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A STUDY OF PRICING EFFICIENCY AND THE VALUE OF INFORMATION

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I. Introduction

Concern about conceptualizing and even measuring, if possible, pricing efficiency arises because it has become one criterion used to make comparisons among alternative marketing systems. The concept of pricing efficiency has its roots in the quality and quantity of information available to marketing channel participants. Pricing efficiency therefore has important implications for public market information and price reporting as well as performance. The process of price formation is recognized as having an impact on pricing efficiency (Forker 1975)

There are two major concepts which conventional agricultural economics literature recognizes as pricing efficiency. One is a micro, intrafirm concept inextricably woven around the relationships between and among vertically related pricing points within a marketing segment. The purpose of this paper is to discuss and refine both concepts of pricing efficiency. The macro concept is extended to include various elements of pricing efficiency appropriate in a subsector context. The intrafirm concept is extended to include a theoretical measure of the value of information to the individual firm.

II. The Macro Concept

The macro concept of pricing efficiency refers to the role of price in a marketing segment or subsector. Macro pricing efficiency centers on the role of price in a marketing system, especially as it may relate to the public policy issues or society's welfare and performance of the system.

Conventional wisdom on the concept of macro pricing efficiency is to recognize two crutial elements-timeliness and accuracy of price signals (Williams and Stout 1964). Some authors have outlined elements of pricing efficiency without distinction between micro and macro concepts.

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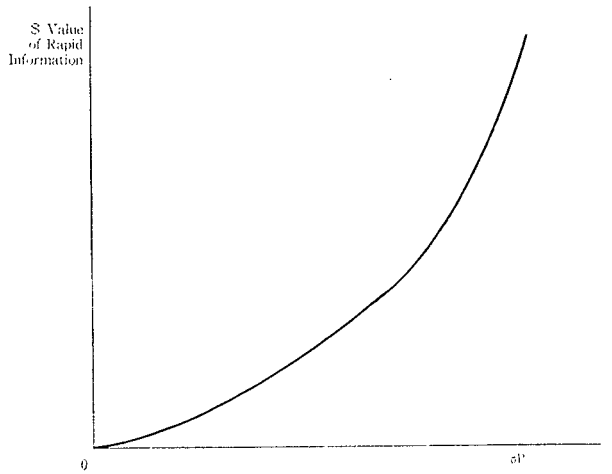
FIGURE 1 RELATIONSHIP BETWEEN THE VALUE OF RAPID PRICE TRANSMISSION AND VOLATILITY OF PRICE PER UNIT TIME.



As a consequence, they define the elements of pricing efficiency to include "optimum cost levels, correct resource and long run" (Rogers 1971).

Without necessarily solving the argument about an exhaustive taxanomy of the elements of macro pricing efficiency, one can accept the primary elements as rapidity of transmission or timeliness and accuracy. This section will focus on these elements and examine the aspects of timeliness and accuracy as they relate to marketing subsectors, market information and price reporting.

Timeliness: Assume, for the moment, that all price messages transmitted vertically or horizontally within a marketing subsector are clear, definite, and reliable messages. The element of timeliness then refers to the time lag between when a price is discovered and when it is "received" by other marketing channel participants that may be interested in receivng that price message.

Intuitively, accurate prices for last year's cattle or beef market are of minimal short run decision-making value for today's market. The value of current information must be higher than past information to these decision-markers.

The premium placed on the need for rapid transmission of price signals is related to volatility of price at any particular pricing point. Figure 1 illustrates that as price volatility increases for any time unit, so does the value of rapid transmission of price information. As an example, the importance of rapid transmission of price signals on urban developed land for investment purposes is relatively less than rapid transmission of price signals on wheat at terminal elevators. For any given time unit, price volatility is more in wheat than land, and the need for rapid transmission is relatively greater. Stated another way, the value of timely information

is relatively greater for wheat than for land.

In a macro context, timeliness of price signal transmission could be conceptualized as the ratio between actual transmission time and some normative transmission time. The normative time, however, is a function of price volatility per unit time. Thus, norms would vary across commodities, products, or pricing points.

The singnificance of rapid transmission for various marketing alternatives as applied to various commodities or product is clear. Computerized spot markets hold the potential for relatively rapid transmission of price which would be most valuable in cases where price volatility is relatively great. Other alternatives, such as marketing orders as used in fluid milk pricing, have as one purpose to minimize volatility per unit time. The need for rapid transmission of price signals is dimished by the marketing order structure. Thus, while some alternatives may not change the volatility of price but increase timeliness others may minimize volatility so that timeliness is no longer as important.

