The Relationship Between Industry Structure and Production Contracting:

Raising Questions at the Beginning of a Trend

by

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ABSTRACT

This study assesses the possible relationship between industry structure and the expanding use of production contracting. We propose that there are unique structural constraints in each commodity market that determine the potential for production contracting. We test hypotheses on (1) the expected positive relationship between concentration in an agribusiness industry and the extent of production contracting for the relevant commodity, (2) the expected negative relationship between the share of a commodity produced on contract and the number of products made from that commodity, and (3) the expected negative relationship between the number of commercial uses applicable to a commodity and the concentration of buyers of that commodity. We present empirical data from a small cross section of commodities that are consistent with these hypotheses. Also, we explore the significant differences between agricultural producers who enter into production contracts and those who remain independent. Based on our results, we draw preliminary inferences on the future of production contracting in American agriculture–its potential for expansion as well as its fundamental limitations.

THE RELATIONSHIP BETWEEN INDUSTRY STRUCTURE AND PRODUCTION CONTRACTING: RAISING QUESTIONS AT THE BEGINNING OF A TREND

The structure, conduct, and performance of American agriculture are continually changing. This may be most easily seen in the agribusiness sector where firms are becoming larger and more industrialized, causing industries to become more concentrated. This change in the agribusiness sector's structure is being driven partly by economies of scale. Conversely, the location-specific nature of agricultural production (which is driven by the comparative advantage of natural resources and micro-climates) is likely to prevent that sector from becoming as concentrated as the agribusiness sector, thus the current imbalance in the bargaining positions of commodity sellers and buyers is expected to get worse in the future. The structural changes leading to concentration, in turn, are likely to change the conduct of commodity markets such that the economic performance of the two sectors will be affected, with the agribusiness sector expected to benefit at the expense of the production sector. This could have serious implications for American farmers, ranchers and, possibly, consumers.

One of the ways this change in commodity market conduct is manifesting itself is through the increasing use of production and marketing contracts between agribusiness firms and farmers or ranchers. The trend of increasing contracting was slow to start, but has become more important over the last decade. The overall share of agricultural production value under contract in the U.S. has increased from 12% in 1969 to 39% in 2003 (MacDonald and Korb). As shown in Figure 1, production and marketing contracts are two methods of vertical coordination. Thus, it has long been hypothesized that the use of these contracts, especially production contracts, is an indicator of industrialization in agriculture (e.g., Mighell and Jones; Drabenstott; Ahearn, Korb, and Banker). However, the question of why different degrees of industrialization are found across agricultural markets has not been directly addressed. One of the reasons for this research void is that very little data are available at the beginning of a trend.

The general objective of this study is to contribute to the understanding of the relationship between industry structure and production contracting. In this effort we pursue two specific objectives. First, our objective is to provide a base for future research. Given the limited amount of data available at this early stage in the trend toward increased use of production contracting, we propose an explanation for what is driving that trend. Drawing from the literature, we propose that there are unique structural constraints in each commodity market that determine the potential for production contracting.[1] We conjecture that there is a positive relationship between the number of commercial uses applicable to a commodity and the number of buyers in that market, and we test hypotheses on (1) the expected positive relationship between concentration in an agribusiness industry and the extent of production contracting for the relevant commodity, (2) the expected negative relationship between the portion of a commodity produced on contract and the number of products made from that commodity, and (3) the expected negative relationship between concentration and the number of products in a commodity industry. We explain the origin of these conjectures, then we present empirical data from a small cross section of commodities that are consistent with these hypotheses.

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[1] We define "the potential for production contracting" as the share of total sales of a commodity that will be under production contract once the trend is complete in that all possible structural changes have occurred in commercial firms producing that commodity in the United States. In other words, the potential will be reached when a new equilibrium in contracting share is reached for a commodity. Each commodity has a unique potential.

Our second specific objective is to evaluate whether there are farm-level economic explanations for the trend toward production contracting. We explore significant differences between agricultural producers who enter into production contracts and those who remain independent. Thus, we raise questions about whether the trend is being driven from the top down (i.e., by industry or market factors), from the bottom up (i.e., by farm-level factors), or a combination of the two. Based on our results, we draw preliminary inferences on the future of production contracting in American agriculture–its potential for expansion as well as its fundamental limitations.

Vertical Coordination in Agriculture

This study focuses on production contracting, which is a form of vertical coordination between processors and producers. "Vertical coordination refers to the synchronization of successive stages of production and marketing, with respect to quantity, quality, and timing of product flows" (Martinez). As shown in Figure 1, a production contract offers more control to a contractor than does a marketing contract, but both types of contracts offer only partial control compared to complete vertical integration achieved through common ownership of production and marketing activities at successive stages of the supply chain. A processor firm seeking complete control would prefer vertical integration over the partial control of contracts, *ceteris paribus*. However, farmers and ranchers prefer to be independent operators (Key 2005) ideally selling their commodities in spot markets, such as auctions.[2] Thus, the actual distribution of production being sold at different points between the two end points in Figure 1 may indicate (among other factors) the relative market power of market participants.

Contracts formed between agricultural producers and processors replace traditional spot markets (called "open production" in Figure 1) for all parties involved. According to results from the USDA's Agricultural Resource and Management Survey (ARMS), contract use is expanding in the United States. The total share of production value under contract has increased from 28.9% in 1991 to 39.1% in 2003. However, there are two different categories of agricultural contracts.

Under marketing contracts, prices, quantities, and delivery schedules are agreed upon before crops are harvested or livestock are delivered. Farmers and ranchers own their commodities throughout the entire stage of production and therefore they retain control over management decisions, including those related to inputs used in production. Katchova and Miranda (p. 101) found that "personal and farm characteristics mostly affect the adoption decision rather than the quantity, frequency, and contract type decisions." Marketing contracts cover a greater share of crop production than livestock production, with 29.7% of total crop production value under marketing contracting compared to 13.7% of livestock production value in 2003. For all commodities produced in the United States, the total share of production value under marketing contracts has been about 21% since 1994 (MacDonald and Korb).

