A CENTURY OF RESEARCH ON AGRICULTURAL MARKETS

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This article provides a perspective on major innovations in research on agricultural markets over the past century. We review research on market structure and performance, vertical coordination arrangements, and institutions for producer collective action. Contributions to empirical modeling of agricultural price determination and marketing margins are also evaluated, as are innovations in research on spatial market relationships and the role of storage. Finally, we discuss contributions to understanding market information systems and the functioning of market-based mechanisms for agricultural risk management, including futures, options, and insurance. Although progress over the century has been remarkable, we conclude by highlighting possible directions for future research.

Key words: agricultural price analysis, food system, futures, insurance, market structure, options, spatial equilibrium, storage, vertical coordination.

JEL codes: G13, L13, L2, Q11, Q13.

This article provides a perspective on major innovations in research on agricultural markets experienced over the past century. The discussion is not meant to be an exhaustive review, a task that would be impossible given length restrictions here. So the treatment is necessarily selective and at the outset we apologize to researchers past and present whose work is not included or discussed in detail.

Agricultural markets extend through the entire food system from input supply to farm production, collection, processing, packaging, transportation, and all the way to final consumption of retail food products. Vertical coordination throughout the system ranges from spot market transactions through contracting to full vertical integration. There is potential for noncompetitive behavior and for collective action to countervail it. Agricultural marketing activities occur over space and through time, linked by interregional trade and storage. Agents throughout the food system are subject to risk and uncertainty, which has led to an important role for market information systems and risk management through futures, options, and insurance. Agricultural markets also have been a rich source of data, providing impetus for numerous advances in econometric modeling of price and market systems.

We begin by addressing contributions on food market structure and institutions because in many ways this represents the heart of the food system. Next, we focus on empirical price analysis, and in particular the pathbreaking contributions that agricultural economists made to the emerging field of econometric market modeling in the first part of the twentieth century. The third major section turns to research innovations in understanding spatial and temporal price relationships in agricultural markets. The final major section examines the role of market information and market-based mechanisms for agricultural risk management. Concluding comments offer some thoughts on future research directions and priorities.

Food Market Structure and Institutions

This section begins by discussing analyses of market structure, competition, and performance and then turns to prominent research on vertical market coordination. The final part of the discussion reviews key work on institutions for producer self-governance.

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Market Structure, Competition, and Performance

Contribution #1: Oligopoly and oligopsony power of market intermediaries are important considerations in many agricultural markets. Research has documented links between structure and performance and has produced quantitative estimates of departures from competition in key industries. Additional research has shown that policy analysis based on the competitive markets model may be misleading when the true market structure involves oligopoly, oligopsony, or both.

Nourse (1922) was one of many writers in the early part of the twentieth century who expressed misgivings about an imbalance of power between farmers and the marketing firms they sold to. This early work was often directed toward encouraging farmers to form cooperatives to address the perceived market-power imbalance. Market-structure research conducted during this early era tended to follow a case-study approach. Particularly influential was the study of the U.S. red-meat packing industry and its so-called "big five" processing firms conducted by the U.S. Federal Trade Commission (1919). This report was highly critical of the industry, accusing it of manipulating markets, restricting throughput, harming producers and consumers, and eliminating competition. The report provided direct impetus for establishment of a regulatory structure for the industry via the Packers and Stockyards Act of 1921.

Despite these early expressions of concern about competitive conditions in agricultural markets, research momentum grew slowly. Two major contributions came from Hoffman (1940) and Nicholls (1941). Hoffman studied six major U.S. food processing industries, and his work inspired application of the *structure-conduct-performance* (SCP) paradigm to agricultural industries some twenty years later. Hoffman concluded that twenty-five large food manufacturers dominated their industries, with the abundance of smaller firms comprising little more than a competitive fringe.

Nicholls is the father of analytical industrial-organization (IO) research on agricultural markets. His work is remarkable in its sophistication and analytical rigor for the time, but it seems to have been largely ignored by contemporary researchers, despite being widely available in several articles in leading journals and a book (Nicholls 1941), which summarized much of his thinking. Nicholls espoused a theory based on tacit, not overt, collusion among large processing firms, arguing that they adopted a cooperative stance toward rivals because they knew that aggressive competition would be met by retaliation. This behavior led to market sharing and stable market shares over time for leading firms, an outcome Nicholls documented extensively for livestock and tobacco procurement.

A renaissance for IO research in agriculture commenced about the time of Clodius and Mueller's (1961) influential article applying the SCP framework to food industries. Their work identified the key strategic characteristics of market structure as: (*a*) number and size distribution of buyers and sellers, (*b*) extent of product differentiation (including information), and (*c*) conditions of entry. Structure then determined market conduct defined to include decisions on price, quantity, product characteristics, product promotion, and interactions with rival firms or entrants. Conduct in turn determined market performance, which was evaluated in several dimensions, including price-average cost margin, efficiency of production, relative promotion expenditures, design/quality of products, and innovativeness of the industry. In contrast to earlier IO work, SCP studies typically included cross-industry analysis and were more focused on oligopoly power and impacts on consumers than oligopsony power and impacts on farmers.

The first SCP food-industry studies examined the relationship between structure and profit or price-cost margins (e.g., Schrader and Collins 1960; Collins and Preston 1968). Later studies focused on the price-performance relationship and examined specific product categories, rather than entire industries (e.g., Albion 1983; Wills 1985). The structure-price relationship in food retailing was also examined, with Cotterill (1986) representing a key contribution. These studies on balance found a positive relationship between concentration variables and profit or price, affirming earlier concerns about market power in the food system.

The pinnacle for SCP applications to the food industry came with publication of influential books by Connor et al. (1985) and Marion (1986). Connor et al. concluded that consumers paid from 6% to 10% more for food due to oligopoly behavior, caused in roughly equal parts by overcharges, excessive selling costs, and excessive factor payments. Both books contained strong policy recommendations advocating extensive government regulation and oversight of the food industry.

The next wave of IO research in agriculture was based on structural econometric models that sought to estimate key parameters characterizing an industry's degree of market power, an approach known as the *new empirical industrial organization* (NEIO). Applications of NEIO to the food system also signaled a refocusing on oligopsony power of food marketing firms because it was relatively straightforward to adapt NEIO models to allow for exercise of both oligopsony power over farmers and oligopoly power over consumers.

The basic econometric model includes equations representing marketing firm costs and behavior, which include parameters measuring the extent of oligopoly and oligopsony power, usually formulated as an index with 0 denoting perfect competition, 1 denoting monopoly/monopsony, and intermediate values denoting various degrees of oligopoly and/or oligopsony power. A key methodological issue is econometric identification of the market power parameters. Two noteworthy early contributions were made by agricultural economists—Just and Chern (1980) investigating monopsony power in processing tomato procurement, and Sumner (1981) studying monopoly power of cigarette manufacturers.

Many other early applications of NEIO to agriculture were studies of market power in red-meat packing (Schroeter 1988; Schroeter and Azzam 1990; Azzam and Pagoulatos 1990). Despite a high level of firm concentration in the industry, these and subsequent studies found at most only small departures from competitive pricing. Furthermore, other empirical studies found that efficiency gains from consolidation in meatpacking dominated any possible losses from market power (Azzam and Schroeter 1995; Morrison-Paul 2001).

In fact, the general conclusion from NEIO studies on agricultural industries has been that there are only quantitatively small departures from competition in both procurement and selling. As a consequence, more recent recommendations for competition policy in agriculture have been modest relative to the activist policies emanating from earlier SCP work. However, it may be that the NEIO methodologies are better than the datasets to which they have been applied, leading to estimates that are fragile and on balance have tended to underestimate the degree of market power in the food sector (Sexton 2000).

More recently the research agenda has shifted from measurement of market power to understanding its implications. Distributional impacts of market power are much larger than pure efficiency impacts, with even modest market power enabling market intermediaries to capture large shares of market surplus at the expense of consumers and/or producers (Alston, Sexton, and Zhang 1997). Furthermore, impacts of policies such as price supports (Suzuki, Lenz, and Forker 1993) and tariffs (Lanclos and Hertel 1995) may be dramatically different under market power compared with perfect competition. Researchers have also begun to focus on the product-differentiation, quality, and information dimensions of market structure (e.g., Caswell and Mojduszka 1996; Crespi and Marette 2001; Lence et al. 2007), which should continue to be important areas in future research.

Contribution #2: Research has demonstrated that agricultural contracts can help solve asymmetric information problems, reduce transaction costs, and reallocate risk toward those best able to bear it. Efficiency gains from close coordination through contracts can be substantial.

