



AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search

<http://ageconsearch.umn.edu>

aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

Pricing Efficiency in Agricultural Markets: Issues, Methods, and Results

Steven T. Buccola

The notion of price efficiency is discussed in the context of an optimal information market. Approaches for assessing price or market efficiency are examined, including temporal, spatial, and form-transformation paradigms. The interdependent nature of these paradigms is stressed. Finally, a review is conducted of recent price efficiency research in cash, futures, and manufacturing-retailing markets. Research generally has paid inadequate attention to agents' costs, including the cost of risk and the human capital cost of acquiring and evaluating information.

Key words: informational efficiency, market efficiency, pricing efficiency.

A large portion of research in agricultural economics is concerned with the efficiency of prices in some industry or subsector. Efficient prices are ones that induce an efficient resource allocation, that is, maximize (individuals' utilities of) output given the current resource stock. Thus, pricing efficiency is inseparable from, and an important part of, economic efficiency and growth in a broader sense.

The present paper reflects on the price efficiency literature with a view to identifying its major lessons and weaknesses. It is not the first essay of its sort, and I owe a great deal to the more specialized reviews in Farris (1964, 1983); Tomek and Robinson; Hayenga; Marion; and more recently in Kilmer and Armbruster. These works have considered many of the nonprice factors with which price interacts, including managerial (productive) efficiency, property rights, contract enforcement, consumer rationality, market regulations, and exchange institutions.

The justification of my own effort is that it attempts to draw together some common themes in what heretofore have been distinct efficiency research traditions. Although they address fundamentally the same questions, these traditions are only beginning to take notice of one another. I argue that we have learned

a great deal in the past several decades about agricultural markets' price efficiency but that our view is obscured by inadequate attention to agents' costs.

Issues in Price Efficiency

It is helpful to consider first the proximate causes of price inefficiency since these often are easier to locate than the inefficiency itself. Potential causes, unfortunately, are numerous including nonoptimizing behavior, inefficiency in related markets, missing markets, non-excludable consumption, successful collusion, and risk. The last factor is an important element in all the others.

Risk Distortions

Risk or incomplete information induces inefficiency in a number of ways. First, experiments show that when supply or demand has just shifted in response to changes in external value-relevant information, transaction prices do not immediately adjust to the new equilibrium. Traders have not yet discovered the changes in one another's reservation prices which the new information has brought about. Prices fluctuate out of equilibrium and cannot be completely efficient. Excluding adjustment cost, efficiency improves as (a) mean price approximates competitive equilibrium, and (b) price variance diminishes. Factor (a) depends

Steven Buccola is a professor, Department of Agricultural and Resource Economics, Oregon State University.

Oregon Agricultural Experiment Station Technical Paper No. 8761.

on relative supply and demand curve slopes, information (dis)advantages of buyers over sellers, and mean-buyer versus mean-seller risk aversion (Smith 1962). Factor (b) depends on communication costs, the commodity's average budget share, intertrader distribution of reservation price information, and risk aversion (Stigler; Buccola 1983). These causes are not necessarily related to market manipulation, entry forestalling, or other anticompetitive conduct.

Second, each trader's long-run reservation price in a risky market is the expectation of future price less full cost of transferring the good to the future market. An optimizing trader seeks to minimize the sum of information cost and of losses stemming from ignorance (Theil, pp. 73-81). If marginal information cost is positive, price and cost expectations frequently are in error because they are based on erroneous interpretations of value-relevant information; hence, current reservation prices often misforecast the future price. Stein shows that any such forecast error incurs a social cost; the part of the error that is avoidable is the deviation between subjective and objective price expectation (Bayesian error). As the mean and variance of Bayesian error approach small quantities, the market approaches a (noisy) rational expectations equilibrium and is as efficient as possible.

Traders cannot have rational expectations as soon as new information arrives (DeCanio; Lovell). Expected implications of the new information must be learned. In the meantime, average price generally will be biased away from the objective competitive expectation. An optimal learning rate and thus rate of approach to equilibrium is achieved if traders use external information so as to equate its marginal social costs and benefits (Grossman and Stiglitz). Traders will do so if they are permitted to make long-run human and physical capital adjustments and if information markets are undistorted.

Anticompetitive Distortions

It is important then to ask whether information markets are undistorted, that is, fully competitive. First, information's marginal social cost may not equal its marginal private cost because value-relevant information becomes impounded into price and thus has free

riders (Grossman). If the externality inhibits information acquisition, prices cannot be efficient in any meaningful sense. Second, knowledge about the quality of an information set may be inadequate (Akerlof). Buyers will bid the information's value down to a risk-adjusted expectation, discouraging production of better and more costly information. Third, if effective barriers are raised to information entry, information use may be collusive (Perloff and Rausser; Spolleder). Informed individuals then may react to downsloping marginal benefit functions and so undercommunicate information. Price forecasts will be noisier than they should be.

A possible form of collusion is where one side of a market excludes information from another, biasing the equilibrium price. It is unclear, though, whether buyer-seller information asymmetry is itself a proximate source of price inefficiency. The average buyer may have accumulated more information processing capital than has the average seller and he will demand (at least) a competitive return to capital. One could not include among entry barriers the mere cost of acquiring information capital; anticompetitive barriers to the acquisition of the capital must be present.