Accuracy: Assume that all prices are transmitted instantaneously among all market channel participants interested in receiving the information. An element of pricing efficiency which would yet remain in such an instantaneous world is accuracy, or the reliability of the price messages transmitted. There are at least two meanings for accuracy in this context, one economic and one statistical. The economic meaning has most significance for market information while the statistical meaning has most significance for price reporting.

The economic meaning of accuracy can be conceptualized as the reliability of price, or the extent to which price signals are unbiased indicators of the forces determining supply and demand for a food or service.

All price signals, assuming they have not been previously received, contain some information. In the broad sense, all prices reflect "value," by definition. However, the economic meaning of pricing efficiency resides in a subjective world of reliability.

Consider the situation where price levels or price differentials attributable to space or quality for a commodity are "administered", or set by governmental regulation (e.g. interest rates on savings deposites), or otherwise set non-market noncompetitive means. Signals on these levels or differentials would not be judged as unbiased indicators of forces determining supply and demand for that commodity.

A generalization can be made that price differences across location, quality, or form are all components of accuracy in its economic meaning. The norm for accurate prices within a marketing subsector then becomes price differences over location, quality, or form which are unbiased indicators of supply and demand in competitive markets. Deviations from this norm are judgemental but are important for public policy and performance evaluations of a marketing subsector.

The economic meaning of accuracy then relates to the type of market information which should be available to marketing channel participants, in a normative sense. For example, suppose price differentials over qualities should be an important factor in allocation of productive resources and the guidance of production decisions for firms producing a particular commodity. If only average prices over all or several qualities are known, pricing would be deemed inaccurate in the long run (Fama, 1970).

Statistical Meaning: The statistical meaning of accuracy refers to the extent of statistical error in reporting prices. Assume that price signals are instantaneously transmitted and that prices discovered are unbiased indicators of the forces determining supply and demand for a good or service so that timeliness and economic accuracy of prices are ideal (in a normative sense). The element of accuracy remaining is the statistical error involved in collecting and disseminating prices. Such may be of significance for price reporting whether the price reporting is intrafirm as is the case of transfer price in ownership vertical integration or done by private business or public agencies. The well known statistical concept of sampling error is applicable to this situation. In a pratical way, however, there are two important considerations to sampling error in price reporting. One is relevant definition of the universe to be sampled. Another is the size of the sample necessary to reflect the true price with some acceptable degree of confidence.

Statistical procedures start with the premise that the universe to be sampled is clearly defined. In the context of price reporting, especially for agricultural commodities, this may not be an easy task. In fact, relevant portions of a universe may not be sampled because access to sample observations are impossible. Consider the case of direct feeder cattle sales or contractually traded beef which is formula priced. These are legitimate transactions within the scope of the relevant universe of prices, yet cannot be sampled or are extremely expensive to sample for purposes of public price reporting. Thus, coverage or definition and sampling from the relevant universe of prices discovered for a particular commodity may lead to inaccuracies in price reporting.

The more conventional problem in price reporting is the sample size necessary to estimate true universe prices within some acceptable range or at an acceptable level of confidence on reported prices. Of course, the size of the sample (stated in terms of a percent of the universe) necessary for any predetermined level of confidence is positively related to the variance of prices for identical time, form, space, and quality within the relevant universe.

III. The Micro Concept

The Farrell Case: The concept of intrafirm technical and pricing efficiency

was introduced by Farrell in 1957. Farrell conceptualized a measure for the pricing efficiency of a firm as the amount that a firm exceeds the minimum outlay necessary for a given optimal combination of factor inputs and prices. More conventionally stated, any firm which fails to maximize profits is price inefficient.

The Farrell definition has limited usefulness in terms of comparison among different groups of firms and does not recognize the possibility of differing initial endowment of fixed factors among firms. A reformulation is possible which recognizes that firms meet with differing degrees of success in equating the value of the marginal product of each variable factor input to its price and allows for firms to operate at different sets of market prices for factor inputs.

Technical and price efficiency has been extended by Lau and Yotopoulus by defining the "Unit-Output-Price" (UOP) profit function of a firm which is equivalent to a conventional profit function but possesses arguments which are easier to manipulate. Using the UOP profit function the decision rule for a price efficient firm may be shown to be equating the marginal product to a constant times the normalized price of each input (Lau and Yotopoulus, p.99). Farrell's case is *perfect* profit maximization and is a special case of the more general *relative* price efficiency suggested by Lau and Yotopoulus.

