that competition in the beef-packing sector must involve a forward-looking decision process (Rosen, Murphy, and Scheinkman (1994)). A nine-month gestation period, plus a one- to two-year growth lag is required to produce an animal for slaughter. Consequently, ranchers and feeders face an unavoidable lag from the time they receive a price signal to increase production until increased supply is actually realized. The static CV model implicitly assumes that packers face the same supply conditions across multiple production periods. This assumption directly contradicts the literature on cattle supply, and raises serious questions about the inferences drawn from the static CV approach (although it is difficult to specify all of the difficulties caused by fitting a static CV model to temporally dependent cattle supply conditions).

If competition in beef packing is repeated, it makes sense to take observations of some economic variable over time as a measure of market power. Most models using this approach look at price movements over time as a measure of collusive behavior.[6] This approach moves us away from the one-period nature of CV models, and allows for a more realistic characterization of the competitive setting.

Several theoretical models of repeated competition between oligopolists show that firms may be able to collude to raise profits by basing their actions on some observable variable from the previous period (Rotemberg and Saloner (1986), Bagwell and Staiger (1997), Haltiwanger and Harrington (1991), Staiger and Wolak (1992)).[7] In order to generate these results, each of these models directly specifies firm actions, firm information sets and the timing of the game. They tell a story about what firms know and how they coordinate their actions. This leads to many different results, but the strategic choices firms make are transparent and market outcomes can be understood as the result of a particular game firms play. Studies based on conjectural variations cannot lead to such clear results, since they do not specify how the competitive process unfolds.

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[6]Alternatively, one might wish to look at throughput and how it changes over time. As far as we know, this approach has not been used to test for collusive behavior in the beef packing industry.

[7]These models are based on papers by Green and Porter (1984) and Abreu et al. (1986) who demonstrate that basing actions on previous period observations, and taking actions that do not maximize current period profits is an equilibrium to an infinitely repeated game (i.e., competition which is expected to go on forever). All of these models demonstrate that firms may not maximize single-period profits, since they are concerned about the flow of future profits, and since their competitors may punish them in future periods if they are "greedy" in the current period. If competition between beef packers fits this description, then the static CV model cannot correctly describe packer behavior.

Strategic Variables Other Than Price May Matter

Variables other than price may be important to beef packers in their attempts to be- have non-competitively. The concern here is that the CV model assumes the wrong strategic choice variable for packing firms. Schroeter and Azzam (1991) point out that packing plant size has been steadily increasing since the 1980s, which may lead to "...a breakdown in the industry's oligopolistic discipline" (page 997). This discipline may break down, they say, as plant managers become more interested in ensuring a steady supply of inputs to keep plants operating at optimal capacity. As plants expand, the need to operate at efficient scale may outweigh any benefits obtained from exploiting the market's oligopsony structure. This fact is noted by Purcell (1999) who mentions that packing plants may attempt to "smooth" through- put through the use of captive supplies. Azzam and Park (1993) also suggest that throughput may explain why the beef packing industry appears to be competitive (based on input price measures) even as the market share held by the largest four firms has more than doubled.

Contractual relations with suppliers and buyers may be an important instrument to limit fluctuations in packing plant throughput rates. Efforts to measure and understand the role of live cattle procurement through contractual mechanisms have recently appeared in the literature (Ward, Koontz, Dowty, Trapp, and Peel (1999)) but the potential impacts of contractual procurement and varying through-put rates have yet to be thoroughly explored. The implication for market power in beef packing is that research to date may be analyzing the wrong strategic decision variables, i.e., assuming firms choose quantities when in fact they choose contractual form or throughput rates. An analysis of competition-in-contracts that clearly specifies each firm's information set, available actions and timing of decisions may lead to very different results. While this added attention to detail may be viewed as a shortcoming of extensive form games, since it limits the generality of models, it may also be a strength since it can lead to new insights and directions in modeling competition in beef packing. In contrast, the CV model leads us back to the marketing margin as the only indicator of noncompetitive behavior.

Inaccurate Estimates of Market Conditions

In empirical applications of the CV model, the conjectural elasticity parameter reflects the vertical distance between the packers' marginal valuation of live cattle--the boxed-beef price minus the marginal packing cost--and the ranchers' reservation supply price. If the shape or slope of the packers' demand function, or the ranchers' supply function are misestimated, this vertical distance will be incorrect. That is, estimated conjectures depend critically on the estimates of the demand and supply elasticities, and on in-plant packing costs. If either is misspecified, conjectures may also be incorrect.