Vertical Coordination

Possibilities for vertical coordination in the food system can be viewed as a continuum—at one extreme, pure arm's-length spot market transactions; and at the other, vertical integration. Between these extremes are various contracting arrangements. A vast theoretical literature on contract design emerged in the late 1960s and into the 1970s to address asymmetric information problems regarding agents' actions (moral hazard) or characteristics (adverse selection), with considerable research on contracting in agriculture spawned as a consequence. Transaction costs also play an important role in determination of vertical coordination mechanisms, with transaction-cost theory positing that coordination mechanisms evolve to maximize value net of transaction costs (Coase 1937).

Vertical coordination is especially important in agriculture due to the perishable nature of many raw commodities and the need for precisely timed farm production and delivery to facilitate efficient operation of processing facilities. A perishable commodity is a prime candidate for opportunistic behavior because it becomes a "transaction-specific asset" at harvest time, so either a buyer or a seller is potentially vulnerable to hold up and appropriation of quasi-rents by the other. In such situations, long-term contracts or vertical integration often provide the most cost-effective solution. The increasing emphasis on provision and certification of quality in the food system has provided further impetus for stronger forms of vertical coordination (Hennessy 1996).

Despite having a clear efficiency rationale, close vertical coordination between farming and downstream marketing stages has long been controversial in agriculture because of its implications for the economic freedom of farmers, exercise of buyer market power, and the survival of traditional farms (Breimyer 1965; Barkema and Drabenstott 1995). One early response was to promote farmer-owned cooperatives as mechanisms for coordination and countervailing power.[1] More recently, attention has been directed toward regulations and legislation to proscribe certain coordination practices.[2]

Mighell and Jones (1963) provided the first detailed description of vertical coordination mechanisms in agricultural markets. They estimated shares of production under either contract or vertical integration to be near 100% for broilers and milk.[3] The share dropped to 75% for sugar beets, citrus, and processing vegetables, but cattle and hogs were still transacted mainly through spot markets, a status soon to change. Frank and Henderson (1992) formalized the notion of coordination on a continuum in the form of a vertical coordination index which they constructed for forty-two food industries and explained empirically using a transactions-cost approach. More recently, MacDonald and Korb (2006) reported that contracts governed 39% of U.S. agricultural production in 2003, up from 28% in 1991 and 11% in 1969.

The emphasis of vertical coordination research soon changed from farmers coordinating downstream stages, often through cooperatives, to marketing firms coordinating the upstream dimensions of farm production, especially through contracting. Mighell and Jones (1963) provided a clear taxonomy of contract types that remains in use today. Market-specification contracts offer only limited control in terms of identifying location and timing of marketing and providing a mechanism for determining price. Production-management contracts add cultural and resource requirements. Resource-providing contracts feature the downstream firm providing key inputs to the farm.

More recent research has focused on understanding contract provisions and their implications for particular industries, especially livestock. Most attention has been given to contracting between the farming and processing sectors. Although vertical control between retailers and food manufacturers is an important and growing phenomenon, we understand little about it due to a paucity of information on these interactions. The study by Villas-Boas (2007) offers a promising approach because it provides a framework for analyzing this issue in the presence of limited data.

Industry-based studies of contracting have paid particular attention to the broiler industry. Broiler contracts are resource providing, with growers providing labor, chicken houses, and basic utility services. Processors provide chicks, feed, and medicine. Because of the difficulties in transporting live chickens, growing houses are located in close proximity (usually 20 miles or less) to a processing facility, meaning that assets are specific, and contracts or vertical integration is needed to avoid opportunistic behavior (Knoeber 1989).

Many broiler contracts have a "tournament" payment mechanism based on growers' relative efficiency of feed conversion. Knoeber (1989) argued that the tournament structure provides a way to adapt to technological change without recontracting and enables transfer of common production risk from risk-averse growers to owners of publicly traded processing firms. Knoeber and Thurman (1995) found empirical support for the risk-shifting hypothesis. Goodhue (2000) relaxed the assumption of homogeneous growers (whose results differed only due to idiosyncratic shocks) to allow heterogeneous growers of *ex ante* unknown abilities (an adverse-selection setting). In the classic principal–agent

[1] Although writers at this time could not express their concerns in the language of modern contract theory, they did recognize the issues, claiming that cooperatives would both handle marketing more efficiently than intermediaries (Jesness 1923) and protect farmers from buyer market power (Smith-Gordon 1918).

[2] For example, a serious effort was made to ban packer ownership of cattle in the 2002 Farm Bill. Also, the Mandatory Livestock Reporting Act of 1999 was passed in part to bring transparency to "marketing arrangements where neither the arrangements nor the final purchase price are publicly disclosed" (Azzam 2003).

[3] In the case of milk, this was due to the presence of milk marketing contracts and the constellation of marketing-order agreements.

model, high-ability agents are able to capture informational rents, but Goodhue showed how processors, through controlling flock placements and exposing growers to placement risk, could reduce these rents.

Years later, hog production underwent a dramatic transformation to production through resource-providing contracts (Martinez 1999). The transition period when independent and contract growers operated "side by side" provided researchers with good opportunities to examine the impacts of contracts. Martin (1997) found that growers with production contracts faced reduced risk relative to independent growers. Key and McBride (2003), in a careful econometric study, found dramatic efficiency gains to contract production, on the order of 20% output gains holding inputs constant—gains they attributed to knowledge transfer from integrators to growers.

Vertical coordination mechanisms have been particularly controversial in the cattle industry. Cattle finishing transformed from an industry coordinated primarily through spot markets to one where over half of cattle marketed during 2001–2003 were packer owned or exchanged via contracts. The increasing scope of these vertical coordination mechanisms, collectively known as "captive supplies," along with a rapid increase in processing-sector concentration, led to great concern among ranchers and feedlot operators as to the competitive impacts of these arrangements. One issue when contracts and spot exchanges exist together is the impact, if any, of the captive supplies on spot prices. The issue is especially germane when, as is often the case, contract prices are pegged to the spot price. Empirical research has found a persistent but small negative relationship between cash cattle prices and the percentage of deliveries from captive supplies (Ward, Koontz, and Schroeder 1998; Schroeter and Azzam 2003), but no consensus has yet emerged as to a causal explanation.

Given the growing emphasis on quality and safety throughout the food system, and the potential for increased efficiency through greater coordination in the supply chain, the trend toward increased vertical control through contracting is sure to continue. And there is a need for better understanding of the implications, particularly the effects of particular contract provisions and their impacts on the balance of market power. Economic theory provides a strong rationale for efficiency gains from coordination through contracts, although careful quantification of the magnitude of impact, such as by Key and McBride (2003), is rare and more is needed. The primary benefit to producers from contract production is usually claimed to be risk reduction, a conclusion often supported by survey results and empirical analysis. However, any risk-reduction benefit to agents is captured by the principal via a lower contract payment in the standard model. This result depends upon the principal holding the position of power regarding the transaction and making a take-it-or-leave-it contract offer, emphasizing the imperative of understanding the competition effects of agricultural contracts.

Institutions for Producer Self-Governance

Contribution #3: Research suggests that collective action enables farmers to counteract market power and overcome free-rider problems associated with product promotion and quality certification. However, use of collective action to exercise market power is unlikely to be successful due to failures to reach agreement, free riding, and adverse long-run adjustments to supply and demand.

One policy response to the imbalance of power often perceived to exist between farmers and downstream marketing firms has been to provide a legal framework enabling farmers to engage in collective action through *producer-controlled marketing organizations* (PCMOs). The goal is to improve farmers' relative power in the marketplace and increase farm incomes. Producer-owned cooperatives are common in many countries. In the United States, marketing orders operate with either federal or state authorization to allow producers to act collectively to fund research and advertising, regulate volumes produced or marketed, and impose grading and/or minimum quality standards. In Europe, Geographical Indications (GI) provide a framework for producers to create and certify differentiated product specifications.

PCMOs are diverse in the functions they perform and the legal infrastructure that supports them. Cooperatives have the longest history and have been studied extensively by agricultural economists. Early work, exemplified by Jesness (1923) and Filley (1929), concentrated on providing practical guidelines for forming and operating cooperatives. Two competing schools of thought on the economic role of cooperatives emerged during this time. Under the "yardstick of competition" school (Nourse 1922), cooperatives played a limited role and existed mainly to ensure adequate performance of other firms operating in the market.

