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### Publication Date

1983-07-01

Division of Agricultural Sciences  
UNIVERSITY OF CALIFORNIA

2008 page  
For website →

Working Paper No. 264

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THE EFFECT OF ASYMMETRICALLY HELD INFORMATION AND MARKET POWER  
IN AGRICULTURAL MARKETS

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## THE EFFECT OF ASYMMETRICALLY HELD INFORMATION AND MARKET POWER IN AGRICULTURAL MARKETS\*

In industries in which a firm (or small number of firms) have superior information about demand in the future, the firm can use its information to increase its market power in later periods. Further, market power in one sector of an industry may provide a firm with information which it can use to gain market power in another sector.

The role of information in concentrated agricultural markets has received little theoretical attention to date. The traditional theory of competitive markets presupposes that all information is costless and, thus, fully and equally available to all participants. Such theories obviously do not apply to agricultural markets in which there are both information asymmetries and market power.

In recent years, economic theories have been developed which recognize that information is costly to acquire, especially in markets such as those for agricultural commodities. Much of the economic theory of information is in an embryonic state. In context of atomistic agents, Grossman has shown that information has a public element which may lead to underinvestment in information where uninformed agents with rational expectations may be able to use prices as a sufficient statistic.<sup>1</sup>

Where prices are not sufficient statistics, however, he shows that it may pay to invest in obtaining information. In all his examples, there are social gains to collecting information from better intertemporal allocation of a crop; yet there may be little or no private gains in equilibrium because some or all of the information will be reflected in market prices.<sup>2</sup>

In this paper, we present a number of illustrative examples which suggest that large processing or exporting firms are likely to possess asymmetric information and market power. These examples motivate the specification of a theoretical model which is presented in section II. This model generalizes the previous literature by not only admitting a symmetric information but also market power. The social welfare implications and distributional impacts of improved information are examined. Finally, some concluding remarks are presented.

### I. Asymmetric Information in Agricultural Markets

There are many examples of agricultural firms possessing asymmetric information about future period prices, harvest, or other relevant factors. The following examples suggest that firms with market power in processing or exporting industries are likely to have more information than other agents.

In a recent study, Gilmore argues that the major grain-trading companies (Cargill, Continental, Dreyfus, Munge, and Garnac) purchase grain supplies at the lowest possible prices in order to sell them in markets they virtually dominate. In this fashion, according to Gilmore, they gain the advantage of oligopsony as well as oligopoly power. He contends that the oligopolists manipulate prices and market information. Throughout his analysis, Gilmore describes how the major firms take advantage of information they alone possess, e.g., information on foreign subsidiaries, contract positions, the price reporting system, export data, and commodity exchanges. In essence, Gilmore argues that the major firms in this industry hold a monopoly on information which is a major barrier to entry and is the key to their success.<sup>3</sup> He recommends that major firms be required to report their output to public

agencies. In this fashion, he suggests that the information advantage of such firms may be reduced.

In the U. S. rice industry, the importance of the role of information was revealed when a New Orleans exchange submitted a proposal to the Commodity Futures Trading Commission to begin trading contracts in rice futures. The nation's largest millers and exporters opposed the introduction of the New Orleans contract, claiming it was unnecessary. The eight largest rice millers handled approximately 60 percent of U. S. production during the years 1972-1980. One company (Connell Rice and Sugar, Inc.) negotiated more than 90 percent of the sales of American rice to Korea. As a result, these firms have superior information about both supply and demand factors. A Business Week article, in effect, alleges that this opposition was motivated by an attempt to increase the uncertainty faced by potential entrants. The introduction of the future market might eliminate a risk-related barrier to entry and, thus, reduce the margins of noncompetitive rice processors.

Still another industry in which asymmetric information has played a crucial role is cocoa manufacturing. This industry is heavily concentrated with the four-firm concentration ratios over time running in the neighborhood of 70 percent or more. One of the largest, Mars, was the first to collect supply information in African producing countries. Statisticians were employed by Mars to sample the "bush" to determine accurate estimates of production of main and mid crops. The comparative advantage this information gave Mars resulted in more effective forward contracting procurement prices; as a result, the company was able to lower its output prices and enhance its market share. In response, Mars' three major competitors have also introduced such information collection functions. There are many other similar examples

in other agricultural and natural resource markets such as beef, orange juice, and wines.

## II. Model

Unlike the atomistic models of Radner, Grossman, Grossman and Stiglitz, and others, our model presupposes that entry into the industry is limited so that some or all firms possess market power (or, at least, make positive economic profits).

As the examples in Section I indicate, a firm is likely to have asymmetric sources of information if it has a monopoly in an output market (say, a processed food or export market) which it can use when it competes against other firms in purchasing the crop and selling in the unprocessed markets. The firm will be able to price discriminate if it can identify several distinct output markets and prevent resale.

Suppose, for example, that a firm knew that demand would be unusually high in a nonharvest period, while other agents thought the demand would be relatively low. The first firm could forward contract for the crop at a low price and sell at a high price.