The Value of Information: A perplexing situation exists in terms of identifying the theoretical impact of increases in information to marketing channel participants. Conventional wisdom among economists has been that more information is "better" than less, but questions about benefit/cost, individual firm demand for information, and the impact of this information on firm decision-making have lacked any sharp focus in the literature.

Publications such as "Marketing Alternatives: Is There a Better Way?" implicitly (and sometimes explicitly) recognize that market information is an important consideration when evaluating alternative institutional arrangements for marketing. There is little doubt that various arrangements have different implications for the quantity and quality of information which is available to either private firms or to society in terms of performance evaluation. The purpose of this section is to suggest a model for analyzing the value of price information to the individual firm.

Following the profit function approach of Lau and Yotopolus, a single product firm in perfect competition with a production function of usual neoclassical properties is:

$$(1) \qquad Y = f(X_i, \ldots X_m; Z_i, \ldots Z_n)$$

where X_i is variable input i and Z_i is fixed input. Profit as current revenue less current total variable cost is:

$$(2) \qquad P' = P_y f(X_1, \ldots X_m; Z_1, \ldots Z_n) - \sum_{i=1}^{m} P_i X_i$$

where P' is profit, P_y is unit price of output, and P_i is the unit price of the i^{th} variable input. the marginal productivity conditions under profit maximization are:

$$(3) \qquad P_y \frac{\partial f(X, Z)}{\partial X_i} = P_i, i = 1, \ldots . m.$$

Using P_y as numeraire and rewriting (3) the marginal productivity conditions become:

$$(4) \qquad \frac{\partial f}{\partial X_i} = P_i', i = 1, \ldots, m.$$

The marginal productivity conditions may be solved for optimal quantities of variable inputs, X_i^*, and become:

$$(5) \qquad X_i^* = f_i(P', Z), i = 1, \ldots m.$$

where P' is a vector of normalized input prices and Z is a vector of fixed input quantities.

By substitution of (5) into (2) the profit function may be defined:

$$(6) \qquad \Pi = P_y [f(X_1^*, \ldots X_m^*; Z_1, \ldots Z_n) - \sum_{i=1}^{m} P_i' X_i^*]$$

the firm exhibits both technical and price efficiency.

This model can now be extended to reflect the value of information to the firm from receiving accurate price messages. Consider, in a comparative statics context, that a firm received price information which embodies an inaccurate message (denoted P_W). Assume the firm establishes optimal input and output quantities based upon this erroneous information (i.e. $X_W^* Y_W^* / P_W$). Further, let P_R represent accurate and reliable price information (or the price message the firm would receive under conditions of perfect knowledge). The firm then optimizes according to the preceding framework and the profit function which the firm would experience under conditions of correct information is stated as:

$$(7) \qquad \Pi_R^* = P_{yR} Y_R^* - \sum_{i=1}^{m} P_{iR} X_{iR}^*$$

Equation (7) represents the profits which would occur under conditions of technical and price efficiency as well as perfect knowledge.

In the event the firm received erroneous information, the profit function may be stated as:

$$(8) \qquad \Pi_W^* = P_{yR} Y_W^* - \sum_{i=1}^{m} P_{iR} X_{iW}^*$$

The profit function of equation (8) expresses the firm's profits when it is efficient but optimizes under conditions of erroneous information. The expression denotes that, even though the firm receives erroneous information and bases optimization on that information, it will *eventually* be paid or pay the "correct price (i.e. P_R rather than P_W). Thus, the realized Π of the firm is a function of P_R, X_W^*, and Y_W^*.

Storage decisions are another important consideration. Firms constantly face decisions concerning the amount of a commodity to hold in storage. Prices impact on firm decisions concerning the optimal quantities to place in storage. The supply of storage for an individual firm in a competitive market is:

$$(9) \qquad Y_t = f(E_t(\Delta P))$$

This can be shown to be the supply of storage function for an industry also (Brennan). The optimum Y_t clearly depends on $|P_t - P_W|$ and the optimal storage decision for an individual firm will depend on the quantity and quality of price messages it receives.