The other school of thought, known as the "California model," was promoted by Sapiro (1923), who advocated a much more prominent role for cooperatives organized along commodity lines, not based on locality. He believed that with the proper structure, commodity-based cooperatives could dominate their markets. Despite lacking formal training in economics, Sapiro had a solid understanding of the requirements for exercising cartel power. He stressed that long-term membership contracts with liquidated damages provisions and a large market share (50%–75%) were required for success. However, Erdman (1941) lucidly outlined key difficulties with the California model: (*a*) Restricting supplies through carry-overs depressed next year's prices; (*b*) diseconomies of size might result from large-scale operations; and (*c*) noncooperators could free-ride on efforts to support the market.

Analytical inquiry into the nature of farmer cooperatives soon began, and it too split into two schools of thought. One approach viewed cooperation as a vertical extension of the farm enterprise (Emelianoff 1942; Phillips 1953), and thus a theory of behavior for cooperatives was girded with theory pertaining to vertically integrated firms. The competing framework treated cooperatives as ordinary firms, albeit with an objective function that may differ from that of the investor-owned firm (IOF). A key contribution was Enke's (1945) model of a consumer or purchasing cooperative, where equilibrium was set at the intersection of the co-op's marginal cost of providing the product with the members' demand (marginal value)—a value-maximizing solution.

Clark (1952) used the same framework but imputed a price-maximizing/-minimizing objective and found that equilibrium occurred where the consumer co-op provided the product at the lowest possible cost (the minimum point of its average cost) and the marketing co-op paid the maximum possible price—the maximum of its *net average revenue product* (NARP). Gislason (1952) proposed a third solution, namely the intersection of average cost and member demand for a purchasing co-op and the intersection of NARP and member supply for a marketing co-op—a breakeven or zero-surplus solution. Researchers pursuing the vertical integration framework independently arrived at the same set of solutions, although this appears not to have been recognized as the debate unfolded.

Much of the confusion in this work was due to authors relying on verbal or graphical arguments and failing to state assumptions clearly. Helmberger and Hoos (1962) and Helmberger (1964) provided clarity through the first complete analytical models of agricultural co-op behavior.[4] Grounded firmly in the cooperative-as-a-firm school, Helmberger and Hoos assumed that the marketing co-op had fixed short-run membership, accepted all member deliveries, and paid the maximum price subject to covering costs, leading to the Gislason zero-surplus equilibrium. A closed-membership cooperative attained Clark's price-maximizing solution in the long run by restricting supply to intersect the maximum of NARP.

These papers were considered definitive treatments, so much so that little subsequent work ensued for nearly two decades. However, an uptick of research interest in cooperatives began in the 1980s along multiple fronts. Instead of focusing on the behavior of the cooperative per se, Staatz (1983) and Sexton (1986), using cooperative game theory, studied the motivations for farmers to act collectively in cooperatives. Other work (e.g., Fulton and Giannakas 2001) tackled the difficult question of positioning cooperatives in modern agricultural markets, where they often compete with IOFs in oligopoly/oligopsony settings. This area is an important and potentially fruitful direction for future research.

Federal and state marketing-order legislation was implemented during the Great Depression to provide tools to raise farm incomes and overcome free-ridership that plagued cooperatives. Unlike cooperatives, compliance with marketing-order provisions was mandatory once they were enacted by a supermajority of producers.

The immediate focus of agricultural economists in the aftermath of the authorizing legislation was volume controls, through either reduction of total output or restriction of allocations across markets to achieve price discrimination (Stokdyk 1933; Erdman 1938; Waugh 1938). These authors clearly understood the short- and long-run tradeoffs of

[4] Helmberger and Hoos (1965) also wrote a defining treatise on cooperative bargaining in agriculture based on a model of bilateral monopoly. Although bilateral monopoly does not characterize most cooperative bargaining in agriculture, little progress has been made in extending this model despite considerable advancements in bargaining theory.

volume control. Over the long run, supply controls could cause consumers to "turn away from that product" or "abandon it entirely" (Wellman 1935), and programs that stimulated returns above those obtainable from other crops would cause supply to increase. Subsequent authors, taking the cartel power of marketing orders as given, studied the decision-making process to implement a marketing order (Filson et al. 2001) and the types of controls that would be imposed in the presence of heterogeneous producers and dynamic market adjustments (Berck and Perloff 1985).

Key empirical studies on the welfare impacts of volume-control programs were also conducted. A pioneering example is the dynamic structural model of the lemon industry by French and Bressler (1962). The lemon order allowed the industry to regulate the flow of lemons to fresh and processed market outlets, and French and Bressler evaluated three alternative market-control scenarios: (*a*) the status quo, (*b*) a scenario where more stringent restrictions were imposed on fresh market sales, and (*c*) a scenario where the marketing order was abolished. This and subsequent related work emphasized that supply controls, by stabilizing and increasing grower incomes, could increase supply over the long run and improve consumer and total welfare.[5] More critical assessments that focused primarily on the short-run deadweight losses from market allocation schemes were provided by Ippolito and Masson (1978) for milk and by Shepard (1986) for California-Arizona citrus.

Despite the continuous research interest in volume controls, most federal orders do not utilize them and no state order does. Generic commodity promotion is much more frequently authorized and implemented, and this issue received increased research attention following amendment of the federal marketing-order legislation in 1954 to permit mandatory promotion programs on a broad scale. Waugh (1959) recognized the difficulty in measuring effectiveness of commodity advertising due to its dynamic impacts and cross-commodity effects, but nonetheless expressed confidence that agricultural economists would be able to advise industries regarding expenditure on promotions in the same way that experiment stations provided advice on the optimal application of fertilizer.[6]

Nerlove and Waugh (1961) collaborated on a key study that both derived the condition for optimal advertising in a static framework and provided a rigorous evaluation of advertising effectiveness. They assumed a lump-sum expenditure on advertising and derived an optimum from equalizing the marginal net return from advertising expenditure with the rate of return for alternative investments. Promotion funds, however, are almost always raised from a per-unit assessment that shifts back the supply curve. Effectiveness in this case is measured by the size of the demand shift relative to the supply shift. Alston, Carman, and Chalfant (1994) subsequently demonstrated that the optimal expenditure in a competitive market is found where the change in quantity is zero (the marginal demand and supply shifts from an incremental assessment and expenditure just balance) and that the optimal advertising-to-sales ratio is characterized by the well-known Dorfman–Steiner condition.

In their empirical study of advertising by Florida orange growers Nerlove and Waugh (1961) used a demand model with distributed lags to estimate short- and long-run elasticities of promotion demand of 0.17 and 0.24, respectively. This yielded a quantity-constant marginal return of over 20:1 on advertising expenditure. Many empirical studies of specific industries' promotion programs have been conducted in the ensuing years, with the vast majority finding handsome rates of return, although few as large as 20:1.

Given the apparent success of generic promotion programs in providing positive returns, researchers have turned most recently to evaluating distributional impacts of these programs (Chung and Kaiser 2000). Alston, Freebairn, and James (2001) revisited the concern raised initially by Waugh (1959) that advertising could have a "beggar thy neighbor" effect through cross-commodity impacts. Crespi and Marette (2002) examined the core assumption of homogeneous products and showed that generic programs could undermine individual

[5] French and Bressler anticipated a key criticism of this structural approach—namely the stability of the estimated coefficients to shocks in the industry structure: "Unpredictable changes in technology, psychology, biology, and other factors may alter both the coefficients or form of the equations and the environment within which they must operate" (p. 1036). Of course, abolition of the marketing program would itself represent just such a structural shock.

[6] Waugh provided a clear discussion of demand shift and demand elasticity impacts of advertising, including that a benefit of advertising might be to make demand *more* price elastic because inelastic demands were incapable of accommodating rapidly expanding farm supplies and also created instability.

firms' attempts to differentiate their products, while Zhang and Sexton (2002) showed that imperfectly competitive downstream market intermediaries could capture much of the benefit from commodity promotion programs.

An important recent trend in analysis of PCMOs is their role in promoting product differentiation and certifying quality. Implementing grades is a way to differentiate products and mitigate adverse selection that might result in their absence. Zusman (1967) developed the first analytical model of grading schemes determined by a competitive market and identified the conditions under which government intervention is appropriate. However, many grading schemes are implemented by PCMOs themselves, and the question of what grading scheme would be implemented under a producer-profit criterion has not yet been fully resolved. Some evidence that social and private objectives in grading are not likely to be consonant is provided by Chalfant and Sexton (2002), who showed that grading error could be strategic so as to restrict supply of inelastic-demand, high-quality product, and therefore increase returns for a given crop volume. Bockstael (1984) focused on effects from the additional step of banning the sale (or requiring diversion to secondary markets) of product graded below a minimum quality standard (MQS). In her perfect-information environment, any MQS that increased producer price, and hence would be imposed voluntarily by producers under a PCMO, was certain to harm all consumers and reduce total welfare.