Under production contracts, the commodity buyer sets specific input specifications and typically provides inputs such as veterinary services, feed, and young animals in the case of livestock. In some cases, the buyer owns the commodity being produced from the beginning of the contract period and has managerial control over the production process. In all cases, the producer provides technical and managerial inputs plus all labor and physical facilities needed to create the specified output. Additionally, the producer's payment is not agreed upon prior to the

[2] Producers do not like selling in uncertain spot markets, but they prefer competitive spot markets to imperfectly competitive markets in which they are at a disadvantage relative to the buyers they face.

harvest but rather is determined at the end of the arrangement and is based on quantity and the degree to which the final product meets the buyer's specifications. Production contracts are much more prevalent among livestock commodities than they are among crops. In 2003 only 1.1% of total crop production value was under production contracts, compared to 33.7% for livestock. Furthermore, the share of total U.S. agricultural sales under production contracts increased from 10.6% in 1996 to about 18% in 2003, in contrast to the stable trend in marketing contracts (MacDonald and Korb). Table 1 summarizes the share of production under contract by commodity and contract type for recent years.[3] Given that producers lose some of their autonomy under the terms of production contracts, their choosing these contracts over spot markets is somewhat surprising, thus justifying a quick review of producers' motivation.

Producer Motives for Production Contracting

Over the last five decades the literature has offered a fairly consistent list of motives for farmers and ranchers to choose contracting, but there has been no consistency in opinions of which motives are most important. In 1963, Mighell and Jones identified four reasons for coordinating by nonmarket means: to increase efficiency, to obtain (or reduce the cost of) financing, to reduce uncertainty, and to gain market advantage. In 2005, Ahearn, Kolb, and Banker said the two most commonly cited reasons for entering into contracts were risk management and minimization of production and/or transaction costs. These two reasons for contracting are essentially the same as the first three listed by Mighell and Jones, with efficiency gains and financing being lumped under the production-transaction cost minimization umbrella. Some recent studies (e.g., Allen and Lueck; Boehlje and Ray; Martinez) have focused on the single explanation of transaction cost economics (Williamson 1979) and its emphasis on asset specificity as the driving force behind the decision to contract. For example, Lajili *et al.* (p. 279) found "the degree of asset specificity significantly influences farmers' choices of contractual arrangements." However, as pointed out by MacDonald, Ahearn, and Banker (p.745), "one weakness of transaction-cost analyses is that they typically don't nest market power and efficiency explanations. In Joskow's summary, they 'frequently ignore the possibility that there may be market power motivations or market power consequences for these organizational arrangements as well.'" Surprisingly, Mighell and Jones' fourth motive cited, to gain market advantage, has received the least research attention although it is argued here that it is the most likely explanation in American agriculture's current evolutionary state.

Gaining a market advantage may be easy in an industry like agriculture which has imbalances in its structure (such as having many sellers and few buyers of a commodity). For example, in 1960 Lanzillotti detailed how firms dealing with agriculture were already taking advantage of the production sector. He concluded that "leading firms possess considerable market power and are inclined to utilize such power to manage or administer their market situation" (pp 1240-1241). The result of that market power imbalance was a significant difference in the profit margins of agribusiness firms and agricultural producers. In other words, gaining market power facilitates taking actions that improve a firm's profit margins, thus providing the strongest of incentives to seek bargaining power. As a result, it is surprising that relatively little empirical research was done to sort out the relationship between industry

[3] In the empirical analysis of this study, survey data are used in which the distinction between production and marketing contracts is made by survey respondents. The survey asks producers questions about both production and marketing contracts, but there is no way to know how those contract types are being interpreted. At this point in the trend of increasing contracting, the definitions of contract types are not standard.

structure and market power. By 1986 the story was still unsettled, as reported by Schrader (p. 1161):

> "The relation of integration or nonmarket vertical coordination to market power has two interpretations. Integration and contract coordination are viewed by some as a means to enhance the integrator's market power. Others see market power on one side (or both sides) of a market as an incentive for vertical arrangements to capture gains from the side possessing market power or to achieve joint profit maximization."

The uncertainty was still apparent in 2005 when Ahearn, Korb, and Banker reported on the increasing concentration in agriculture and agribusiness and noted that "it is not obvious whether this concentration is the desirable result of cost efficiencies in production or the undesirable result of market power on the part of various players in the supply chain," citing the question raised by Williamson (1968). Thus, more research is needed on the influence of agricultural market structure on conduct such as contracting.

There is little literature dealing directly with the recent rise in production contracting. This is due partly to the scarcity of data on contracting (Ahearn, Korb, and Banker). A review of the scant literature points to three possible explanations for the increased share of production under production contracts. These are risk aversion, the increase in processor concentration in U.S. agribusiness, and the increase in the total scale of agricultural production. While risk management is virtually undisputed in the literature as a catalyst for contracting in general, MacDonald *et al.* and Key (2004) stress that it should no longer be considered the sole motivating factor for farmers in choosing production contracts. The respective causal relationships between the increase in processor concentration and the increase in the scale of production with production contracting are less clear, but it is proposed here that concentration and size lead to market power that is used to expand contracting.

A defining characteristic of the ongoing transformation of U.S. agriculture may be the rise in concentration in the food manufacturing industry (Ollinger *et al.*). According to data from the USDA, the mean industry four-firm concentration ratio (CR4) in food manufacturing has risen from 35% in 1982 to 46.1% in 1997.[4] The rate of increase in concentration for the meatpacking industry, in which there is also the highest degree of production contracting, significantly outpaced agriculture as a whole. The meatpacking CR4 increased from 29% to 57% over this time period. This trend continues in various processing industries. For example, the CR4 of U.S. beef packers was estimated at 81% in 2002 and the CR4 for pork packers in 2002 was found to be 64%. The last four columns of Table 2 present CR4 data for a cross section of commodities over time.