Collusive arrangements biasing price away from competitive equilibrium, therefore, are distorting whether they appear in goods or information markets. The arrangements cannot long survive without entry barriers, so identifying barriers has become an important topic of research. The most obvious entry barriers are those erected by governments: restrictive licenses, marketing quotas, minimum quality standards, and the like (French). Size economies and incumbents' threats to employ unused capacity often are considered effective barriers, but game theoretic studies cast doubt on this. The threat to use the excess capacity may not be believable (Dixit; Fudenberg and Tirole). Advertising generates brand-specific goodwill that entrants have difficulty acquiring as long as the brand is legally protected (Connor); this would be anticompetitive if returns exceed the cost of producing the advertisable differences. Perhaps the most impervious entry barrier is the difference between individuals' capacity to learn. Some cannot, even if information is free, acquire as much human capital as others and this advantage will generate a rent. The rents imply inefficiency in a

broad sense, but efforts to overcome them would be redistributive rather than wealth creating.

Finally, (in)efficiency in a single market does not necessarily imply aggregate (in)efficiency. If a market is distorted, a related market may have to be distorted so that the wealth sum of the two is maximized (Lipsey and Lancaster). This second-best concept is useful in evaluating statements that some agricultural markets tend to overshoot—form biased forecasts of future prices. The biases may be socially efficient if they partially compensate for distortions in nonagricultural markets (Frankel). Thus, some markets may be inefficient in the small but efficient in the large.

Methods of Assessing Price Efficiency

Analysts assess markets' price efficiency by looking for signs of disequilibrium in either the short or long run. There is disequilibrium in a short-run sense if market quantities do not clear; disequilibrium in a long-run sense if profits have nonzero expectation or variance that is too large given information cost. The distinction is not as precise as it sounds. If markets do not clear, someone earns a loss or excess profit. If mean profit is nonzero, quantities do not clear in the sense of equating demand with long-run unit and marginal cost. Yet the literature on quantity disequilibria or bid-ask price differences typically refers to rather short-run supply and demand schedules.

Short-Run Efficiency

Such a short-run genre has occupied little of agricultural economists' time. Students of centrally planned economies often cite evidence of empty shelves, waiting lines, parallel markets, and favoritism. These signs are useful in highly inefficient environments but typically are not refined enough for developed agricultural markets. A more accurate approach is to conduct experiments with subjects whose short-run reservation prices are known. Observed disequilibria then can be related to experimental conditions known to exist in nonlaboratory environments—such as the relative inelasticity of demand in some farm-level markets (Smith 1982; Buccola 1983). Ziemer and White (1982a, b) take the alternative strat-

egy of including in their econometric model disequilibrium expressions $Q = \text{Min}(D, S)$ and $dP = \lambda(D - S)$, where S , D are supply and demand quantities, Q is actual trade, dP is price change, and λ determines the rate of Walrasian price adjustment. As a market's inability to maintain equilibrium grows, adjustment parameter λ falls.

Long-Run Efficiency in the Time Domain

Equilibration to a long-run ideal has, in contrast to the short run, been extensively studied. Agricultural firms earn profits by adding time, form, or place utility. Research tends to specialize in one or another of these dimensions.

Consider, first, the time domain and let C_{st} be full competitive unit cost (including interest, brokerage, capital costs, and any risk premium) of carrying a good or contract from t to $t + 1$.¹ Perfectly efficient storage requires storage profit, $\pi_{t+1} = P_{t+1} - (P_t + C_{st})$, be zero, that is, all information about P_{t+1} be impounded in P_t . In practice, information, Φ_t , available at t about P_{t+1} is incomplete. If all available information is impounded in P_t , profit's conditional probability distribution, $f(\pi_{t+1} | \Phi_t)$, is identical to its unconditional distribution, $f(\pi_{t+1})$, since Φ_t already is contained in π_{t+1} through P_t .

Identity of conditional and unconditional distributions has two immediate consequences. First, conditional and unconditional expected profits equal each other and are zero:

$$(1) \quad E(\pi_{t+1} | \Phi_t) = E(P_{t+1} | \Phi_t) - (P_t + C_{st}) \\ = E(\pi_{t+1}) = 0.$$

Using forecast information, Φ_t , will not improve expected profit, which was eliminated when competitive traders incorporated Φ_t in their reservation bids on P_t . Since profits are considered net of risk premia, this corresponds to the zero certainty equivalent condition in Paris (p. 135).

Second, conditional and unconditional profit variances are equal to one another and are a minimum given Φ_t :

$$(2) \quad \text{Var}(\pi_{t+1} | \Phi_t) = \text{Var}(P_{t+1} | \Phi_t) = \text{Var}(\pi_{t+1}).$$

Using Φ_t will not reduce *ex ante* profit vari-

¹ Term C_{st} includes the various forms of transactions costs outlined in Raussler, Perloff, and Zusman. With efficiency research, these costs must be at their competitive levels.

ability through a reduction in price forecast variance, which already was minimized when traders acted on Φ_t to bid on P_t . Similar conditions might be defined for profit's higher central moments.

Fama's distinction between Φ as a good's own profit history, as all "public" information, and as all "public and private" information has guided most research on efficiency in the time domain. Price is weakly efficient if (1) and (2) hold for the first information class, semistrong efficient if they hold for the second, and strongly efficient if they hold for the third. In reality, most information has a non-zero finite cost and the distinction between public and private information is misleading.