Additional contributions have been made recently by researchers focusing on the economics of GI, mostly using models of vertical product differentiation. Although geographically differentiated products have a long history, the European Union's action in 1992 to create categories of protected designations provided new research impetus. The studies by Zago and Pick (2004) and Lence et al. (2007) are key in the investigation of the role of PCMOs in the creation and certification of quality-differentiated products. Their work opens the door to possible net welfare enhancement by allowing producers to collectively exercise monopoly power through a PCMO to raise returns so as to justify investments in development and certification of socially beneficial, high-quality products.

PCMOs have been and are likely to remain integral marketing institutions. Their roles have evolved considerably over the years from emphasizing supply controls to collectively promoting products thought to be fundamentally homogeneous to facilitating quality enhancement and product differentiation. Research in agricultural marketing has evolved to mirror these trends, albeit with some lag.

Agricultural Price and Marketing Margin Analysis

Empirical modeling of price determination processes has played a central role in research on agricultural markets. Two frameworks have been used. The first is a structural approach based on econometric estimation of supply, demand, and market equilibrium models. An advantage of the structural approach is that it provides an explanation for observed price movements that is grounded in microeconomic theory. Second, there is a more nonstructural approach which provides a "reduced form" representation for variables based on historical correlations estimated from time-series data. The nonstructural approach does not provide a direct economic explanation for observed prices, but the resulting reduced-form representations have proven useful in a variety of ways. This section addresses contributions of both structural and nonstructural modeling to research on agricultural price and marketing margin analysis.

The Structural Approach

Contribution #4: Empirical research has dramatically improved knowledge of the structure of supply, demand, and price determination in agricultural markets. This research has also evolved to better represent the complexities of agricultural markets, including the effects of time lags in the production process, measurement of expectations and risk, and heterogeneous characteristics of commodities.

Early structural analyses of agricultural market relationships were limited by the availability of relevant data and by rudimentary computational capacity, and yet great strides were made as various pioneers paved the way for recent developments. Moore (1914) was an early contributor to the study of price–quantity relationships. His regressions for corn, hay, oats, and potatoes had negative slope coefficients, and he interpreted the results as demand equations. But Moore also claimed to have found a "new type of demand curve," with a positive slope, for pig iron, and this motivated E. J. Working (1927) to point out that a regression equation using price and quantity might be an estimate of a demand equation, a supply equation, or neither. Additional information was needed to identify particular structural relationships.

Among early studies, Warren and Pearson's (1928) monograph on the interrelationships of supply and price is noteworthy because they recognized the importance of the food supply chain and the need to distinguish among farm, wholesale, and retail prices. Bean (1929) was an early contributor to empirical supply analysis. He found that the dominant factor explaining changes in acreage and hog numbers was the price received by farmers in the preceding season. The price received two years preceding was also often important.

Building on these early studies of supply and demand, Ezekiel (1938) proposed a recursive system of equations in which lagged prices determine current production which in turn determines current price—the famous cobweb model. This model implies that prices and quantities are negatively autocorrelated, which appears not to be the case for most agricultural commodities. Nevertheless, the cobweb model recognized the importance of time lags in a biological production process and has been instrumental in shaping subsequent thinking about the way agricultural markets work. For example, Cochrane (1958) used a cobweb model in his well-known book to explain price volatility and the persistence of a "price-income problem" in commercial agriculture.

Important developments in quantitative price analysis continued to take place. Fox (1953b) formalized the argument that aggregate demand for many agricultural commodities should be specified in price-dependent (inverse) form because production is determined by past events. A set of USDA Technical Bulletins provided estimates of such models for a variety of commodities. This research became the basis for an influential handbook by Foote (1958) that summarized useful practices in empirical price analysis. This research also provided an empirical foundation for the view that farm-level demands and supplies are price inelastic, a result that has been ingrained ever since and regarded as a key dimension of the "farm problem" (Gardner 1992).

Nerlove's (1956) adaptive expectations model quickly became a popular alternative to naive expectations in empirical supply analysis because it was more general and seemed to fit the data better. But it soon became apparent that coefficients of lagged dependent variables can be statistically significant for numerous reasons, not necessarily because the adaptive expectations hypothesis is correct. Just (1974) developed an innovative extension of the adaptive expectations model by adding an adaptive risk component and investigating the effects of risk on supply response. Subsequently, Gardner (1976) proposed using futures quotes to represent expected prices in supply models, and although he did not explicitly use the term "rational expectations," such a description is justified by the assumption that futures quotes are unbiased forecasts of the terminal month's futures price.

Seasonality in agricultural prices is usually incorporated into structural models by allowing for seasonality in production and/or demand, along with the cost of carrying inventories. But longer cycles that have persisted for some livestock markets have been a puzzle. Shouldn't any seemingly predictable cycles in prices be arbitraged away? Important papers by Rosen (1987), Mundlak and Huang (1996), and Holt and Craig (2006) suggest that the answer is no. Producers must form expectations about future costs and returns of maintaining, expanding, or reducing their herds. These decisions are based on imperfect information and have a delayed impact on supply. Thus, it is possible that even an efficient market can generate cyclical price behavior. Another interesting feature of dynamic livestock models is the possibility of a negative short-run response of beef and perhaps pork supply to prices (Jarvis 1974). An increase in expected price may induce producers to retain a sufficient number of females for the breeding herd that the current quantity slaughtered declines.

Demand models for agricultural commodities have typically emphasized retail-level rather than farm-level specifications. As models moved beyond simple price–quantity regressions, a common specification was to make real prices a function of per capita consumption of the product and of its close substitutes and the per capita real disposable income (Foote 1958). If monthly or quarterly observations were used, specifications often allowed for seasonal effects and sometimes for dynamics (lagged response).[7] Dynamics may be needed because consumers face costs of adjusting to price changes or are slow to change

[7] A difficulty in demand analysis is how to model other factors besides prices and income that sometimes influence demand (e.g., demographics, health information, advertising). This topic is covered in other papers in this issue.

consumption habits. But if these adjustments are sufficiently fast, they may not show up in annual observations. If dynamics are included, short- and long-run elasticities may diverge. Waugh (1964) provided initial evidence that demand is more price elastic in the long run.

Agricultural products are inherently heterogeneous, and a single "market" price masks much variability in the prices received for particular lots of a commodity, which are influenced by characteristics such as location, size, color, and presence of various defects. The hedonic price model specifies lot price as a function of its characteristics and provides a way to estimate a market value for specific product characteristics. This approach was envisioned early by Waugh (1929), but the seminal exposition is Rosen's (1974) analysis of beef cattle attributes. Several hedonic studies have been conducted for wheat (e.g., Veeman 1987), a commodity often treated as homogeneous in textbook applications of the competitive model. The "characteristics literature" has been extended by using contingent valuation to estimate the value consumers place on retail food product attributes, such as store location and organic certification (e.g., Ward, Lusk, and Dutton 2008).

The structural price analysis literature has a clear line of contributions starting with simple models of supply and demand and evolving to address contemporary issues like the effects of risk on supply and of generic advertising and product attributes on consumer demand. Although researchers have developed innovative sources of data, including data generated by experiments, obtaining data relevant for addressing specific important research issues remains a potential problem, but one rarely discussed in the literature.

The Nonstructural Approach

Contribution #5: Empirical researchers using time-series data have been made aware of the importance of testing for seasonality, unit roots, cointegration, and conditional heteroscedasticity when studying agricultural markets. But research has also shown that conventional linear ARIMA (autoregressive integrated moving average) and error correction models do not completely capture the time-series behavior of many commodity market variables, and more general models that account for nonlinearities and regime shifts are often required.

The nonstructural approach to agricultural price analysis is grounded in the early work of Bachelier (1900) and Mandelbrot (1963), both of whom focused on modeling the statistical distribution of commodity price changes. Their models provided valuable insights but could not capture all of the statistical dependence between successive price changes. Early attempts to deal with this dependence problem involved decomposing movements into trend, cyclical (often viewed as seasonal), and random components. Applications of this "harmonic analysis" are seen in works by Abel (1962) and Nerlove (1964). Harmonic analysis has been especially useful in identifying flexible seasonal patterns in commodity market data.