Inaccuracies in prices received by an individual firm are not difficult to perceive. Price reporting mechanisms from public sources may reflect only unweighted average prices over a range of qualities (the case of feeder cattle), or the price "discovered" or reported from a particular transaction may inaccurately reflect form or location differentials because of "thin" markets. Clearly, a multitude of reasons exist for an individual marketing channel participant to receive inaccurate, delayed, or conflicting price messages.

The value of information which is accurate can now be expressed as:

$$(10) \qquad V = \Pi_R^* - \Pi_W^*$$

The firm could improve profits by optimizing under conditions of perfect knowledge, hence V will always be positive or $\Pi_R^* > \Pi_W^*$. Equation (10) expensses the amount of profit, in an opportunity cost sense, foregone by making decisions under erroneous price messages.

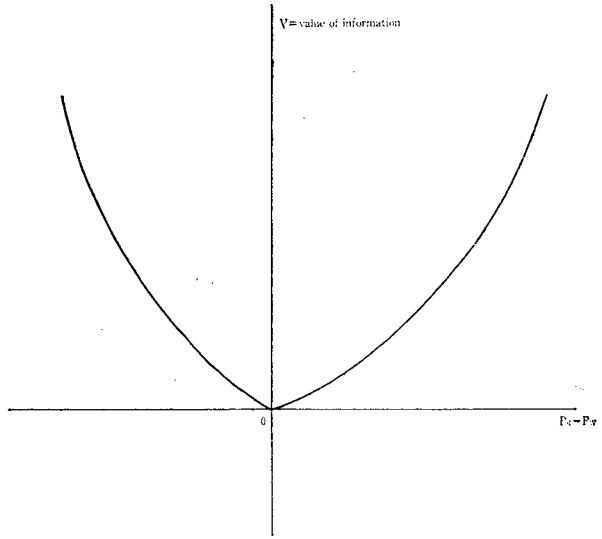
Assume that P_W is normally distributed and that $E(P_W) = P_R$. Note that the value of information is a function of P_W. The relationship between the value of information and the distribution of P_W is illustrated in Figure 2. As $|P_R - P_W|$ increases so does the value of information, or the amount that a firm would be willing to pay to receive the correct information. The relationship need not be symmetric about V but is depicted as such in Figure 2.

Under conditions of risk neutrality, expected losses to a firm from inaccurate price signals would be:

$$(11) \qquad E[V(P_W)] = \Pi_R - \Pi_W.$$

Let σ_{P_W} represent the variance of the possible inaccurate price signals.

FIGURE 2 RETATIONSHIP BETWEEN THE VALUE OF INFORMATION AND A DISTRIBUTION OF P_W.



Expected losses to the firm increase as σ_{P_W} increases, depicted in Figure 3. If the variance is zero, $P_W = P_R$ and $E(V) = 0$. If the variance of P_W is large so will be the expected losses to the firm.

Intuitively, any rational firm would be willing to pay an amount less than or equal to their expected losses from inaccurate prices in order to receive accurate prices. Thus, the framework defines a demand function for information (Figure 4) where $1/\sigma_{P_W}$ is a proxy for the quantity and quality price messages received by the firm.

Application to Marketing Alternatives: Various institutional arrangements for price discovery represent alternatives for the supply of accurate and reliable information to individual firms. Computerized spot markets, forward deliverable contract markets, mandatory public reporting, marketing orders and marketing boards all have different capabilities for market information and price reporting as various costs. The alternatives could be viewed theorectically as capable of supplying various amounts of information to market channel participants.

A hypothetical array of supply functions arising from various arrangements is depicted in Figure 5, along with the demand for information as before. Conceptually, any alternative could be compared in terms of the accuracy of price information attributable to that alternative. Each supply function represents the relationship between pricing accuracy (measured by $1/\sigma_{P_W}$ and the costs of receiving that information, under the assumption that cost is a continuous increasing function of σ_{P_W}. This is reasonable since as $\sigma_{P_W} \rightarrow 0$ for any particular alternative, costs for the information

would increase.

Consider the case of computerized spot markets. Assume a voluntary system were implemented at a particular pricing point by a proprietary firm which charged for price reports generated by the market. Under these circumstances, a well-behaved "supply" function for information could be drawn (similar to the one for vertical integration or public market reporting in Figure 5).

Another case could be where government implements a voluntary computerized spot market where price reports were publicly available. If the market were funded by a fixed tax on users, the same type supply function would be relevant. In this case, the makret reports would be

FIGURE 3 RELATIONSHIP BETWEEN EXPECTED LOSSES AND THE VARIANCE OF $P_{w'}$.