Given that commodity producers have a strong preference for autonomy (Key 2005), the observed increase in processor concentration suggests that bargaining power on the part of farmers and ranchers is decreasing, thus fueling the trend in production contracting. This certainly appears to be the case in the hog industry where producers who value autonomy less than they fear the risks of being without a contract eagerly adopt contracts (Davis and Gillespie). However, there are exceptions to this argument. For example, the soybean processing industry saw an increase in concentration from 1982 to 2002, yet only a small portion of total soybean production is under any form of contract, as indicated in Table 1. The broiler industry has by far

[4] CR4 is the concentration ratio measured using sales data from the four largest firms in the industry. It is the percentage of total industry sales revenues that are accounted for by the four largest firms. CR8 and CR20 are also used in some analyses.

the largest share of production under production contract, yet among livestock commodities it has both the lowest CR4 and the slowest growth in concentration over the comparable time period.

Producer concentration is also on the rise in U.S. agriculture. According to USDA data, the percentage of farms in the United States with annual sales of $500,000 or more has increased from 2% in 1991 to 4.4% in 2001. More strikingly, these farms' share of total agricultural production increased over this period from 39% to 57.4%. Examining individual commodities, Rios and Gray determined that the share of industry total sales from farms with annual sales of $500,000 or higher increased from 10.9% to 77% for hogs from 1982 to 2002. Production contracting is relatively very high for hog production, even though the rate of growth in hog producer concentration significantly outpaced the equivalent numbers for commodities with low production contracting, such as wheat, corn, and soybeans. Just as increased processor concentration implies increased buyer bargaining power, increased producer concentration would normally suggest increased seller bargaining power. However, concentration of hog producers may be an outcome caused by the trend of processors offering contracts most often to larger producers only. Thus, the hog industry case indicates there are some commodity-specific factors influencing the level of production contracting and the direction of causality in that contracting (Key and McBride).

Due largely to the location specific nature of agricultural production, the food manufacturing sector is likely to consolidate faster than the commodity production sector. That is what happened in the United Kingdom (Duranton and Overman). However, concentration in the American manufacturing industry is not the primary determinant of the pattern of production contracting, particularly when considering the current trends in producer concentration. Clearly, many factors are significant, as noted below.

Key (2004) examined the supply side of agribusiness by evaluating the relationship between the scale of production and contracting. The scale of production, as measured by changes in the size and output of the largest farms by sector, was found to be directly correlated with the prevalence of contracting. Explanations offered by Key for this correlation included the usual stories of grower risk aversion and contractor transaction costs, as well as newer theoretical justifications such as asset specificity.

Finally, another possible determinant of contracting is the growth of production contracting itself. Recent research suggests that farmers in some commodity markets are turning to contracting out of necessity due to the incomplete markets created by other market participants' decision to contract (Young and Burke). Roberts and Key demonstrated that in some markets, farmers who choose to engage in production contracts could impose negative externalities on other farmers in the form of increased search and transaction costs. The farmers facing the externalities are induced to enter into contracts, which they would not have done otherwise, because contracts may represent the only available access to a buyer. This finding is consistent with the idea that spot markets have "tipping points" at which a market is thinned enough to induce all remaining participants to enter into contracts (MacDonald *et al.*).

It is clear from the literature that questions still remain as to the principle determinants of production contracting in agriculture. Also, much is yet unknown regarding the effects of contracting on producers, agribusiness, and consumers. Yet, it is understood that contracting has played a large role in improving product consistency and traceability throughout the stages of food production (MacDonald *et al.*). Furthermore, research has shown that contracting has a positive effect on farm productivity (Ahearn, Yee, and Huffman; Key and McBride; Morrison

Paul, Nehring, and Banker). There remain concerns over the effects on farmers who enter into contracts against their best interests (Roberts and Key), and the managerial control imposed on farmers by the processors with whom they contract (Farm Foundation). However, much of the rise in production contracting has occurred in just the past decade, suggesting that it may take years for the large-scale effects of production contracting to become evident in empirical analyses across a wide range of commodities.

Structural Constraints on the Development of Production Contracting

It is proposed here that the relationships between the extent of production contracting and both industry structure and market diversity can be represented as a continuum and that each commodity can be plotted at some point on that continuum. Shown in Figure 2, this continuum is based on the hypothesis that product attributes of each commodity influence the structure of the processing/manufacturing industries which can develop for that commodity and, in turn, the structure of those industries affect the extent of production contracting that will ultimately be seen at the farm/ranch level.

To explain the continuum and its underlying hypotheses, we begin at the top of Figure 2. The top line of the four lines in the figure represents the range of possible shares of total production of a commodity that could be contracted. The ends of the line are labeled "low" and "high" (which could be labeled "zero" and "100%" in this case), thus the points along the line indicate that there is a continuous range of possibilities. The second of the four lines in Figure 2 represents the level of concentration in the agribusiness industry related to the commodity. The fact that the same ends of the second line are labeled "low" and "high" as is the case for the first line illustrates one of the main hypotheses of this paper: there is a positive relationship between the (potential) level of production contracting and the level of concentration in the agribusiness industry that buys the commodity from producers.

The third line in Figure 2 represents the number of agribusiness firms buying a commodity. By definition, there is an inverse relationship between the number of firms in an industry and the level of concentration in that industry. Thus, the third line has labels of "low" and "high" at opposite ends relative to the first two lines. That illustrates the hypothesis of a negative relationship between the number of buyers available to producers of a commodity and the (potential) share of total sales of that commodity which is production contracted.

The fourth line in Figure 2 represents the number of products made from the commodity. The physical attributes of a commodity determine how many different products can be made from it. Some commodities, such as wheat, can be made into a large number of products while other commodities, such as tobacco, can be processed into only a few products. It is expected that the more products derived from a commodity, the more firms there will be buying the commodity from producers, hence the positive relationship illustrated in the figure. Also, it is hypothesized that if there are a high number of products made from a commodity, producers will generally have more buyers to choose from, hence giving those producers more bargaining power. With that bargaining power, producers may be more likely to avoid production contracts, if possible. Thus, it is hypothesized that there is a negative relationship between the number of products made from a commodity and the share of that commodity's output that will be under production contract.