An alternative nonstructural approach rose to prominence in the 1960s and early 1970s following popularization of the Box–Jenkins methodology for identifying and estimating ARIMA models. Early applications in agriculture include Larson (1960), Leuthold et al. (1970), and Brandt and Bessler (1981), and ARIMA modeling quickly became the dominant paradigm for nonstructural analysis of agricultural time series. A common finding in this research, particularly when using high frequency (e.g., daily, weekly) data, was that commodity prices need to be differenced to induce stationarity.

This unit root behavior in commodity prices soon became controversial because nonstationarity implied that conventional estimation and inference procedures for models with commodity price variables were inappropriate, including most structural econometric models of commodity markets that existed at the time. Furthermore, just differencing nonstationary variables and proceeding normally was unsatisfactory because differencing removes information on the long-run equilibrium relationship between variables, which was often the issue of primary concern in structural models. Cointegration and error correction analysis (Engle and Granger 1987) provided a way forward, and Ardeni (1989) was one of the first to bring these issues to the attention of agricultural economists. His work ushered in an explosion of interest in the nonstationarity/cointegration properties of commodity market data (e.g., Goodwin and Schroeder 1991; Bessler and Fuller 1992).

Despite these advances in modeling under nonstationarity and cointegration, it has become clear that stochastic theoretical models of commodity price determination generally do not produce equilibrium prices that satisfy the ARIMA property, nor are they well represented by linear cointegration/error correction models (Williams and Wright 1991; Deaton and Laroque 1992; Peterson and Tomek 2005). In fact, these theoretical models suggest that equilibrium commodity prices are subject to nonlinear behavior caused by structural breaks and regime shifts, especially for storable commodities. Wang and Tomek (2007) showed that once regime changes are allowed for, the unit root hypothesis was rejected in most of the commodity prices included in their study. Ongoing research is attempting to model these nonlinearities in commodity prices directly (e.g., Balagtas and Holt 2009).

Time-varying volatility is another empirical regularity often observed in commodity price data. This property is commonly modeled using Engle's autoregressive conditional heteroscedasticity (ARCH) or Bollerslev's generalized ARCH (GARCH) models. Yang and Brorsen (1992) were among the first to test for GARCH in commodity prices series. They found that GARCH models fit data on daily price movements better than a number of alternatives. ARCH and GARCH models have also proven useful in many application areas of agricultural market analysis. For example, Aradhyula and Holt (1990) showed how a GARCH model could be used to measure changes in price risk over time and estimate supply response to risk. And Baillie and Myers (1991) used GARCH to estimate time-varying conditional variances and covariance for cash and futures prices that characterized time-varying optimal hedge ratios on futures markets.

Marketing Margins

Contribution #6: The farm–retail price spread has expanded considerably over time, and research has helped identify causal factors, including changes in marketing costs, additions of marketing services, substitution among inputs, changes in risk, and increased market power of market intermediaries.

Marketing margins are defined as the difference between prices at different levels in the supply chain, with due allowance for level-to-level production conversion relationships. The most studied marketing margin is the farm–retail price spread, which accounts for all marketing activities performed as the product moves from the farm gate to the final consumer.

The farm share of consumer expenditures on food was relatively stable at about 33% from 1955 to 1980 but has declined steadily since then to 19% in 2006. The growing size of the marketing bill illustrates the increased importance of marketing activities in the food system. The farm share of the consumer dollar is often considered an indicator of the relative health of the farm sector, although for multiple reasons this interpretation is not warranted.[8] Marketing margins say little directly about the efficiency of food marketing or the welfare of various stakeholders in the supply chain, but they have been and likely will remain closely monitored food sector outcomes.

Initial marketing margin research was primarily descriptive and intended to characterize the size of the farm–retail spread for various commodities.[9] Many of these analyses were undertaken at the Bureau of Agricultural Economics in the 1930s (e.g., Waugh 1934). Beginning around 1960, however, researchers began to undertake more detailed empirical studies with the goal of explaining the structural determinants of marketing margins. An important step was taken by Buse and Brandow (1960), who modeled marketing margins for individual commodities as a function of the average margin across all farm goods, retail price, and other variables. They found that most of the variation in individual commodity

[8] For example, changes in composition and packaging of foods and/or technological change in the marketing sector may change the farm share without any corresponding change in the health of the farm sector.

[9] There was also considerable emphasis on price adjustments to allow accurate comparisons of prices at different points in the supply chain, given processing and transformation of the product that occurred between points.

margins could be accounted for by the average margin across all farm commodities and that higher retail prices were associated with higher margins. George and King (1971) also focused on marketing margins and estimated price transmission elasticities between farm and retail levels, converting their comprehensive matrix of retail demand price elasticities into farm-level demand price elasticities.

This early empirical work was hampered by lack of a formal theoretical model explaining the determination of marketing margins in a comprehensive, multilevel model of the food supply chain. Gardner (1975) filled this void in a key article which paved the way for many further refinements of the theory, as well as stimulating new empirical studies that took a much more structural modeling approach based on a theoretically consistent system of farm-supply, consumer-demand, and marketing-firm cost equations. Foremost among these structural studies was that by Wohlgenant (1989), who investigated eight aggregate food industries and found that results were generally consistent with competitive behavior by marketing firms, a result affirmed in Holloway's (1991) subsequent study of the same industries.

Empirical research around this time began to include lags and dynamics in marketing margin models. Heien (1980) was one of the first to address the possibility of dynamic and asymmetric adjustment in marketing margins. He found no evidence of asymmetry in his study of multiple disaggregated food commodities. But asymmetry has been studied virtually continuously ever since, with focus on asymmetries in both the magnitude and the timing of price transmission. The Kinnucan and Forker (1987) study on milk margins is especially notable in that it provided a flexible estimation framework and found strong evidence supporting both dynamic and asymmetric adjustment.

Technical change is important in marketing margin analysis because it is likely a major driver of changes in the farm–retail price spread. However, it has received surprising little attention in the literature. Miedema (1976) provided a theoretical model of the impacts of technical change on the farm–retail price spread, and Brester and Marsh (2001) undertook an empirical investigation for the cattle industry. Many studies of marketing margins, however, have either ignored technical change or simply included a time trend to try and account for it.

Risk also might affect food marketing margins. This issue was first addressed in work by Brorsen et al. (1985) and Brorsen, Chavas, and Grant (1987). These studies used intuitively defined time-varying measures of price variability over the recent past to measure price risk and found statistically significant evidence that marketing margins were risk sensitive, though the size of the effect was small in each case. More recent studies by Schroeter and Azzam (1991) for pork and Holt (1993) for beef used GARCH models to capture changes in risk (now considered a superior modeling framework) and affirmed its statistically significant presence as a margin determinant.

Agricultural Markets in Space and Time

The spatial dimension of marketing includes transporting commodities from production locations to processing locations and ultimately on to final consumers distributed across population centers. Interregional trade, if performed efficiently, results in a set of spatial arbitrage conditions among prices in different locations. Spatial market analysis has therefore often focused on computing efficient interregional trade flows and testing spatial price efficiency. The time dimension focuses on storage which redistributes commodities over time. Efficient storage implies its own set of intertemporal arbitrage conditions, but complicated by the fact that future prices are uncertain and storage cannot be negative. Concerns surrounding instability in commodity prices have also been a major impetus for research on intertemporal price relationships. In this section, we first outline key contributions to spatial market analysis in agriculture and then turn to commodity storage and price stabilization.

Spatial Equilibrium and Efficiency

Contribution #7: Research on spatial market relationships has provided valuable tools for solving market equilibrium models using math programming and for computing trade flows and optimal locations of production and processing facilities. Generalized versions of the model have also facilitated empirical tests for spatial market efficiency. Evidence has shown that continuous adherence to spatial efficiency conditions is rare in agricultural markets, but progress on understanding the seriousness of such deviations and what is causing them has been slow.

The first modern theoretical treatments of spatial price equilibrium were by Enke (1951), who used an electric circuit algorithm, and Samuelson (1952), who characterized competitive spatial equilibrium as a social planning problem solved via math programming. Although some initial applications in agriculture used variants of Enke's approach (e.g., Fox 1953a), Samuelson's optimization solution resonated more strongly with economists and provided the foundation for most subsequent applied work in the field. Nevertheless, there were many initial obstacles to practical implementation, and it was not until Takayama and Judge (1964a, b) reformulated the problem as a quadratic programming problem, and provided general methods for its solution, that quantitative analysis of spatial price relationships in agriculture began in earnest.