Long-Run Efficiency in Time-Space-Form

A joint weak-form test of (1) and (2) is to determine whether $f(\pi_{t+1} | \pi_t, \dots, \pi_{t-k}) = f(\pi_{t+1})$, that is, whether the regressors in

$$(3) E(P_{t+1} - P_t - C_{st}) = f[(P_t - P_{t-1} - C_{s,t-1}), \dots, (P_{t-k} - P_{t-k-1} - C_{s,t-k-1}), e_{t+1}] = f(\pi_t, \dots, \pi_{t-k}, e_{t+1})$$

are nonsignificant and whether error term e_{t+1} is serially independent with mean zero.² Testing (3) requires imagination because numerous specifications of f are possible and nonlinear serial dependence may persist in e_{t+1} even if $E(e_{t+1} | e_t) = E(e_t)$. Searching for nonlinear dependence usually involves seeing whether alternative mechanical trading rules earn money; this method does not lend itself well to significance testing. Tests of (3) also have low power when long lags are utilized. Of course, even if (3) is tested adequately, it tells us little unless unit storage costs have been correctly modeled. In particular, if (3) is estimated in the absence of $C_{s,t-k}$, all k , significant lags may appear even if the null hypothesis in (3) is true. Pricing efficiency is gauged through profit behavior not price behavior.

Semistrong- and strong-form tests of (1) and (2) require a market model of the factors influencing P_t . Suppose that under competitive conditions P_{t+1}^i is determined by price P_{t+1}^j

a supply- or demand-related item and by other information, θ_t , such as inventories. Competitive traders will bid on P_t^j, P_t^i so as to equate $E_t[U(\pi_{t+1}^j)]$ with $E_t[U(\pi_{t+1}^i)]$, where C_{st}^i in $\pi_{t+1}^i = P_{t+1}^i - P_t^i - C_{st}^i$ may include relative production cost of i and j . Thus, information about P_{t+1}^j (such as $\pi_{t-1}^j, \dots, \pi_{t-k}^j$) will be reflected in P_t^i . The market for j (i) is efficient with respect to i (j) if P_t^j (P_t^i) fully impounds information on i 's (j 's) previous net returns as well as information on θ_t . That is, for instance, conditional probability $h(\pi_{t+1}^j | \pi_t^j, \dots, \pi_{t-k}^j, \pi_t^i, \dots, \pi_{t-k}^i, \theta_t)$ equals unconditional probability $h(\pi_{t+1}^j)$. These conditions may be tested jointly by determining whether the regressors in

$$(4) \begin{aligned} \pi_{t+1}^j &= g_1(\pi_t^j, \dots, \pi_{t-k}^j, \pi_t^i, \dots, \pi_{t-k}^i, \theta_{1t}, u_{t+1}) \\ \pi_{t+1}^i &= g_2(\pi_t^j, \dots, \pi_{t-k}^j, \pi_t^i, \dots, \pi_{t-k}^i, \theta_{2t}, v_{t+1}) \end{aligned}$$

are significant and whether u_{t+1}, v_{t+1} are mutually and serially independent with mean zero.

Much energy has been expended searching for lags between prices of supply- or demand-related goods. Significant lags in these studies do not necessarily imply inefficiency, since (4)'s null hypothesis permits P_t^j and P_t^i to be correlated with P_{t+1}^j and P_{t+1}^i . Further, if unit costs C_{st}^j, C_{st}^i are omitted from (4), lengthy lags may arise even in price first differences, reflecting serial changes in competitive unit cost. Popularity of futures market studies likely owes much to the fact that futures costs (brokerage, real interest, and possibly a risk premium) are serially more stable and easier to assess than are the physical storage and production costs in cash markets. When (4) is applied to futures in which costs are serially constant, the null hypothesis says simply that current futures prices P_t^j, P_t^i are better forecasts of the respective maturity-date cash prices than are econometric models incorporating $\pi_t^j, \dots, \pi_{t-k}^j, \theta_t$. Walraven and Rausser lately have proposed a dynamic multiplier test of the joint efficiency of several related cash or futures markets.

If the alternative hypothesis in (4) is true, using information, $\Phi_t \equiv (\pi_t^j, \dots, \pi_{t-k}^j, \theta_t)$, would reduce mean square error of profit forecasts. Current prices evidently do not completely impound this information, and it is appropriate to ask why. The value of the information may not be worth its cost. More generally, a market is price efficient with respect to Φ if

$$(5) E_t\{U[(\pi_{t+1} - C_\Phi) | \Phi_t]\} < E_t[U(\pi_{t+1})],$$

where C_Φ is the cost of collecting, analyzing,

² In Fama's definition of weak-form efficiency, all costs are ignored except a good's purchase price. Thus, Φ , consists only of the good's "price history." This framework may be useful in securities speculation where other costs often are minor or stable, but it is not useful in agricultural cash markets.

and disseminating Φ . That is, Φ should not, taking into account its cost, improve forecast ability enough to increase expected utility. The case of P_i fully impounding Φ_i —the null hypothesis in (4)—is only a special case of (5) in which further considering Φ_i is useless because it is already present in P_i . Another special case is where Φ_i is not present in P_i but its forecast value is too low to compensate for its cost.³ Rausser and Carter refer obliquely to (5) when they say (p. 471) that a market is inefficient if Φ “generates probability distributions which in some sense stochastically dominate” use of the current price. Either criterion may, depending on the form of U , reflect forecast error moments of higher order than mean square error.

Spatial Analysis, Industrial Organization, and Price Efficiency

Spatial price efficiency usually also is based on a profit relation, the arbitrageur's income $\pi^{ij} = P^i - P^j - C_r$, where i, j refer to spatially separated markets that trade with one another and C_r is unit transport cost. Early studies ignored risk, concerned only whether $\pi^{ij} = 0$ or whether the two markets are “integrated” in the sense that P^i and P^j are correlated over time. Other than ignoring serially variable transport costs, these models were misspecified because they assumed the markets were efficient in time and form domains. That is, the models did not adequately allow for the alternative hypothesis that current prices in either market depend upon previous prices and on nonprice information. Spatially separated prices more accurately are treated as are any other prices in demand- or supply-related markets. Spatial arbitrage occurs in the face of risk and (5) applies. Ravallion, for example, shows that a complete set of price lags in each market can be used to distinguish between immediate spatial price adjustment and a tendency toward adjustment.