Each agricultural commodity has a unique set of physical attributes and a unique industry which has developed to process the commodity into various products, thus it is expected that each commodity would be plotted at a unique point along the continuum. In other words, it is

proposed here that each commodity would fall on a single point along the continuum and, as a group, the array of commodities produced would be distributed along the continuum as determined by the composition of each industry. Each commodity would fall on the same horizontal point on each of the four lines making up the proposed continuum. So, for example, broilers are expected to be plotted far to the right on the horizontal lines of the continuum. A very low number of products are made from the livestock commodity and the low number of buyers (i.e., broiler processing firms) means the agribusiness industry has a high degree of concentration, all leading to the expectation of a high share of broiler production (potentially) being under contract. Wheat, on the other hand, is expected to fall on a point far to the left on the continuum, while most commodities will fall between these two examples.

Methodology

The analysis in this study, in general, is limited in its ability to test the ideas embedded in the Contracting Continuum presented in Figure 2. The evolutionary shift in market conduct which is creating the changes in production contracting is at such an early stage that data are very limited. Too little data means the conjectures derived here using induction can only be turned into propositions by preliminary analysis. Future testing, once adequate data are available, will be required for a thorough assessment of the hypotheses raised.

The two specific objectives of this preliminary analysis require very different methodologies. Strong-form tests of the hypotheses underlying the continuum shown in Figure 2 would require data from a large cross section of commodity markets but, as Ahearn, Korb, and Banker point out, the major rise in production contracting has occurred within the last decade, so data are scarce and hypothesis testing is difficult.[5] Therefore, this study uses two approaches to drawing inferences on the future of production contracting in the United States. First, weak-form tests of the industry-level hypotheses underlying the continuum are conducted with the limited data available. Second, farm-level data across a small cross section of commodities are used for strong-form tests of differences between producers that production contract versus independent operators (i.e., those producers of a commodity who do not participate in a production contract).

To begin, industry-level data are used to test three of the basic hypotheses underlying the continuum illustrated in Figure 2. Those hypotheses are (1) there is a positive relationship between the share of a commodity which is production contracted and the level of concentration in the agribusiness industry which buys the commodity from producers, (2) there is a negative relationship between the share of a commodity contracted and the number of products made from that commodity, and (3) there is a negative relationship between the number of products and the concentration of firms buying that commodity. Weak-form tests are conducted using simple regressions with data from the 14 commodities listed in Table 2. These commodities represent a cross section of major crop and livestock industries.

The exact numbers of buyers in a market and products made from a commodity both vary over time and are subject to measurement error, therefore a proxy is used for this national-level analysis. We derive a "commodity usage index" using the number of product categories processed from the commodity and the share of the commodity going into each of the categories.

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[5] What we call a "strong-form" test is one that is conducted on adequate data using appropriate procedures that give results sufficient to support or reject the hypothesis. A "weak-form" test is conducted with limited data, thus limiting the power of its results. Weak-form test results that are not consistent with a hypothesis may be used to reject that hypothesis, but weak-form results that are consistent with the hypothesis are a necessary, but not sufficient, condition to ultimately support the hypothesis.

Our usage index is a type of buyer concentration index calculated like a Herfindahl index. Normally, a Herfindahl index is a measure of the size of firms in relation to the industry and an indicator of the amount of competition among them. In this study, our commodity usage index is an inverse measure of the number and market share of products made from a commodity. The index is defined as the sum of the squares of the shares of the commodity going into each processed product category. As such, it can range from 0 (indicating there are a very large number of product categories) to 1 (indicating there is a single product). The index is expressed as

$$H = \frac{1}{n} + nV \tag{1}$$

where n is the number of product categories and V is the variance of the shares (s) of the commodity going into each category, defined as

$$V = \frac{\sum_{i=1}^{n} (s_i - 1/n)^2}{n} . \tag{2}$$

If all product categories have equal shares (in which case $s_i = 1/n$ for all i), then V is zero and H equals $1/n$. If the number of product categories is held constant, then a higher variance due to a higher level of asymmetry between category shares will result in a higher index value.

The Commodity Usage Index for each commodity was calculated using industry-product data from the 2002 Economic Census of manufacturing industries conducted by the U.S. Department of Commerce (shown in the appendix table). The index is based only on commodity flows to manufacturing, excluding other buyers such as export purchasers and intracommodity purchases. As an example, the index for cotton was calculated as follows. First, the census listed cotton as having three categories of use, hence n was assumed to be 3. Those product categories (proxying for separate firms) and their respective shares of total purchases for the commodity were "apparel" 0.247, "home furnishings" 0.545, and "industrial" 0.206 (these values are rounded, thus they do not total 1.0). Substituting 3 for n, and the three share amounts for s, into the equations gives a Usage Index of 0.40 for cotton.

The second portion of our analysis uses farm-level survey data to test several hypotheses about the size, structure, and financial position of production operations. We compare producers who have production contracts with those who remain independent. Based on the literature (e.g., Key 2004; Roberts and Key; Morrison Paul, Nehring, and Banker) we hypothesize that farmers entering into production contracts are likely to be larger than independents, significantly less diversified in terms of commodities produced, and facing increased risk, relative to the risk exposure of independents. We conduct independent-sample t-tests of these and related hypotheses for a cross section of commodities. Using pooled farm-level data from the USDA's Agricultural Resource Management Survey for the years 1996 through 2004 (USDA/ERS) gives us a total of 95,517 observations.

Industry-Level Results

At least two of the three hypotheses underlying the continuum shown in Figure 2 are supported by the limited cross-sectional data. Table 2 presents data on the number of products made from the commodity (proxied by the Commodity Usage Index) and the agribusiness

industry's concentration, and Table 4 (to be discussed later) presents data on the share of the commodity under production contract. Simple regressions[6] indicate that two hypothesized relationships have the correct sign and the other is inconclusive. To begin, the correlation between the share of contracting and industry concentration (r = -.12) is not significantly different from zero (the t-statistic is 1.43) due to limited data on contracting for most commodities. Thus, this result needs data from additional commodities to provide the degrees of freedom needed for a stronger test.