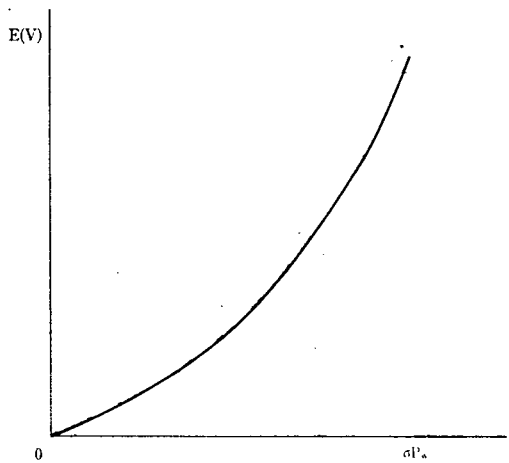


FIGURE 4 DEMAND FOR INFORMATION BY AN INDIVIDUAL FIRM.

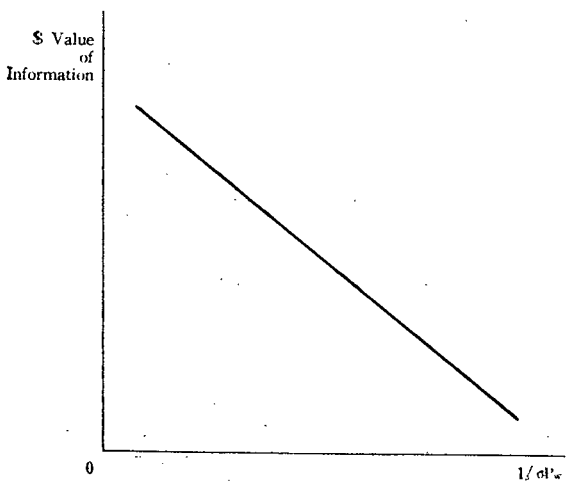
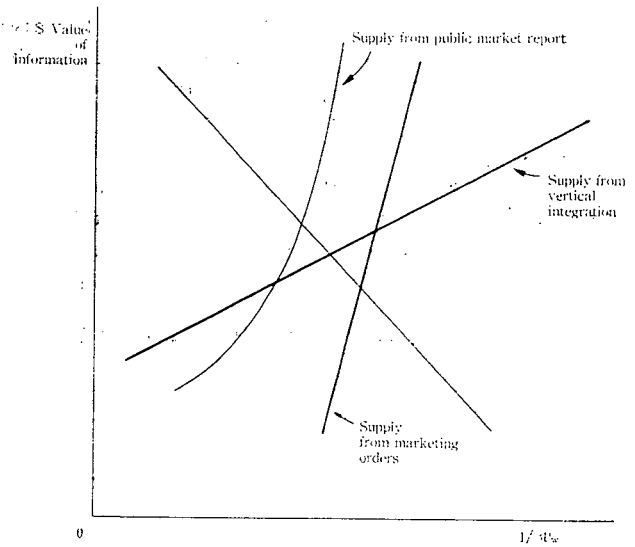


FIGURE 5 SUPPLY FUNCTIONS OF INFORMATION FROM VARIOUS INSTITUTIONAL ARRANGEMENTS.



public goods.

In a mandatory case of government implementation, the supply function would be vertical above some minimum cost. If the market were funded by a tax on users then the demand function of Figure 5 would change from the previous cases. Clearly, there exist welfare implications for non-users and users of any marketing alternative.

Extensions of the Model: There are various extensions of the basic model which are possible. One would be to a multiproduct firm. In this case the profit function of equation (7) would include terms for the multiple products and the analysis would proceed along similar lines.

Another extension would be to allow lagged expectations for P_W into the model. Cost of storage or other time related variables could be considered in a dynamic analysis of the value of information.

Risk aversion could be incorporated through a more general objective function stated as the present value of the expected utility of profit. It would also be possible to extend the model to allow firms to "search" for additional information by incorporating optimal stopping rules.

IV. Relationship Between Micro and Macro

There is a direct relationship between the micro and macro concepts of pricing efficiency as presented in this paper. The macro conceptualization details the potential nature of the inaccuracy in price messages. That is, price messages may be received too late or price differentials may not be reliable over space, form, or quality. In addition, prices may

simply be reported inaccurately in a statistical sense. Regarldess of the nature of the inaccuracy, the micro model suggested captures the consequences of inaccurate price messages.

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