Although it rarely employs the language we have been using, the structure-conduct-per-

formance literature is greatly concerned with price efficiency. A performance ideal frequently tested is whether $\pi^{fr} = P^f - P^r - C_p = 0$, where P^f is final product price, P^r is price of a principal raw product, and C_p is competitive unit production cost. More often, mean annual unit profit, π^{fr} , is related to aspects of industry structure such as concentration ratios, product differentiation, and advertising expenditures (Marion; Marion et al.). These are tests for efficiency in the form domain. Inasmuch as processing occurs over time, C_p should include a risk premium as well as competitive return to capital. And since final product price is unknown at production time, profits randomly will deviate from zero. Prices P^f and P^r are examples of supply-related goods, so (5) again should apply.

In practice industrial organization has ignored expectations formation or it has treated the issue qualitatively. Such a lapse is serious when dealing in industries with substantial risks and in which, therefore, a firm's success depends heavily on its ability to process incomplete information. On the other hand, this literature dwells extensively on processing and storage costs, items often assumed away in tests for serially independent price changes. It is sobering to recognize that if unit costs in (1)–(5) are not competitive—minimum in some sense—the associated efficiency tests are invalid. In order to know whether costs are minimum, we need to assess productive efficiency, technological progressiveness, product differentiation, and conditions of entry in both input and output markets (Shaffer). These issues require qualitative judgment.

State of Empirical Results

Price efficiency research has been so extensive that no single summary can treat it exhaustively. However, a look at a sample of results is instructive.

Grain and Oilseed Markets

Studies of grain and oilseed efficiency usually have concentrated on the joint performance of futures and cash markets. Futures markets arose to reduce transactions cost of speculation (Stein) and thus encourage speculators to reveal more information about future cash prices (Grossman). Some of the elicited information

³ Criterion (5) can be violated in one of two ways: (a) inequality (5) is intact but traders use Φ , anyway; or (b) the inequality is reversed but traders do not use Φ . Condition (b) says that information is underutilized and this is the form of inefficiency most analysts consider. Condition (a) says information is overutilized: too much of it is impounded into price, given its cost. I do not believe it has occurred to anyone to test for (a). Yet, it may arise when agents behave irrationally or are forced by statute to take into account value-irrelevant information.

is impounded into cash prices themselves, so futures markets promote cash market efficiency (Burns; Peck, pp. 264-65). Still, a futures market may fail to reflect all the information it ought to given the information's cost.

One sign of such failure might be that the futures price is weak-form inefficient. Recently, Carter verified weak-form efficiency by finding that first differences of logs of Winnepeg barley and Chicago corn futures are non-significantly autocorrelated and that technical trading profits would be negligible. Gordon reported similarly that daily price changes in rice and sunflower seed futures were serially uncorrelated and that the number and position of turning points have been random. Gordon did find evidence that futures prices give biased forecasts of themselves. He hypothesized the bias results from excessive effect of a buy or sell order on sunflower's thin market price.

Another sign of failure might be that serial changes in a futures price are led by those in a related futures or cash market. Brorsen, Bailey, and Richardson conducted such causality tests in cotton markets and saw no evidence of cash leading futures. They found futures prices briefly lead cash ones, suggesting the latter are imperfectly competitive.

A third sign of poor information use might be that futures do not forecast the cash delivery price as well as do other sources of information. Early tests implied grain futures are unbiased forecasts of cash prices, although there were dissenting voices. Chavas, Pope, and Kao lately note that futures prices do not well reflect changes in government programs, so the latter can be useful, along with futures, in forecasting cash prices. Just and Rausser's report that corn and cotton futures prices give higher mean square forecast errors than do some econometric models seems to imply the futures are inefficient.

Confidence in these studies' conclusions about price efficiency varies directly with their attention to information cost. Buccola and Smith recently have shown that when traders' costs are ignored, price formation models tend to negatively bias the rate at which prices approach an efficient steady state. Cost of developing and maintaining forecast models is especially important. In a competitive information market, a price forecast service reduces forecast error enough to pay for the service's subscription cost, and I do not agree with Peck's conclusion (p. 266) that costs of many of these

models are "minimal." Even "simple" models are maintained, updated, and disseminated at substantial expense, considering the full salary and support costs of research and extension. Underestimating traders' costs usually will lead to overreporting the incidence of price inefficiency.

A clear implication of traders' costs for efficiency studies is seen in bias tests often conducted for futures markets. The standard bias model is to test for $a = 0$, $b = 1$ in $F_t = a + bF_{ti}$, where F_t is futures or cash price at delivery time t and F_{ti} is the price i periods ago of a contract to mature at t . The framework is derived by equating the expected right-hand side of (3) with zero, dropping storage costs, and moving P_t to the right. A finding that bias exists implies either that pricing is inefficient or that positive storage costs such as risk premia or convenience yields are present. Thus, Gray's attempt to find risk premia through backwardation in futures markets involved a presumption that any backwardation would not have been caused by inefficiency. Similarly, Kitchen and Denbaly's finding that current futures and current storage-cost-adjusted cash price differ by less than interest charges implies either that there is convenience yield to stockholding or that traders are inefficient. In order to determine which, we need independent evidence of storage costs and returns. Brorsen et al. and Antle take a step in this direction by econometrically assessing aggregate risk aversion, a component of the current aggregate risk premium.