The second hypothesis suffers from the same contracting data limitation, but has significant results. Using only the cross-section of five commodities in Table 4, the correlation between contracting share and the number of products made from the commodity (r = 0.85) is positive, which indicates a negative relationship between the two factors, as expected (due to way the Usage Index is calculated). This correlation is significant with a t-statistic of 3.59.

The third hypothesis was tested with the Usage Index and 2002 concentration data for 13 of the commodities listed in Table 2.[7] The correlation coefficient of .22 was positive (due to the inverse nature of the Usage Index) and significant with a t-statistic of 6.81.

These three correlation results are only weak-form tests because so few observations (i.e., commodities) are available at present. However, it is expected that as more commodities are studied and as more of the potential for production contracting materializes, the continuum relationships will strengthen and become more apparent in empirical data. In the meantime, we focus on the more-plentiful farm-level data to detect factors influencing the decision to contract, and the effects of contracting on the structure of commodity industries.

Farm-Level Results

The share of total sales (or value of production)[8] under production contract varies greatly among commodities in the United States. We examined 14 major U.S. commodities for which adequate data were available and found that a continuum exists with regards to production contracting, ranging from virtually all production being under contract for broilers to no production contracting in the case of tobacco. Also, previous research has found significant differences between producers that enter into production contracts and those that remain independent (Key 2004).

Patterns across both commodities and producers emerge from the survey data we evaluated. Table 3 provides farm-level descriptive statistics for eight of the agricultural commodities examined in this study.[9] For all of those commodities the producers operating under production contracts have higher average total sales value than do the independents producing the same commodity. This result supports previous research (e.g., Key 2004) which found that production contracts, and contracting in general, is more prevalent among larger producers. The average total household income statistics in Table 3 tell a similar story. Average incomes are higher for contractors of most commodities, however, in the cases of broilers and

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[6] These regressions between two variables were estimated with the intercept defined to equal zero so the regressions are, essentially, tests of correlation between the variables. This method gives a finite t-statistic that enables us to determine whether the correlation is significant given the limited degrees of freedom.

[7] Dairy was dropped because it is defined as a processed product, not a commodity, as are the other products.

[8] It may be more appropriate to use the term "value of production," rather than "sales," because for production contracts, especially livestock contracts, the grower does not own the output.

[9] Peanuts, oats, barley, rice, and cotton were dropped because there were too few contractors in the data; tobacco is omitted because, although a majority of total tobacco output is under contract, surveyed growers reported that they use marketing contracts rather than production contracts.

sugar beets, production contractors have lower total household income than the independent producers, on average. In those two cases, the operations under production contract have significantly lower "profit margins" than independent operations despite having significantly higher total sales value.[10] In other words, a smaller share of total farm sales revenues (values) are captured as income by average broiler or sugar beet operations under production contracts, compared to average independent producers of those commodities.

The differences in household incomes and "profit margins" between contractors and independent producers of broilers is particularly interesting given that broilers have the highest level of contracting among all commodities. Also, the hog market is second only to broilers in terms of the percentage of sales under production contracts and hog contractor total sales values are triple those of independents, on average, yet contractors report total earnings only 4% higher than independents. These results are important, given that they are from the two commodities with the greatest percentage of producers contracting. They suggest there may be significant differences in "profit margins" between producer groups, thus indicating the need for additional research to determine whether production contractors in these industries are receiving lower average prices (i.e., unit values) than independent farmers for identical outputs, or whether contractors may have higher average costs of production.[11]

For nearly every other commodity in Table 3, the average total household income is higher for contractors than independents, and independents also earn a noticeably greater share of their income from off-farm sources. This suggests that when only a few producers are contracting, they tend to be large operations that specialize in the commodity and, as a result, are relatively more profitable than independent producers of the same commodity. This might be partly due to the stronger bargaining position of those large producers in an industry with little contracting going on. For example, wheat contractors, though very few in number, derive a relatively high amount of annual income ($197,309) from their total sales values ($604,476). Independent wheat producers' average "profit margin" is far lower. This result indicates that the terms of production contracts may be financially beneficial to the handful of wheat producers (who may be offering a higher quality product), which is not the case for producers of commodities for which production contracting is the market norm, like broilers.

Some of the commodities in Table 3 were evaluated in more detail to enable formal tests of hypotheses about differences in farm characteristics between production contractors and independent producers.[12] Table 4 presents various statistics, by commodity, and the results of independent-sample t-tests of differences in the reported average values for the two groups. Several patterns appear across the results, as described below.

The first hypothesis tested is that production contractors have a higher per farm output of

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[10] The "profit margins" are calculated simply as income from farm operations as a percent of total farm sales values. Farm operation income is not presented in Table 3 to save space, but it can be calculated using the other data presented for each commodity and producer group. For example, total household income for sugar beet contractors is a small amount–approximately one-tenth of the amount earned from off-farm sources–because about nine-tenths of off-farm income is needed to cover the losses from farming operations, on average. Independent sugar beet growers, on the other hand, have strong profit levels, on average.

[11] No price or cost data are analyzed here because it is beyond the scope of this paper. However, for profit *margins* to differ between producers of a commodity, there must be a difference in either average prices (unit values) received, costs incurred, or both. These hypotheses need to be tested for each commodity separately.