The beauty of Samuelson's approach is that it exploits the mapping between competitive equilibrium and a corresponding social planning problem (maximizing the sum of producer and consumer surpluses minus transportation costs, subject to market clearing constraints). This technique solves not only the primal problem of finding the efficient spatial distribution of production, consumption, and interregional trade, but also the dual problem of computing competitive equilibrium prices. The approach has been extended in a variety of directions, as summarized comprehensively by Takayama and Judge (1971). Judge pioneered applying spatial equilibrium methods to investigate optimal patterns of spatial production, consumption, and price for many U.S. agricultural commodities, in many cases using emerging econometric estimates of regional supply and demand functions (Judge and Wallace 1958; also see numerous agricultural experiment station bulletins produced by Judge and his colleagues in the early 1960s).

Researchers soon realized that these same programming methods could be used to compute optimal spatial locations for agricultural production activities and food manufacturing and processing facilities (e.g., King and Logan 1964; Heady and Egbert 1964). Much of this early work on the spatial dimensions reached its zenith with the publication of Bressler and King's (1970) book, which goes beyond standard spatial equilibrium modeling to examine the spatial boundary between competing markets, plant location, noncompetitive spatial behavior, the notion of a region's production potential, and the distribution of land use based on resource endowments and the opportunity for interregional trade.

The next wave of research interest in spatial models turned to formal tests for spatial market efficiency. Early studies simply evaluated the degree of correlation between prices from different locations, but it is now well known that strong correlation between spatial prices is neither necessary nor sufficient for spatial efficiency. The search for stronger tests led to two main alternative testing frameworks. The first was pioneered by Ravallion (1986), who allowed for spatial equilibrium in the long run but also permitted short-run deviations from equilibrium, possibly due to poor information flow, transport bottlenecks, and/or poor arbitrage decisions. If equilibrium reestablishes quickly after a shock, then the evidence supports a high degree of spatial efficiency. But if adjustment back to equilibrium is slow or nonexistent, the evidence supports inefficiency. Of course, one problem is that there is no objective criterion for deciding how fast the adjustment has to be before markets should be viewed as "spatially efficient." Ravallion's work anticipated many of the subsequent developments in cointegration analysis of spatial price relationships and can be recast easily in a cointegration/error correction framework.

The second testing framework is based on switching regressions and was first applied to spatial prices for agricultural commodities by Sexton, Kling, and Carman (1991). They separate observations into three regimes depending on whether spatial price differences equal, exceed, or fall below transfer costs. Results show the proportion of observations that are estimated to be in each regime, but there is no objective criterion for deciding whether markets are overall spatially efficient or not.

A problem with both of these testing frameworks is they are often applied when prices are the only data available, with little or no information on transfer costs or trade flows. This forces the assumptions that transport costs are constant (or perhaps follow a trend) and that trade flows are unidirectional. Unfortunately, these assumptions are often at odds with the reality of many agricultural market data. McNew and Fackler (1997) have shown that using price data only can lead to serious inference problems when applying the standard approaches to testing for spatial market efficiency.

Both testing frameworks have been extended in notable directions. The study by Barrett and Li (2002) is one of the few that does use trade flow data. Their innovation was to extend the switching regression approach by allowing for a richer set of regimes depending on both price differentials and trade flows. Negassa and Myers (2007) allow regime probabilities to adjust systematically over time in response to changes in marketing policies and/or the market infrastructure and environment. This approach can provide an explanation for why spatial efficiency might be changing over time.

Ravallion's model has also been extended to allow the speed of adjustment to change depending on whether shocks exceed or fall below an estimated threshold value, which presumably represents transfer costs between markets. The resulting threshold error correction model was first applied to spatial price relationships in agriculture by Goodwin and Piggott (2001) and has since spawned a number of additional applications and extensions.

Storage and Price Stabilization

Contribution #8: Research on commodity price stabilization and storage has provided a coherent framework for investigating the welfare effects of price stabilization policies. This framework emphasizes the important role of private storage and the costs of price stabilization policies. The development of rational expectations storage models has also improved understanding of the nature of dynamic equilibrium in agricultural markets and enhanced computational methods for solving these models.

Early concerns about the effects of extreme fluctuations in commodity prices and supplies grew out of experiences during the Dust Bowl era, the Great Depression, and the World Wars, all of which caused major disruptions in commodity prices and supplies. Also, agriculture was relatively more important in the macro economy during these early days, which caused fears that fluctuations in commodity prices could spill over into other sectors of the economy and cause general macroeconomic instability. The reasons why commodity prices are more unstable than those of most manufactured goods and services, and some of the implications for both agriculture and the general macro economy, were laid out comprehensively in Schultz (1945).

These early concerns about unstable commodity prices were motivated primarily by the general notion that price stability is, in and of itself, a desirable macroeconomic trait. A key turning point in the way economists conceptualized price instability occurred with the influential article by Waugh (1944), who was the first to use a Marshallian surplus framework to formally investigate the welfare effects of price stabilization. While Waugh focused on welfare impacts on consumers, subsequent papers by Oi (1961) and Massell (1969) using the same Marshallian framework examined welfare effects on producers and society as a whole. The conclusions from the Waugh-Oi-Massell analyses were that (costless) price stabilization around a constant mean always increased net social welfare, but the distribution of gains and losses among consumers and producers depended critically on the source of the underlying price fluctuations. While the limitations of the Waugh-Oi-Massell framework are now well known, this line of research was noteworthy because it shifted the focus of the debate and showed that conventional microeconomic theory could be applied to analyze the effects of commodity price instability.

About this same time, other researchers began focusing attention on optimal commodity storage rules. In innovative early studies, Gustafson (1958a,b) was the first to apply dynamic programming methods to this problem. Gustafson was clear to point out that his model could be applied equally well to private speculative storage or to public buffer stock programs. As such, this initial research did not directly address the underlying issue of whether there is an economic rationale for public buffer stock programs to stabilize commodity prices. But the work did focus attention on the role of private stockholding, a role that was ignored in the Waugh-Oi-Massell framework. In the end, it took another key contribution to bring these different strands of literature together and clarify the theoretical relationship between private and public stockholding.

The unifying development was the application of Muth's rational expectations hypothesis to dynamic programming models of private speculative storage. The first application of this idea appears to have been by Samuelson (1971), who solved the competitive equilibrium rational expectations storage model assuming risk-neutral speculative storers and showed that the resulting equilibrium is Pareto optimal. This implied that there was no theoretical justification for public buffer stock schemes on economic efficiency grounds, once storage costs and rational forecasting are included in the model. This basic modeling approach was subsequently embraced by many agricultural economists doing both theoretical and empirical research on commodity price stabilization and storage (e.g., Miranda and Helmberger 1988). The many contributions of Wright and Williams, beautifully summarized in their wide-ranging book (Williams and Wright 1991), are particularly noteworthy, not only because they extended the basic model of storage under rational expectations in so many directions, but also because they made the difficult numerical methods required to solve these models more accessible to a generation of agricultural economists.

The lasting value of the dynamic rational expectations competitive storage model is that it sharply illuminates the role of private storage in reducing price instability, highlights the fact that some price instability is required for the efficient allocation of resources and consumption, and emphasizes that any mechanism used to stabilize commodity prices has a cost that must be taken into account when evaluating the economic performance of price stabilization schemes. The model also forced agricultural economists to reevaluate the economic rationale for public buffer stock programs—if competitive private storage markets can provide the economically efficient level of price stabilization, what market failures would justify public buffer stock schemes?

One possible answer is that the standard framework ignores risk, and in the presence of risk aversion and incomplete contingent claims (risk) markets, public buffer stock programs might be a second-best response that improves efficiency. This issue was studied extensively by Newbery and Stiglitz (1981), who concluded that this is a valid theoretical argument but that in applied settings the potential efficiency gains are likely to be small and difficult to achieve.

Market Information and Risk Management

Agricultural markets are subject to production and price uncertainty due to the biological nature of the production process, the vagaries of weather, and typically price inelastic short-run supply and demand responses. This exposes market participants to an unusual degree of risk and puts a premium on good information and forecasting ability. One approach to these problems, which we address first in this section, is to provide market participants with information about current market conditions as well as forecasts of future conditions. A second approach, which we discuss next, is to manage risk via market-based mechanisms such as futures, options, and insurance.

Market Information

Contribution #9: Research suggests that publicly provided market information and forecasts can move markets and have economic value, though the returns to such investments remain controversial. No clear consensus has emerged as to the relative magnitude of benefits from private marketing advisory services.