Livestock Markets

Live cattle and hogs are not strictly storable and so have no clearly defined "storage cost." Hence, as Leuthold points out, there is no reason to expect a stable trend in the difference between current livestock futures and current livestock cash price. Inasmuch as futures prices serve to forecast holding costs as well as demand, one would not expect futures to be as efficient in livestock as in grains. In fact, there is little reason why livestock futures should outforecast cash prices.

Empirical results do suggest livestock futures are "inefficient." Leuthold, and later Martin and Garcia, found live cattle cash prices tend to do as well or better than futures prices in predicting delivery date cash prices. Peterson and Leuthold developed mechanical trad-

ing rules that earned profits in hog futures. Brandt, and Leuthold and Hartmann, provided mixed evidence that univariate and econometric forecasts outperformed hog futures prices. Shonkwiler showed that cash price expectations implicit in distant hog (and to some extent cattle) futures do not correspond to objective expectations, that is, are not rational. Hartzmark's recent review of actual trading profits showed positive long-run returns to speculation in live cattle and feeder futures.

These results easily can lead to false conclusions. First, many studies appear to give inadequate attention to the cost of analyzing and reporting information and to the cost of risk (Garcia et al.). In the absence of such analysis, inefficiency verdicts are premature. Perhaps the most we can derive from the negative evidence is that futures markets are less efficient in livestock than in grains. This failure might be explained by the relatively more difficult forecasting problem that livestock futures traders face. Second, inefficiency would not imply livestock futures are valueless. Stein (p. 14) indicates that weak-form efficiency in cattle and hog cash prices increased dramatically after futures markets were introduced, implying expectations became more rational. Cash-versus-futures efficiency tests can be misleading because performances in the two markets are mutually dependent.

Evidence has accumulated that some inefficiency in livestock cash prices is related to industry structure. For example, packer concentration appears to depress significantly regional fed steer prices (Menkhous, St. Clair, and Ahmaddaud) and slaughter lamb teleauction prices, although the relation between lamb packer size and profits is unclear (Ward). Fed beef prices may take several quarters to approach equilibrium after being shocked by new information (Ziemer and White 1982a); this apparently isn't matched in the nonfed sector (Ziemer and White 1982b) and is difficult to explain (Shonkwiler and Spreen). Lang and Rosa note that local cattle prices frequently are more variable than those in centralized markets because local buyers have more information than do local sellers. But appeals to information asymmetry sometimes are overly hasty. Experiments suggest noncentrally discovered prices vary more around competitive equilibrium than do centrally discovered ones even when information is symmetric (Tomek; Buccola 1985).

Food Manufacturing and Retailing

Many view concentration, advertising, and product proliferation rather than poor information use as the principal threats to price efficiency in food manufacturing and retailing. Consensus is that concentration in food manufacturing is growing and that there is a positive relation between concentration and unit profit (Kinnucan and Sullivan). The relation may be discontinuous, showing bursts of increased profitability at critical concentration ratios (Miller). Indeed, oligopoly theory would suggest such discontinuity. Concentration-profit correlations give no clear idea of the welfare losses from concentration, and it helps to keep loss magnitudes in mind. In a study that may provoke response, Gisser estimates that if pricing is collusive, deadweight welfare loss from oligopoly in U.S. manufactures is at most .29% of GNP. His tests suggest that pricing instead is more typically Cournot-Nash, giving an annual welfare loss of about one steak dinner per family. It would be useful to conduct such a study in the agricultural processing industries.

Positive correlations between advertising expenditures and unit profits also are strong and there is evidence these two are simultaneously determined with concentration (Connor; Zellner). Food retail industry performance is especially complex and remains controversial. Advertising either may clarify or confuse buyers' alternatives. Stiglitz' work implies that when consumer search costs are positive, reducing the number of retailers can reduce, not increase, price. Benson and Faminow argue cross-store differences in food prices may well be Pareto optimal given consumer travel and convenience costs.

There is longstanding concern that oligopoly prices are too rigid. Carlton lately confirms that price stability grows with concentration in a wide variety of industrial markets and Shonkwiler and Taylor show that frozen orange juice prices respond only to nonzero minimum changes in input prices. Price stabilization improves efficiency as long as it successfully moves prices nearer the long-run competitive equilibrium implied by current information. Thus, it is efficient to ignore input price movements that are temporary and non-equilibrating. The task in price efficiency research is to determine whether stabilization reduces a market's sensitivity to long-run as

well as to short-run equilibria. Insensitivity to the long run occurs if price stability comes chiefly from a firm's uncertainty about competitors' responses. A fruitful area for research of this type is in the discovery of contract terms (Rausser, Perloff, and Zusman). Food processors' heavy use of annual grower contracts appears to stabilize intrayear changes in row crop prices. Portions of the avoided changes likely were disequilibrium ones but significant long-run error in processor pricing may occur (French and King).

Finally, food subsectors tend to have price discovery centers (often where the product most notably changes form) and noncenter firms' price markup practices may be inefficient (Hayenga; Rogers). First, the markup or other formula may ill represent mean supply and demand for the value added. Second, noncenter firms' responses may be slow, so that price information is not passed on in a timely manner (Heien; Kinnucan and Forker). However, some lags are cost based. Wohlgenant demonstrates that quadratic inventory cost functions generate a lag between wholesale and retail prices if processors have rational expectations. Even if price formulae induce inefficiency in a gross sense, they are efficient in a net sense if the social cost of the distortion is less than the cost advantage of permitting a center to specialize in price discovery. Accurate estimation of such costs is necessary before conclusions about efficiency can be drawn.