[12] Some commodities in Table 3 were not included in this analysis because the small number of farmers under production contracts made statistical tests difficult. Also, sufficient data were not available on the various farm-level variables to allow for the inclusion of sugar beets, despite the relatively high percentage of farmers using production contracts.

the relevant commodity than do independent operators. The results are shown in the two rows labeled "sales value of the commodity" in Table 4. The values are the annual average sales of only the commodity of interest, not total farm sales. For example, of the operators surveyed who produce broilers, those with contracts covering broiler production averaged $675,979 in broiler sales value annually from 1996-2004. In contrast, independent broiler producers sold only $27,513 worth of the commodity annually, on average. For all of the commodities listed in Table 4, contractors produce significantly greater quantities per farm than do independents, on average. Also, in each case the t-test indicates that the difference in average sales is statistically significant, thus supporting the hypothesis. One implication of this result is that having a production contract may encourage operators to expand the scale of their output of the contracted commodity, although the direction of causality could be the reverse; producers who want to go large-scale adopt contracts to share risk, reduce transaction costs, and share managerial responsibilities.[13]

The result above leads to a second hypothesis, that producers with production contracts will be more specialized, less diversified, in their commodity output. Diversification is a tool used by producers to reduce risks, so the implication is that having a production contract substitutes for diversification as a risk management tool. In Table 4, the commodity share of total sales is used as a measure of specialization. For all the commodities listed, contractors get a higher share of their total sales from the contracted commodity. As anticipated, livestock contractors are significantly less diversified than are independent producers. Moreover, as the percentage of producers engaged in production contracts increases among livestock commodities, the degree of diversification decreases. These results support the hypothesis, especially for livestock producers.

The limited data available here do not make it possible to directly test whether or not livestock producers are yielding net economic benefits from production contracts. However, the statistics in Table 4 show that among livestock commodities average total income and average farm net worth for contractors decrease in both absolute terms and relative to independent producers as the share of production contracting increases and diversification decreases. Both broiler and cattle producers earn the majority of their total household income off the farm, in contrast to independents. The debt-to-asset ratio is a commonly used measure of financial risk for producers, and livestock contractors have a significantly higher ratio than do independent producers. In general, these results indicate that livestock operations using production contracts are larger, but less profitable, than independent operators and face slightly more financial risk. However, these observations vary inversely with the physical size of the animal involved, applying most strongly to broilers and to a lesser extent to hogs and then cattle.

Crop producers using production contracts are less diversified than are independents, on average, but the differences between the two categories of producers are smaller in the case of crops than they are between livestock producer categories. Also in contrast to the relationships governing livestock production, crop contractors typically have significantly greater household income and net worth than do independents, plus significantly smaller shares of income coming from off-farm sources. Finally, crop contractors have lower average debt-to-asset ratios than

[13] The risk-reducing character of production contracts may enable producers to comfortably expand their operations to achieve economies of scale. For example, Key and McBride found that for hog producers the use of production contracts is associated with a substantial increase in factor productivity, and represents a technological improvement over independent production.

their independent counterparts.[14]

The most readily apparent difference between the livestock and crop commodity markets is that production contracting is a less popular choice among crop producers, as noted in the existing literature. Among most of the crop commodities in Table 2, the percentage of farmers using production contracts is less than one percent.

Crop contractors produce significantly greater quantities of the commodities contracted than independents, as was true in livestock markets, but the average differences are considerably smaller in magnitude. Among crop contractors, commodity sales values exceed those of independents by 55.5% on average, while the equivalent margin for livestock producers is 94.0%. In turn, crop contractors are more specialized than are independent crop producers, but crop contractors are more likely than livestock contractors to rely on some combination of contracting and diversification to manage risk.

Formal hypothesis testing on the financial net benefits of contracting is not possible with the limited data available, but our preliminary empirical results suggest that crop contractors reap greater benefits from production contracting than do livestock contractors. This may reflect the difference in producer bargaining power in livestock versus crop markets, with crop producers having more products made from their commodity, thus having more buyers available to them than do livestock producers. Risk, as measured by the debt-to-asset ratio, appears to be a significant motivating factor in favor of using production contracts in the case of livestock producers, but the same cannot be said for crop producers. Finally, these and other circumstances have changed across commodity markets over the past decade as markets have become increasingly concentrated, especially within the livestock sector. Thus, this study has raised many hypotheses to be tested in the future as more data on production contracting become available.

Concluding Comments

This paper proposes answers to some of the questions being raised about the trend of increasing use of production contracts in American agriculture. The answers are embodied in a proposed continuum of commodity contracting potential. The continuum draws its name from the fact that different commodities have different potential maximum shares of producer output that will fall under production contracts with buyers, thus individual commodities can be plotted at points along a horizontal continuum ranging from zero to 100% of output being contracted. It is argued here that the contracting potential for any commodity is related to the industry structure of the agribusinesses buying the raw farm output, and that structure is related to the number of products into which the commodity is processed. Since each commodity has a unique set of physical attributes, the number of products derived from it will be unique, thus leading to a unique industry structure and, ultimately, a specific potential for production contracting.

It is argued here that one factor in determining what share of output actually *is* production contracted is the relative amount of bargaining power held by commodity producers and their buyers. Research dating back to the 1960s shows that agribusiness firms use production contracts as a tool in vertical coordination of markets and, if possible, those firms will exert their bargaining power to improve their profitability. On the other side of the market, commodity producers prefer to remain independent, as shown in recent research. Thus, the degree to which production contracting is used may depend on which side has more bargaining power. For

[14] The difference is significant only in the case of soybean producers because the small number of contracts in the other markets provide too few degrees of freedom for significant t tests.

example, in a market for a commodity like wheat, where producers may have some bargaining power because there are many buyers needing the commodity, a few producers are willing to give up some of their independence only when they are rewarded financially. Thus, the first few wheat producers agreeing to production contracts expect benefits that exceed the costs. In other markets, such as for hogs, shifts in industry structure over time gave buyers (i.e., anyone buying hogs from a hog producer) more bargaining power, which led to higher shares of output being production contracted because some producers have access to no other types of buyer. Eventually, expanding use of production contracts make spot markets increasingly incomplete until they reach a "tipping point" beyond which producers are virtually forced to enter into contracts because of negative externalities imposed upon them by the thinning of the spot markets (Roberts and Key). The broiler and hog markets each show signs of this being the case.