Collecting empirical data sufficient to accurately separate the component of the price-cost margin that can be attributed to market power is a difficult matter. And, misspecification of key functions can impact the empirical analysis in complex ways. The data typically available are aggregated retail market prices, prices of retail beef substitutes or other retail demand shifters, farm-gate prices, aggregate market quantity and prices of factors that are used in the in-plant processing of live cattle. Many empirical studies rely on a subset of these prices or a proxy of the prices of in-plant factor inputs. Aggregation bias and the inability of empirical functional forms to adequately characterize the structure of the in-plant cost structure can significantly reduce the inferential power of the CV approach (see Jones, Purcell, Driscoll, and Peterson (1996)). Future empirical applications of the CV methodology should consider whether the quality of aggregate data currently available is sufficient to generate reliable inferences regarding the existence market power in beef packing.

Implications For Future Analysis

Given the problems outlined in this bulletin, how might the analysis and measurement of market power proceed? What sort of testable hypotheses would arise from models of market power not based on firm conjectures? Clearly the possibilities are endless, but a sharper focus on the competitive process may prove fruitful. Consider the following examples.

One possibility is to focus the analysis on packing firm competition for live cattle supplies by considering both input prices and quantities procured. Suppose that packing firms exercise market power by setting the market price for live cattle. In this case, we would expect to see little (no) variation in the live-cattle purchase price across packers, as per-firm throughput rates vary. In contrast, if the live-cattle input market is competitive, changes in throughput should be accompanied by sharp variations in live-cattle prices. Testing such a hypothesis would involve gathering data on plant throughput, calculating the

variability of throughput rates, and regressing this variability on input price variability, changes in industry concentration and other explanatory variables. To our knowledge, such a test has not been per- formed, although Trapp (1999) concludes that throughput variability significantly affects input costs to packing plants. This suggests that the relationship between live cattle price and throughput variation is strong, and should be tested.

Another possibility involves what we call "economies of ownership." According to this hypothesis, packing plants located near each other are better able to exercise market power over feeders and ranchers if they are owned by the same firm. We thus expect to see that in locations where the boundaries of packing plant's markets overlap, throughput should become less variable (or input prices should fall) if one of the plants is purchased by the other plant's owner. One possible test of this hypothesis would involve determining the extent of each plant's market and looking for areas of overlap. One could then compare overlapping areas served by a single company (where "economies of ownership" are presumed to exist) with those served by separate companies.

Notice that both of these hypotheses are dynamic in that they involve looking at changes in variables over time. We thus avoid the criticism of estimating dynamic competition with static models. Looking at input price or throughput levels over time (as in Rotemberg and Saloner (1986) and the literature it gave rise to) would be another way to measure market power and collusion in beef packing, but these models rely on some trigger price, which is empirically difficult to discover. Thus, it may not be possible to differentiate between competitive and collusive periods in beef packing markets. Koontz et al. (1993) note that conjectures need not vary continuously from collusive to competitive periods and use a switching regression model to demonstrate that two distinct periods existed in the beef packing market. As long as one is willing to forgo actual estimates of the trigger price, it may be possible to find evidence that firms use strategies as in Abreu, Pearce, and Stacchetti (1986) to exercise market power.

Conclusions

Consolidations since the 1970s have generated much interest in potential market power in the beef packing industry. Many studies have attempted to measure market power, but most have resulted in findings of no or very limited ability of packers to exploit feeders/ranchers and consumers. Because these findings are surprising in the face of greatly increased packer concentration, studies continue to be performed.

We suggest that economists step back from the methods, in particular reduced-form modeling approaches, currently used to measure market power. We identify three potential problems of the most common method of estimating market power (conjectural variations). First, CV models are not dynamic, even though known characteristics of the beef production technology would suggest that competition in the beef packing industry is. Second, CV models rely exclusively on price as the lever firms use to exercise market power, even though there is evidence that other strategic variables such as plant capacity utilization are important to packers. Finally, empirical implementation of CV models depends critically on estimates of input supply and output-derived demand. Misspecification reduces the inferential power of the CV model.

Possibly the most promising direction for discovering alternative and more powerful tests of market power in beef packing is the development of extensive form game-theoretic models. As suggested by Fudenberg and Tirole (1987) this approach "forces economists to clearly specify the strategic variables, their timing, and the information structure faced by firms" (page 176). For example, a model of repeated competition with packing firm payoff functions that capture the value of reduced throughput variability would better characterize key features of the beef packing industry. Developing such an extensive form model and generating empirical specifications to test for market power in beef packing is a difficult task. We hope that this bulletin helps initiate these efforts.

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