Conclusions

Most efforts to assess pricing efficiency essentially are attempts to discover unjustifiable profits in markets where costs are assumed minimum. In a nonrandom world, any profit is unjustified because it would imply departure from long-run competitive equilibrium. In a world where news arrives randomly, profit too is random and one can require only that its risk-premium-adjusted distribution collapses to zero to an extent consistent with information cost.

Statistical innovations for assessing distributions' information content seem to have obscured the importance of the analyst's cost specification. Absence of lags in price first differences may indicate efficiency, but presence of lags alone does not signify inefficiency. Se-

rial changes in cost also must be taken into account, including opportunity cost of missed sales in related markets, premia for operating in risky environments, and the full amortized value of physical and human capital. These costs typically are difficult to measure, and it begs the question to estimate them as the mean deviation between current and future price.

Determining whether costs are competitive or minimum involves assessing the relevant markets' structure and conduct. Observed costs might be assumed minimum if firms are numerous, inputs and products are standardized, and there are no evident nonmarket entry barriers in product or input markets. Since industrial organization studies of these issues reasonably should include risk costs, the potential for circularity in efficiency research is great.

Evidence of price inefficiency has varied widely. This reflects, partly, differences in industries addressed and study methods employed. It results also from underlying randomness in economic processes that leave investigators with only probabilistic conclusions about market condition. The most important determinants of a market's efficiency appear to be the amount and volatility of information the market must absorb and the immobility of its physical and human capital. Price-difference lags induced by immobility are efficient if they guide reinvestment so as to minimize disequilibrium losses plus the costs of capital adjustment; that is, profits should be autoregressive if investment costs call for it (Sosnick; Rosen). Similarly, agents are efficient who learn quickly enough the forecast implications of new information. They will do so if they invest adequately in human capital.

An efficient market is one in which welfare cannot be improved without reducing minimum costs, that is, without further economic development. It is a matter of convenience whether utilities are expressed explicitly or as risk-premium-adjusted expectations of willingness to pay. Inasmuch as individuals' utilities differ, some aggregation—a social welfare functional—is required. For studies ignoring welfare distribution, the appropriate aggregation is the average of (perhaps weighted) utilities of the relevant economic groups (Harsanyi). Attention to distribution requires a broader notion of social welfare which permits the welfare functional to be concave in its arguments

(Sen). In either event, efficiency analysis is founded on social values as Just, Ladd, and others have said.

[Received June 1988; final revision received December 1988.]

References

- Akerlof, G. A. "The Market for 'Lemons': Quality Uncertainty and the Market Mechanism." *Quart. J. Econ.* 84(1970):488-500.
- Antle, J. M. "Econometric Estimation of Producers' Risk Attitudes." *Amer. J. Agr. Econ.* 69(1987):509-22.
- Benson, B. L., and M. D. Faminow. "An Alternative View of Pricing in Retail Food Markets." *Amer. J. Agr. Econ.* 67(1985):296-306.
- Brandt, J. A. "Forecasting and Hedging: An Illustration of Risk Reduction in the Hog Industry." *Amer. J. Agr. Econ.* 67(1985):24-31.
- Brorsen, B. W., D. Bailey, and J. W. Richardson. "Investigations of Price Discovery and Efficiency for Cash and Futures Cotton Prices." *West. J. Agr. Econ.* 9(1984):170-76.