The preliminary empirical results here generally show that production contracts lead to production specialization which, in turn, may reduce off-farm income opportunities, both of which can increase the income risk of producers. This is an important observation because it contradicts one of the main arguments used to justify production contracting. Proponents of contracting and much of the theoretical literature have said that producers can use contracts to reduce some types of risk, which is true. The idea that income risk might increase under contracts deserves future research attention.[15] In general, the empirical results of this study are consistent with the hypothesis that commodity producers with some bargaining power (e.g., wheat growers) may earn higher average incomes under production contracts than independent producers of the same commodity, but profitability falls for producers in other commodity markets (e.g., broilers) where buyers have relatively more bargaining power. Future research is needed on the causality of the relationships involved.[16]

It has been argued in the literature that buyer bargaining power increases with industrialization and that the potential for industrialization is influenced by a commodity's physical attributes (e.g., Sheldon). In particular, it has been well established that livestock processing industries have scale economies that encourage continued industrialization and that the resulting industry concentration of the last few decades has facilitated increased use of production contracts in those markets (Ahearn, Korb and Banker; Bhuyan; Drabenstott; Key 2004; MacDonald and Korb; Morrison Paul). In crop industries, however, production contracting is rare in most markets, although marketing contracts cover a majority of output in some markets (MacDonald and Korb). These differences across commodity types were apparent in the analysis here and raise questions for future research.

Looking to the future, the results of this preliminary study indicate that production contracting is likely to continue expanding to cover a higher share of total output for many commodities. This is an incentive for producers to form cooperatives or to use some other type of collective selling arrangements. However, cooperatives, bargaining associations, and other selling arrangements employ a type of production contract with supplier-members. Therefore, all trends indicate it may be increasingly difficult for producers to maintain their independence in the industrialized agriculture of America's future.

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[15] The potential for income risk to increase under contracts was evident in two case studies conducted by the authors (but not reported due to space limitations). One livestock (hogs) and one crop (soybeans) commodity were evaluated over the 1996-2004 time series of annual average data available here. In both cases, the standard deviation of net farm income over time was higher for contractors than it was for independent producers: for hogs it was $48,260 versus $15,016, respectively, and for soybeans it was $110,488 versus $15,462.

[16] In individual cases, it is quite likely that having a production contract leads to production specialization, and in other cases having specialized production leads to production contracting (to reduce risk).

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Figure 1. Methods of Vertical Coordination Along the Spectrum of Control

Control offered to contractor or integrator

Least			Most
Open production	Marketing contract	Production contract	Vertical integration

Source: Mighell and Jones

Figure 2. The Continuum Relating Contracting, Industry Structure and Market Diversity

Contracting:
← Potential share of production contracted →

Low	High

Industry Structure:
← Concentration of agribusiness industry →

Low	High

Industry Structure:
← Number of buyers of the commodity →

High	Low

Market Diversity:
← Number of products made from the commodity →

High	Low

Table 1. Share of total agricultural sales by commodity, contract type, and year, 1991-2003

Item	1991-93	1994-95	1996-97	1998-2000	2001-02	2003
Commodities Produced under Marketing Contract			*Share of Total Sales (%)*			
All Commodities	17.0	21.2	21.5	20.4	19.7	21.7
Crops	22.8	24.0	21.1	22.5	24.7	29.7
Corn	10.2	13.8	12.9	12.6	14.7	13.8
Soybeans	9.6	9.8	13.2	9.7	9.5	13.6
Wheat	5.8	6.2	9.0	6.9	6.4	7.5
Sugar Beets	88.5	83.7	74.6	83.1	95.8	95.1
Rice	19.7	25.2	25.8	30.5	38.6	51.8
Peanuts	45.2	58.3	34.2	44.9	27.9	53.3
Tobacco	0.3	0.6	0.3	1.9	52.6	54.8
Cotton	30.4	44.4	33.8	42.9	52.6	50.9
Fruit	N/A	61.0	54.3	63.3	60.1	67.2
Vegetables	N/A	45.3	32.3	27.3	31.5	36.4
Other Crops	6.3	14.0	18.7	21.2	30.9	44.7
Livestock	11.6	18.2	22.0	18.4	14.5	13.7
Poultry and eggs	5.9	3.4	4.0	3.9	4.2	1.1
Hogs	N/A	2.4	2.7	9.1	6.1	6.8
Cattle	N/A	4.3	5.9	4.6	2.7	3.4
Other Livestock	0.1	6.8	4.9	10.7	3.5	7.4
Dairy	33.6	56.7	58.0	53.4	48.0	50.5
Commodities Produced under Production Contract			*Share of Total Sales (%)*			
All Commodities	11.8	13.0	10.6	16.9	18.0	17.5
Crops	1.9	1.9	1.8	4.2	3.1	1.1
Vegetables	N/A	9.7	6.1	12.4	10.6	6.3
Livestock	21.1	24.7	22.9	29.6	33.8	33.7
Poultry and eggs	82.8	81.2	80.1	84.9	88.1	87.2
Hogs	N/A	28.7	31.5	46.0	56.5	50.4
Cattle	N/A	14.7	11.1	19.7	18.3	25.4
Other Livestock	0.1	2.6	N/A	N/A	5.5	N/A
Dairy	0.2	0.2	0.1	0.2	0.7	0.6

Source: MacDonald and Korb.