It is widely believed that more and better information about agricultural market outcomes has benefits and that there is a role for public provision of such information due to the public-good nature of information. But little rigorous research exists on the returns to investment in agricultural market information. A notable exception is the work by Hayami and Peterson (1972), who developed a framework to estimate the welfare effects of improved forecasting accuracy. In their two-period model, the benefits depend on the true equilibrium price and quantity being forecasted, the error in the preharvest production forecast, and the demand elasticity at the equilibrium point. Better forecasts cause improved allocation of a storable crop between periods. Hayami and Peterson estimated that an extra dollar spent to increase the accuracy of crop-size estimates (yield and harvested acres) would produce benefits ranging from $20 to $100.

The Hayami and Peterson result relies on strong assumptions and abstracts from the behavior of individual decision makers. Micro foundations for valuing market information were later provided by Bradford and Kelejian (1977) and Antonovitz and Roe (1986). Subsequent estimates of the value of market information were more modest than Hayami and Peterson's and negative in some cases. An extreme view is that public crop forecasts provide no information beyond that already held by traders. Sumner and Mueller (1989), however, showed that USDA crop forecasts for corn and soybeans did move the market, demonstrating their information content.

Agricultural Market Advisory Services (AgMAS) addressed the long-standing question of whether market advisory services provide benefits to farmers. Services that provided "real time" marketing recommendations were evaluated against several different standards, as summarized by Irwin, Good, and Martines-Filho (2006). The conclusion was that advisory services as a group could not consistently outperform market benchmarks but that they performed better against farmer benchmarks, raising "the possibility that [advisory services] . . . provide the opportunity for some farmers to improve performance relative to the market" (p. 180). Cabrini, Irwin, and Good (2007) investigated the effect of the "style" of advisory service, measured *inter alia* by the intensity of futures and options use and by the activeness of the marketing recommendations. Active services that made large bets on price movements did obtain a higher average price than more conservative programs, but the higher average return was also accompanied by higher risk.[10]

Of course, this is not to say that public investment in market information systems themselves is not valuable, because these systems provide much of the information used by the professional advisory services, along with the observable "market benchmarks" that both farmer and professional advisory service performance is judged against. Given the AgMAS results, however, it is surprising that more research attention has not been given to estimating the returns from public investment in marketing extension advisory programs for farmers, including those provided by university extension programs.

Futures and Options Markets

Contribution #10: Working's early research shifted the emphasis away from futures markets as pure risk-shifting instruments and toward understanding the importance of capturing profits when making hedging decisions. The application of portfolio management concepts has led to improved conceptual models of hedging and better empirical estimates of optimal hedging rules. An associated literature has improved forecasts of basis levels, basis changes, and future prices, all of which have important implications for commodity market participants.

For many years conventional wisdom held that owners of assets subject to the risk of a price decline would hedge by selling futures contracts in an amount equal to the size of the long cash position (e.g., Hicks 1946). If the two prices moved in parallel, a loss in asset value would be offset by a corresponding gain on the futures contract. Speculators were assumed to require an incentive to hold the offsetting long positions, and if hedgers pay a risk premium to speculators, the current futures price should be a downward-biased prediction of the futures price at maturity.

In a groundbreaking early contribution, H. Working (1953) argued that this view of hedging and speculation mischaracterized how futures markets worked. He stressed that firms

[10] Also, results for the "active group" were influenced significantly by a single firm, and since the sample period was short, it was difficult to determine whether this firm had a superior approach and/or information or was just lucky.

hedged to ensure a positive margin on their business activities. An inventory holder understands that spot and futures prices converge as the maturity month approaches. Thus, the decision of whether to store grain and hedge depends on the expected change in the basis (spot price relative to futures) over the storage interval. A hedge earns the convergence (change in basis) whether the price rises or falls. Working's emphasis on the importance of basis changes was novel at the time and ultimately had a major impact on our understanding of futures markets.

Working (1949) also made important contributions to the understanding of the relationship between futures prices and storage. As the price of storage (futures minus spot price) rises, inventories increase. But with competitive arbitrage, the price of a futures contract cannot exceed the current spot price by more than the cost of storage from the current time to contract maturity, which implies that the supply of storage function is nonlinear. Working's (1933) original empirical estimate of the concept was confirmed in a recent article by Carter and Revoredo Giha (2007).

Working was reluctant to interpret futures prices as forecasts of the maturity-month price (Working 1942) but subsequently wrote that futures prices are "reliable anticipatory prices" (Working 1962). If futures prices reflect all current information about the price at maturity, then in modern terminology we would say a futures quote is an estimate of the "rationally expected price" in the maturity month. Tomek and Gray (1970) suggested that the emphasis on futures prices guiding inventory decisions obscured their forward-pricing function and that futures prices can and do play both allocative and forecasting roles. Tomek and Gray also pointed out that even if futures markets correctly reflect all existing information, the precision of forecasts may differ among markets because forecasts differ in the amount of information available to market participants. In particular, markets with continuous inventories differ from a market with discontinuous inventories.

Working also made important contributions to our understanding of the roles of market participants, especially hedgers and market makers (scalpers), in price formation. One of his hypotheses was that some hedging demand is required for futures markets to be successful, so they cannot exist based on speculation alone (Working 1967). He pointed out that since matching short and long orders do not arrive simultaneously, scalpers are required to temporarily offset transactions. Scalpers earn their living by providing this needed liquidity. He also thought that risk premiums were not required to attract speculation (Working 1962). At about the same time, his colleague Gray (1961) published an important paper that did not find empirical evidence of risk premiums.

As Working's career was coming to a close, his ideas were being extended in a variety of directions. Paul and Wesson's (1967) concept of "the price of feedlot services" developed Working's ideas by investigating the role of relative prices in making hedging decisions for a nonstorable commodity, namely live cattle. When considering the number and types of feeder cattle to place on feed and whether or not to hedge, the feedlot operator can observe prices for the constellation of live cattle futures contracts, for feeder cattle in various weight categories, and for feed ingredients. These prices can be used to estimate a margin, the price of feedlot services, which can be approximately ensured by selling cattle futures and buying the inputs.

To evaluate the expected return to a potential hedge, however, decision makers need basis forecasts. For example, if a cattle feeder sells futures contracts that will be offset in June, the return to the hedge depends on the realized basis in June. Agricultural economists have developed a variety of models of basis behavior (e.g., Hauser, Garcia, and Tumblin 1990), but such forecasts are generally imprecise and so basis risk remains.

In contrast to forecasts of basis levels, forecasts of basis convergence for grains over a storage interval are conditional on a known initial basis and have often been relatively precise. For example, Heifner (1966) demonstrated that Working's simple model provided forecasts of basis convergence for corn in Michigan that performed far better than models forecasting seasonal changes in spot prices. Nonetheless, the degree of convergence of spot and futures prices varies from year to year. Research on this topic has been motivated mainly by occasions of exceptionally poor convergence which appear to have been caused by contract provisions becoming dated (e.g., Paul, Kahl, and Tomek 1981; Peck and Williams 1991). Cash settlements may seem like the solution to the convergence problem, but as Paul (1985) pointed out, an acceptable cash price or index to use for the settlement is often difficult to obtain for agricultural commodities.

Portfolio theory has motivated much research on optimal hedges, with the optimum usually defined in terms of expected returns and the riskiness of these returns, commonly represented by variance. In this context, agricultural economists have derived models of optimal hedges for agricultural firms under a variety of assumptions (e.g., Peck 1975; Baillie and Myers 1991; Lence 1996; Vukina, Li, and Holthausen 1996).[11] Most empirical research has estimated the hedge that minimizes the variance of returns. These estimates typically imply larger hedges than are observed in practice, particularly for farmers. But Peck and Nahamias (1979) found that optimal hedges estimated for flour millers were below the firms' actual practices. The differences between research results and firm practice likely reflect misspecification of hedger objectives and exclusion of transaction costs (e.g., Lence 1995, 1996; Collins 1997).

An assumption often used to justify the variance minimization criterion for optimal hedges is that futures markets are price efficient (futures price changes for a contract with the same maturity cannot be predicted). If this assumption is correct, the size of the optimal hedge is not influenced by a potential speculative return from the futures position. Many articles have tested whether this efficient pricing condition is met in agricultural futures markets. No definitive results stand out, but if there is evidence of predictability, the ability to profit from such predictions is usually low and fleeting, especially in liquid, well-functioning markets. A different but related question is whether futures prices forecast as well as or better than other forecasting models. In an influential paper, Just and Rausser (1981) found that futures prices performed better, on average, than forecasts from commercial sources. But in the same journal issue, Martin and Garcia (1981) concluded that live cattle futures markets (one of the commodities analyzed by Just and Rausser) did not provide better forecasts than lagged prices.