- Brorsen, B. W., W. R. Grant, J. W. Richardson, and L. D. Schnake. "Impacts of Price Variability on Marketing Margins and Producer Viability in the Texas Wheat Industry." *West. J. Agr. Econ.* 9(1984):342-52.
- Buccola, S. T. "Pricing Efficiency in Centralized and Non-centralized Markets." *Amer. J. Agr. Econ.* 67(1985):583-90.
- . "Risk Preferences and Short-Run Pricing Efficiency." *Amer. J. Agr. Econ.* 65(1983):587-91.
- Buccola, S. T., and V. L. Smith. "Uncertainty and Partial Adjustment in Double-Auction Markets." *J. Econ. Behav. and Org.* 8(1987):587-601.
- Burns, J. M. *A Treatise on Markets: Spot, Futures, and Options*. Washington DC: American Enterprise Institute, 1979.
- Carlton, D. W. "The Rigidity of Prices." *Amer. Econ. Rev.* 76(1986):637-58.
- Carter, C. A. "An Evaluation of Pricing Performance and Hedging Effectiveness of the Barley Futures Market." *West. J. Agr. Econ.* 9(1984):1-13.
- Chavas, J-P., R. D. Pope, and R. S. Kao. "An Analysis of the Role of Futures Prices, Cash Prices, and Government Programs in Acreage Response." *West. J. Agr. Econ.* 8(1983):27-49.
- Connor, J. M. "Advertising, Promotion, and Competition: A Survey with Special Reference to Food." *Agr. Econ. Res.* 33(1981):19-27.
- DeCanio, S. J. "Rational Expectations and Learning from Experience." *Quart. J. Econ.* 93(1979):47-57.
- Dixit, A. "The Role of Investment in Entry-Deterrence." *Econ. J.* 90(1980):95-106.
- Fama, E. F. "Efficient Capital Markets: A Review of Theory and Empirical Work." *J. Finance* 25(1970):383-417.
- Farris, P. L., ed. *Future Frontiers in Agricultural Marketing Research*. Ames: Iowa State University Press, 1983.
- . *Market Structure Research*. Ames: Iowa State University Press, 1964.
- Frankel, J. A. "Expectations and Commodity Price Dynamics: The Overshooting Model." *Amer. J. Agr. Econ.* 68(1986):344-48.
- French, B. C. "Fruit and Vegetable Marketing Orders: A Critique of the Issues and State of Analysis." *Amer. J. Agr. Econ.* 64(1982):916-23.
- French, B. C., and G. A. King. "Demand and Price-Markup Functions for Canned Cling Peaches and Fruit Cocktail." *West. J. Agr. Econ.* 11(1986):8-18.
- Fudenberg, D., and J. Tirole. "The Fat-Cat Effect, The Puppy-Dog Ploy, and the Lean and Hungry Look." *Amer. Econ. Rev.* 74(May 1984):361-66.
- Garcia, P., R. M. Leuthold, T. R. Fortenbery, and G. F. Sarassoro. "Pricing Efficiency in the Live Cattle Futures Market: Further Interpretation and Measurement." *Amer. J. Agr. Econ.* 70(1988):162-69.
- Gisser, M. "Price Leadership and Welfare Losses in U.S. Manufacturing." *Amer. Econ. Rev.* 76(1986):756-67.
- Gordon, D. "Performance of Thin Futures Markets: Rice and Sunflower Seed Futures." *Agr. Econ. Res.* 36(1984):1-16.
- Gray, R. W. "The Search for a Risk Premium." *J. Polit. Econ.* 69(1961):250-60.
- Grossman, S. J. "The Existence of Futures Markets, Noisy Rational Expectations, and Informational Externalities." *Rev. Econ. and Statist.* 64(1977):431-49.
- Grossman, S. J., and J. E. Stiglitz. "Information and Competitive Price Systems." *Amer. Econ. Rev.* 66(May 1976):246-53.
- Harsanyi, J. C. "Morality and the Theory of Rational Behavior." *Utilitarianism and Beyond*, eds., A. Sen and B. Williams, pp. 39-62. Cambridge: Cambridge University Press, 1982.
- Hartzmark, M. L. "Returns to Individual Traders of Futures: Aggregate Results." *J. Polit. Econ.* 95(1987):1292-1306.
- Hayenga, M. L., ed. *Pricing Problems in the Food Industry (With Emphasis on Thin Markets)*. Monograph No. 7, North Cent. Reg. Res. Proj. NC-117, 1978.
- Heien, D. M. "Markup Pricing in a Dynamic Model of the Food Industry." *Amer. J. Agr. Econ.* 62(1980):10-18.
- Just, R. E. "Economic Efficiency and Welfare Measurement in a Dynamic, Uncertain, Multimarket World." *Economic Efficiency in Agricultural and Food Marketing*, eds., R. L. Kilmer and W. J. Armbruster, pp. 37-62. Ames: Iowa State University Press, 1987.
- Just, R. E., and G. C. Rausser. "Commodity Price Forecasting with Large-Scale Econometric Models and the Futures Market." *Amer. J. Agr. Econ.* 63(1981):197-208.