Table 2. Commodity Usage Index and Industry Concentration

Commodity	*Commodity Usage Index*	*CR4 1987 %*	*CR4 1992 %*	*CR4 1997 %*	*CR4 2002 %*
Broilers	0.47	29	34	56	54
Hogs	0.52	20	25	64	68
Cattle	0.43	39	50	84	86
Dairy	0.80	21	22	21	30
Soybeans	0.18	71	71	75	95
Corn	0.19	74	73	80	69
Wheat	0.19	44	56	62	49
Oats	0.61	27	33	64	70
Barley	0.37	19	23	46	87
Rice	0.47	41	51	69	57
Cotton	0.40	18	19	20	26
Sugar beets	0.98	83	85	85	85
Peanuts	0.39	68	80	82	87
Tobacco	0.84	70	76	83	89

Notes: The commodity usage index is a buyer concentration index calculated by the authors as a Herfindahl-type index using the number and share of the major product categories for each commodity. "CR4" is the concentration ratio reported by the US Census Bureau for the major product category for the year indicated. The sources for the CR4 and for the data used in the usage index calculations are the Census Bureau's *2002 Economic Census*, and numerous personal communications. The list of personal communication sources included government agencies, industry groups, and academic institutions, shown here:

NASS contacts: Bruce Boess, Benita Hodge, Michael Miller, Benita Hodge, Don Gephart, Anthony Prillaman

ERS: Kenneth Mathews, William Chambers, Allen Baker, Linwood Hoffman, Erik Dohlman, Janet Livezey

Iowa State University: John Lawrence

Industry sources: National Pork Producers Council, National Pork Board, National Cattlemen's Beef Association, North American Millers' Association (contacted the Washington DC and California offices), National Peanut Board, Peanut and Tree Nut Processors Association

Table 3. Summary of Average Farm Results by Commodity, Production Contractors and Independents, 1996-2004 ARMS Data

Commodity	*Number of Producers Surveyed*	*Total farm sales ($)*	*Total household income ($)*	*Off-farm share of income (%)*
Broilers				
Contractors	4,065	909,943	71,003	58.2
Independents	648	626,224	190,669	23.3
Hogs				
Contractors	1,708	1,329,973	104,172	33.4
Independents	4,912	435,290	99,694	39.4
Cattle				
Contractors	426	2,839,963	158,876	21.4
Independents	49,740	395,561	86,188	53.0
Dairy				
Contractors	29	1,720,092	290,274	6.1
Independents	11,490	792,975	115,347	20.1
Soybeans				
Contractors	155	528,445	125,191	26.3
Independents	29,615	453,176	101,333	38.5
Corn				
Contractors	97	558,902	166,548	28.3
Independents	27,755	458,739	96,204	40.3
Wheat				
Contractors	27	604,476	197,309	16.9
Independents	21,762	470,876	98,457	39.0
Sugar beets				
Contractors	46	1,510,000	2,810	980.1
Independents	1,459	772,418	96,235	29.3

Appendix Table: Commodity Usage Data (product market segment and share), 2002

Commodity	*Product segment*	*share*
Broilers	Whole/cut	0.622
	Prepared meats	0.115
	Products	0.263
Hogs	Direct	0.68
	Prepared	0.11
	Products	0.21
Cattle	Direct	0.56
	Prepared	0.13
	Products	0.31
Dairy	Liquid	0.89
	Other	0.11
Soybeans	Whole soybeans	0.12
	Mill Feed	0.092
	48% Soybean Meal	0.336
	Soybean Protein	0.0904
	Soy Flour	0.103
	Lecithin	0.079
	Soybean Oil	0.088
	Soybean Flakes	0.0916
Corn	Glucose	0.083
	Starch	0.1051
	Fuel	0.4973
	Beverage	0.049
	Cereals	0.0709
	HF Corn Syrup	0.1933
Wheat	Bread	0.297
	Pasta	0.134
	Sweets	0.207
	Feed	0.155
	Seed	0.102
	Industrial Use	0.105
Oats	Feed	0.49
	Food Products	0.327
	Industrial Use	0.074
	Other	0.109
Barley	Malt	0.73
	Feed	0.27
Rice	Direct Food	0.627
	Processed	0.224
	Beer	0.148
Cotton	Apparel	0.247
	Home furnishings	0.545
	Industrial	0.206
Sugar beets	Sugar	0.99
	Other	0.01
Peanuts	Snack	0.232
	Peanut Butter	0.535
	Peanut Candy	0.215
	Other	0.018
Tobacco	Cigarettes	0.91
	Cigars	0.01
	Snuff	0.08

Source: Census Bureau's *2002 Economic Census*

Table 4. Production Contracting in American Agriculture, Summary of Average Results per Farm, 1996-2004

	Commodity				
	Broilers	**Hogs**	**Cattle**	**Corn**	**Soybeans**
Total number of producers surveyed	4,713	6,620	50,166	27,852	29,770
Farmers who Production Contract (%)	86.3	25.8	1.04	0.36	0.52
Contracting share of commodity sales (%)	95.5	78.7	18.6	0.77	1.44
Sales value of the commodity, Contractors ($)	675,979***	753,164***	631,546***	201,558***	130,994***
Sales value of the commodity, Independents ($)	27,513	70,979	29,023	60,171	46,772
Total farm sales, Contractors ($)	909,943***	1,329,973***	2,839,963**	558,902**	528,445**
Total farm sales, Independence ($)	626,224	435,290	395,561	458,739	453,176
Commodity share of total sales, Contractors (%)	74.3***	56.6***	30.5***	36.3***	24.8
Commodity share of total sales, Independents (%)	4.1	15.6	7.3	8.8	17.2
Total household income, Contractors ($)	71,003***	104,172	158,879***	166,548**	125,191*
Total household income, Independents ($)	190,669	99,924	86,189	96,204	101,333
Off-farm share of income, Contractors (%)	58.2***	33.4	53.04***	28.3**	26.3*
Off-farm share of income, Independents (%)	23.3	39.4	21.4	40.3	38.5
Farm net worth, Contractors ($)	698,145***	894,956	981,894	1,220,000*	1,010,000*
Farm net worth, Independents ($)	899,987	940,565	975,049	939,469	882,686
Debt-to-Asset ratio, Contractors	0.26***	0.24***	0.31***	0.22	0.26**
Debt-to-Asset ratio, Independents	0.14	0.18	0.18	0.31	0.53

Data source: the U.S. Department of Agriculture's Agricultural Resource Management Survey for the years 1996 through 2004.

***, **, * indicates a statistically significant difference between the mean values for producers who contract versus independent producers at the 99%, 95% and 90% confidence levels, respectively.