Indeed, that firm may be able to buy so much of the crop that it gains market power in the nonharvest period market. At that point, it might want to divert some of that crop to a lower return processed food market or even destroy some of it to further increase its profits in this later market. Obviously, firms which have lower storage costs or alternative markets will have a comparative advantage in developing market power in this fashion. If several firms share the information and storage advantages of the firm

discussed above, however, none may be able to develop substantial market power unless they collude.

A. The Model with Asymmetric Information

There are three markets considered in the model. In time period 1,  $q_1$  is sold by farmers to consumers, speculators, or processing firms at price  $p_1$ .<sup>4</sup> In the second period,  $q_2$  is sold at price  $p_2$ . We will refer to the consumer purchases in periods 1 and 2 as the "fresh" (or unprocessed) product. Some portion of the crop sold in time period 1 goes to firm A which sells it in a processed form,  $x$ , in time period 2 at price  $p_x$ .<sup>5</sup>

The harvest is assumed to be exogenously determined by period 1. The harvest is  $Q + \gamma$  where  $\gamma$  is a random variable which may or may not be known to the relevant parties by period 1 (or ever). The three demand functions are

$$(1.1) \quad p_x = p_x(x, \theta),$$

$$(1.2) \quad p_1 = p_1(q_1) = p_1[Q + \gamma - (A + B + x)],$$

$$(1.3) \quad p_2 = p_2(q_2),$$

where  $\theta$  is a random variable which shifts  $p_x$ ,  $x$  is the amount of crop purchased by firm A in the first period which it sells in the processed state in period 2,  $A$  is the amount of crop firm A buys in the first period and sells in the fresh market in period 2, and  $B$  is the amount bought by all the other (B) firms.

There are  $n$  (exogenously determined) small B firms which are price takers in the period 1 and period 2 fresh markets. Each B firm attempts to maximize its expected profits:



$$(2) \quad E\pi_B = E(p_2 - p_1)b - c_B^*(b),$$

where  $b \equiv B/n$  is the amount each buys in period 1 and sells in period 2 and  $c_B^*(\cdot)$  is its storage cost. For simplicity, we assume the B firms are risk neutral.

The B firms observe  $p_1$  and predict  $p_2$  given  $p_1$ . They purchase  $b$  until expected marginal revenue in the second period equals marginal cost (of purchasing in period 1 and storing until period 2):

$$(3) \quad E(p_2|p_1) = p_1 + c_B^{*'}$$

or

$$(4) \quad B \equiv nb = n \left( c_B^{*'} \right)^{-1} \left( E[p_2|p_1] - p_1 \right).$$

If B firms have marginal costs of storage which are high relative to firm A's costs and if  $n$  is not too large,  $B$  will be small enough that firm A will have substantial market power in all three markets--not just in the  $x$  market which it monopolizes.

We assume firm A acts as a Stackelberg leader; that is, firm A takes the B firms' reaction function (4) as given. If the B firms cannot observe firm A's purchases and sales, they can only infer A's behavior by observing  $p_1$  (which rises as A or  $x$  rise). Hence, B firms act as "followers." Such behavior by B firms is rational given their limited information.

We assume that firm A knows  $\theta$  (or a variable correlated with  $\theta$ ).<sup>6</sup>

Firm A chooses  $A$  and  $x$  to maximize expected profits (given storage costs  $c_A^*$ ),

$$(5) \quad \pi_A = (p_2 - p_1) A + (p_x - p_1) x - c_A^*(A + x).$$

The first-order conditions (assuming an interior solution) for A and x, respectively, are<sup>7</sup>

$$(6.1) \quad p_2 + p_2'(1 + B')A = p_1 - p_1'(1 + B')(A + x) + c_A^{*'}$$

$$(6.2) \quad p_x + p_x' + p_2'B'A = p_1 - p_1'(1 + B')(A + x) + c_A^{*'}$$

where B' is the change in B which occurs given a change in either A or x.<sup>8</sup>

The expressions (6.1) and (6.2) say that firm A chooses A and x so that their marginal revenues [left-hand sides of (6.1) and (6.2)] equal the marginal cost of buying and storing one more unit [the right-hand sides of (6.1) and (6.2)]. Notice that (6.2) contains a term,  $p_2'B'A$ , which reflects the change in price in the second period's fresh market,  $p_2$ , from B firms' reactions to an increase in  $p_1$  (due to an increase in x) in the first period.

Since the right-hand sides of (6.1) and (6.2) are equivalent, we can equate the left-hand sides and simplify to obtain,

$$(6.3) \quad p_2 + p_2'A = p_x + p_x'x,$$

which is the standard two-market discriminating monopolist's solution: equate the marginal revenue in the two markets (ignoring the B firms' reaction which affects both marginal revenues equally).