- Kilmer, R. L., and W. J. Armbruster, eds. *Economic Efficiency in Agricultural and Food Marketing*. Ames: Iowa State University Press, 1987.
- Kinnucan, H. W., and O. D. Forker. "Asymmetry in Farm-Retail Price Transmission for Major Dairy Products." *Amer. J. Agr. Econ.* 69(1987):285-92.
- Kinnucan, H. W., and G. Sullivan. "Monopsonistic Food Processing and Farm Prices: The Case of the West Alabama Catfish Industry." *S. J. Agr. Econ.* 18(December 1986):15-24.
- Kitchen, J., and M. Denbaly. "Arbitrage Conditions, Interest Rates, and Commodity Prices." *J. Agr. Econ. Res.* 39(1987):3-11.
- Ladd, G. W. "Discussion of 'The Food Marketing System: The Relevance of Economic Efficiency Measures.'" *Economic Efficiency in Agricultural and Food Marketing*, eds., R. L. Kilmer and W. J. Armbruster, pp. 32-36. Ames: Iowa State University Press, 1987.
- Lang, M. G., and F. Rosa. "Price Variation in Direct and Terminal Markets for Cattle and Hogs: An Illinois Case." *Amer. J. Agr. Econ.* 63(1981):704-07.
- Leuthold, R. M. "The Price Performance on the Futures Market of a Nonstorable Commodity: Live Beef Cattle." *Amer. J. Agr. Econ.* 56(1974):271-79.
- Leuthold, R. M., and P. A. Hartmann. "A Semi-Strong Form Evaluation of the Efficiency of the Hog Futures Market." *Amer. J. Agr. Econ.* 61(1979):482-89.
- Lipsey, R., and L. K. Lancaster. "The General Theory of the Second Best." *Rev. Econ. Stud.* 24(1956):11-32.
- Lovell, M. C. "Tests of the Rational Expectations Hypothesis." *Amer. Econ. Rev.* 76(March 1986):110-24.
- Marion, B. W. *The Organization and Performance of the U.S. Food System*. Lexington MA: D.C. Heath and Co., 1986.
- Marion, B. W., W. F. Mueller, R. W. Cotterill, F. E. Geithman, and J. R. Schmelzer. "The Price and Profit Performance of Leading Food Chains." *Amer. J. Agr. Econ.* 61(1979):420-33.
- Martin, L., and P. Garcia. "The Price-Forecasting Performance of Futures Markets for Live Cattle and Hogs: A Disaggregated Analysis." *Amer. J. Agr. Econ.* 63(1981):209-15.
- Menkhaus, D. J., J. S. St. Clair, and A. Z. Ahmaddaud. "The Effects of Industry Structure on Price: A Case in the Beef Industry." *West. J. Agr. Econ.* 6(1981):147-53.
- Miller, S. E. "The Structural Stability of the Concentration-Performance Relationship in Food Manufacturing." *S. J. Agr. Econ.* 14(December 1982):43-49.
- Paris, Q. "Long-Run Comparative Statics under Output and Land Price Uncertainty." *Amer. J. Agr. Econ.* 70(1988):133-41.
- Peck, A. E. "Futures Markets and Intertemporal Commodity Pricing." *Economic Efficiency in Agricultural and Food Marketing*, eds., R. L. Kilmer and W. J. Armbruster, pp. 256-69. Ames: Iowa State University Press, 1987.
- Perloff, J. M., and G. C. Rausser. "The Effect of Asymmetrically Held Information and Market Power in Agricultural Markets." *Amer. J. Agr. Econ.* 65(1983):366-72.
- Peterson, P. E., and R. M. Leuthold. "Using Mechanical Trading Systems to Evaluate the Weak Form Efficiency of Futures Markets." *S. J. Agr. Econ.* 14(July 1982):147-51.
- Rausser, G. C., and C. Carter. "Futures Market Efficiency in the Soybean Complex." *Rev. Econ. and Statist.* 65(1983):469-78.
- Rausser, G. C., J. M. Perloff, and P. Zusman. "The Food Marketing System: The Relevance of Economic Efficiency Measures." *Economic Efficiency in Agricultural and Food Marketing*, eds., R. L. Kilmer and W. J. Armbruster, pp. 3-36. Ames: Iowa State University Press, 1987.
- Ravallion, M. "Testing Market Integration." *Amer. J. Agr. Econ.* 68(1986):102-09.
- Rogers, G. B. "Pricing Systems and Agricultural Marketing Research." *Agr. Econ. Res.* 22(1970):1-11.
- Rosen, S. "Dynamic Animal Economics." *Amer. J. Agr. Econ.* 69(1987):547-57.
- Sen, A. K. *On Economic Inequality*. Oxford: Oxford University Press, 1973.
- Shaffer, J. D. "Preference Articulation and Food System Performance." *Future Frontiers in Agricultural Marketing Research*, ed., P. L. Farris, pp. 224-45. Ames: Iowa State University Press, 1983.
- Shonkwiler, J. S. "Are Livestock Futures Prices Rational Forecasts?" *West. J. Agr. Econ.* 11(1986):123-28.
- Shonkwiler, J. S., and T. H. Spreen. "Disequilibrium Market Analysis: An Application to the U.S. Fed Beef Sector: Comment." *Amer. J. Agr. Econ.* 65(1983):360-63.
- Shonkwiler, J. S., and T. G. Taylor. "Food Processor Price Behavior: Firm-Level Evidence of Sticky Prices." *Amer. J. Agr. Econ.* 70(1988):239-44.
- Smith, V. L. "An Experimental Study of Competitive Market Behavior." *J. Polit. Econ.* 70(1962):111-37.
- . "Microeconomic Systems as an Experimental Science." *Amer. Econ. Rev.* 72(December 1982):923-55.
- Sosnick, S. H. "Operational Criteria for Evaluating Market Performance." *Market Structure Research*, ed., P. L. Farris, pp. 81-125. Ames: Iowa State University Press, 1964.
- Sporleder, T. L. "Policy Considerations of Emerging Information Technologies." *S. J. Agr. Econ.* 16(July 1984):15-21.
- Stein, J. L. "Futures Markets Accelerate the Convergence to a Rational Expectations Equilibrium." *Cent. Stud. Fut. Mark. CSFM-153*, 1987.
- Stigler, G. J. "The Economics of Information." *J. Polit. Econ.* 69(1961):213-25.
- Stiglitz, J. E. "Competition and the Number of Firms in a Market: Are Duopolies More Competitive Than Atomistic Markets?" *J. Polit. Econ.* 95(1987):1041-61.
- Theil, H. *The System-Wide Approach to Econometrics*. Chicago: University of Chicago Press, 1980.
- Tomek, W. G. "Price Behavior on a Declining Terminal Market." *Amer. J. Agr. Econ.* 62(1980):434-44.
- Tomek, W. G., and K. L. Robinson. "Agricultural Price Analysis and Outlook." *A Survey of Agricultural Eco-*

- nomics Literature, Vol. 1*, ed., L. R. Martin, pp. 329–409. Minneapolis: University of Minnesota Press, 1977.
- Walraven, N. A., and G. C. Rausser. “Empirical Pricing Efficiency Measures for Futures Markets.” *Cent. Stud. Fut. Mark. CSFM-143*, 1986.
- Ward, C. E. “An Empirical Study of Competition in the Price Discovery Process for Slaughter Lambs.” *West. J. Agr. Econ.* 9(1984):135–44.
- Wohlgenant, M. K. “Competitive Storage, Rational Expectations, and Short-Run Food Price Determination.” *Amer. J. Agr. Econ.* 67(1985):739–48.
- Zellner, J. A. “Some Causes and Consequences of Food Industry Conduct: A Simultaneous Analysis.” WP-6, Dept. of Food and Resource Economics, University of Florida, 1987.
- Ziemer, R. F., and F. C. White. “Disequilibrium Market Analysis: An Application to the U.S. Fed Beef Sector.” *Amer. J. Agr. Econ.* 64(1982a):56–62.
- . “Equilibrium Versus Disequilibrium in the Market for Nonfed Cattle.” *West. J. Agr. Econ.* 7(1982b): 163–72.