Trading in options on agricultural futures contracts started in 1984. Agricultural economists have studied optimal portfolios that included options and found that whether options enter the hedger's portfolio depends on various assumptions. For example, if both futures and options are priced efficiently, the options are redundant assets (e.g., Lapan, Moschini, and Hanson 1991). Option premiums depend critically on the probability distribution of the underlying asset's price movements. The original Black model for valuing options premiums assumed that the underlying price changes are lognormally distributed. Empirical research has shown, however, that the actual distributions of commodity price changes are time varying and not lognormal. This led to alternative commodity option pricing models that allowed for more flexible probability structures for the underlying futures price movements (e.g., Myers and Hanson 1993). Option pricing models also provide a conduit for extracting estimates of the underlying futures price probability distributions from the observed market option premiums (e.g., Fackler and King 1990). In a more recent application, Egelkraut, Garcia, and Sherrick (2007) found that the volatilities implied by commodity options premiums accurately reflect the patterns of realized volatilities observed from past price movements. Moreover, they conclude that the implied forward volatility estimates typically perform better than alternatives as a forecast of the realized volatility.

Regulation of futures and options markets is a topic that has received relatively little research attention despite the growing complexity of markets for derivatives. Futures markets for agricultural commodities have contracts with five to twelve expiration months per year and often trade for delivery two or more years into the future. Put and call options exist on many of these futures contracts, each with numerous strike prices. In addition, elevators and traders offer forward and/or marketing contracts, some of which contain option-like features. Also, the historical debate about the effects of speculation on price behavior has evolved to concerns about the potential repercussions of increased speculation due to the rise of "commodity funds."

Agricultural Insurance

Contribution #11: Research on moral hazard, adverse selection, and systemic risk has helped explain the extensive government participation

[11] Most of these optimal hedging models assume no change in the futures position over the life of the hedge, but a literature also exists on optimal dynamic hedges (allowing the futures position to be revised as new information arrives about yields and prices). The first dynamic hedging model for agriculture was developed by Karp (1987), while Martinez and Zering (1992) provided an empirical application of his approach. Martinez and Zering found that transaction costs generally offset any gains from dynamic updating of the hedge.

in U.S. agricultural insurance markets. Research on index-based insurance, especially area-yield contracts, has provided further impetus for expanding the range of insurance products available to farmers and improving program efficiency. Improved knowledge of loss distributions and factors influencing farmer demand for insurance has led to better understanding and performance of agricultural insurance markets.

Before the Federal Crop Insurance Act of 1938, agricultural insurance in the United States was offered by private companies that primarily insured specific risks, such as hail or fire damage. The 1939 act established the Federal Crop Insurance Corporation, which proceeded to design and underwrite offerings of multiple-peril (all-risk) yield insurance for major crops. These programs were initially plagued by low participation and indemnities that far exceeded premiums—problems that spurred considerable debate and research about the way agricultural insurance contracts should be designed, the problems they face, and ways their performance could be improved.

Halcrow (1949) laid out many of the issues that later became centerpieces of both research and applied interest in agricultural insurance. He highlighted the difficulty of objectively measuring yield loss probabilities for individual farms, pointed to the moral hazard and adverse-selection problems associated with using individual farm yield experiences to rate premiums, and foreshadowed the later development of index-based insurance products (primarily area-yield insurance and weather-based insurance).

While Halcrow and other early writers had raised concern about moral hazard and adverse selection in agricultural insurance, it was not until formal models of insurance under asymmetric information began appearing in the general economics literature that agricultural economists began addressing asymmetric information problems in detail. Ahsan, Ali, and Kurian (1982) provided a formal model of adverse selection in agricultural insurance and found that competitive crop insurance markets would be inefficient or nonexistent under such conditions. They argued that this creates a potential role for welfare-improving direct provision of crop insurance by the public sector. Nelson and Loehman (1987) extended the analysis to moral hazard but argued that public provision of information and the application of contract design principles were better ways of solving asymmetric information problems than public provision of subsidized insurance. Chambers (1989) provided a comprehensive theoretical treatment of moral hazard in individual farm-based crop insurance contracts, including analyzing the conditions under which an insurance market will emerge and investigating the optimality of alternative contract designs.

Increased awareness of moral hazard and adverse-selection problems eventually led to renewed interest in index-based agricultural insurance and, in particular, to a rediscovery of Halcrow's area-yield crop insurance concept (Miranda 1991; Skees, Black, and Barnett 1997). But while this research highlighted the advantages of area-yield insurance in obviating moral hazard and adverse selection, it also noted that area-yield products exposed farmers to the risk of paying premiums, experiencing large losses, but still not getting paid an indemnity because individual farm yields are only imperfectly correlated with area yields. Nevertheless, this research provided a strong impetus for the development of several area-based crop insurance products in the United States.

Other forms of index insurance have also been studied, especially weather-based instruments (e.g., Richards, Manfredo, and Sanders 2004; Turvey, Weersink, and Chiang 2006). Like area-yield insurance, weather-based insurance reduces or eliminates adverse selection and moral hazard, but designing contracts that can insure effectively against individual farmer yield losses remains difficult. Weather-based contracts and those based on other objectively observable indices (such as the normalized difference vegetative index calculated from satellite imagery) have been suggested as effective means of overcoming the incomplete insurance market problem in developing countries. Hazell, Pomareda, and Valdéz (1986) and Hazell (1992) provided early analyses, and Sakurai and Reardon (1997), Skees, Hartell, and Hao (2006), and Barnett and Mahul (2007) have provided more recent contributions.

Another important issue is the systemic (or catastrophic) nature of many insured events in agriculture. Weather conditions and crop yields are often correlated across space, which means that insurers can be exposed to catastrophic losses occurring at a single point in time. Studies by Miranda and Glauber (1997), Skees and Barnett (1999), and Duncan and Myers (2000) emphasized the role of reinsurance in addressing the systemic risk problem, including potential public provision of reinsurance services, and highlighted the conditions under which systemic risks can reduce insurance supply and lead to a breakdown of insurance markets.

Significant contributions to empirical knowledge of agricultural insurance markets have led to improved estimates of probability distributions for insured events (e.g., Goodwin and Ker 1998; Ker and Goodwin 2000), which is critical for pricing agricultural insurance contracts correctly. Sherrick et al. (2004) focused on how to transform these probability distribution estimates into efficient prices for agricultural insurance products. Others have provided empirical estimates of farmer demand for agricultural insurance products, which has helped explain why farmers typically participate so little without premium subsidization (e.g., Goodwin 1993; Smith and Baquet 1996).

Conclusions and Looking Forward

This article provides a perspective on a century of research on agricultural markets. There have been outstanding contributions and much has been achieved. But more work remains to be done. Agricultural market analysis will remain a vibrant research field as the Agricultural and Applied Economics Association moves forward into its next century.

Demands for stronger vertical coordination in the food system as a means of satisfying increasingly diverse consumer preferences are changing the landscape facing food supply chain participants. The consolidation trend in the marketing sector seems inexorable, implying that noncompetitive behavior and its effects will remain high on the research agenda. Similarly, investigating the benefits and distributional impacts of stronger vertical coordination, through contracting and other means, will also remain a fertile area for the future. Empirical price analysis research will face new data challenges in an environment where fewer and fewer transactions are being conducted in open markets, but this creates research opportunities as we seek answers to how different vertical coordination forms coexist and interact with one another. Paying close attention to the time-series properties of commodity market variables will continue to be important, irrespective of whether a structural or nonstructural modeling approach is being used. In the future, however, attention is likely to continue to move beyond linear ARIMA models to better account for the nonlinearities and regime-shift behavior that appears to characterize many agricultural markets.

We also have some cautions. Advances in econometric methodologies and computing power give contemporary researchers great advantages over their predecessors, but these tools must be used wisely. Greater attention needs to be given to the quality of underlying data, whether generated from primary sources or obtained from public or private providers. Results need to be interpreted and evaluated cautiously using detailed knowledge of the relevant economic theory and characteristics of the underlying markets and institutions under investigation, not just the statistical properties of estimates. The understandable temptation to be among the first to apply new advances in theory or methodology to an agricultural market setting should be tempered with an evaluation of the appropriateness and relevance of the application, and recognition that our claim for distinctiveness hinges upon agricultural economists having a uniquely applied focus generating knowledge that informs important questions that are widely viewed as relevant.

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