We now assume, for the purpose of providing a clear example, that demands are linear and costs are quadratic. We rewrite equations (1.1) to (1.3) as<sup>9</sup>

$$(7.1) \quad p_x = \alpha_0 - \beta_0 x + \theta,$$

$$(7.2) \quad p_1 = \alpha_1 - \beta_1[Q + \gamma - (A + B + x)],$$

$$(7.3) \quad p_2 = \alpha_2 - \beta_2[A + B],$$

and write costs as

$$(7.4) \quad c_i^*(q_i) = \frac{c_i}{2} q_i^2, \quad i = A, B.$$

Given linearity, firm A's first-order conditions [corresponding to (6.1) and (6.2)] are

$$(8.1) \quad \begin{aligned} & [\alpha_2 - \beta_2(A + B)] - \beta_2(1 + B')A - \{\alpha_1 - \beta_1[Q + \gamma - (A + B + x)]\} \\ & - \beta_1(1 + B')(A + x) - c_A(A + x) = 0 \end{aligned}$$

$$(8.2) \quad \begin{aligned} & [\alpha_0 - \beta_0x + \theta] - \beta_0x - \beta_2B'A - \{\alpha_1 - \beta_1[Q + \gamma - (A + B + x)]\} \\ & - \beta_1(1 + B')(A + x) - c_A(A + x) = 0. \end{aligned}$$

We also assume that

$$(9) \quad \begin{pmatrix} \theta \\ \gamma \end{pmatrix} \sim N \left[ \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_{\theta\theta} & \sigma_{\theta\gamma} \\ \sigma_{\gamma\theta} & \sigma_{\gamma\gamma} \end{pmatrix} \right]$$

which implies, as we shall show below, that

$$(10) \quad \begin{pmatrix} p_1 \\ p_2 \end{pmatrix} \sim N \left[ \begin{pmatrix} \bar{p}_1 \\ \bar{p}_2 \end{pmatrix}, \begin{pmatrix} \sigma_{11} & \sigma_{12} \\ \sigma_{21} & \sigma_{22} \end{pmatrix} \right].$$

Given (10),

$$(11) \quad E(p_2|p_1) = \bar{p}_2 + \phi(p_1 - \bar{p}_1),$$

where

$$(12) \quad \phi \equiv \rho \left( \frac{\sigma_{22}}{\sigma_{11}} \right)^{1/2}$$

is the coefficient one obtains from regressing  $p_2$  on  $p_1$ , and  $\rho$  is the correlation coefficient between  $p_1$  and  $p_2$ . Substituting into (4):

$$(13) \quad B = \frac{n\{\bar{p}_2 - \phi\bar{p}_1 + (\phi - 1)(\alpha_1 - \beta_1)[Q + \gamma - (A + x)]\}}{c_B - n(\phi - 1)\beta_1}.$$

Differentiating (13) with respect to either  $A$  or  $x$ , we obtain<sup>10</sup>

$$(14) \quad B' = \frac{n(\phi - 1)\beta_1}{c_B - n(\phi - 1)\beta_1} \equiv \delta,$$

which is a constant given the demand for  $q_1$  is linear. Thus,  $B'' = 0$ .

If  $\phi = 1$  ( $[p_1 - \bar{p}_1]$  and  $[p_2 - \bar{p}_2]$  are always equal),  $\delta = 0$ ; and the B firms do not react (the expected profits per unit do not change with  $p_1$ ). If  $\phi < 1$ , the B firms will actually react in the opposite direction from (i.e., accommodate) firm A.

Setting  $B' = \delta$  in equations (7.1) to (7.4) and totally differentiating (8.1) and (8.2), we obtain the following comparative statics results:

$$(15.1) \quad \frac{dA}{d\gamma} = \frac{\beta_1}{D}(2\beta_0 - \beta_2\delta),$$

$$(15.2) \quad \frac{dx}{d\gamma} = \frac{\beta_1 \beta_2}{D} (2 + \delta),$$

$$(15.3) \quad \frac{dA}{d\theta} = -\frac{1}{D} [2\beta_1(1 + \delta) + \beta_2 \delta + c_A],$$

$$(15.4) \quad \frac{dx}{d\theta} = \frac{1}{D} [2(\beta_1 + \beta_2)(1 - \delta) + c_A].$$

where

$$D = [2(\beta_1 + \beta_2)(1 + \delta) + c_A] [2\beta_0 + 2\beta_1(1 + \delta) + c_A] - [2\beta_1(1 + \delta) + \beta_2 \delta + c_A]^2$$

None of these derivatives depend on  $\gamma$  or  $\theta$ ; indeed, they are constants (given the demand, cost, and variance parameters).

Using equation (15), we find that

$$(16.1) \quad \frac{dp_1}{d\theta} = \frac{\beta_1 \beta_2}{D} (2 + 3\delta + \delta^2) \equiv e_1,$$

$$(16.2) \quad \frac{dp_2}{d\theta} = \frac{\beta_2}{D} [2\beta_1(1 + \delta) - \beta_2 \delta - \beta_2 \delta^2 + c_A] \equiv e_2,$$

$$(16.3) \quad \frac{dp_1}{d\gamma} = \frac{2(\beta_1)^2}{D} (\beta_0 + \beta_2)(1 + \delta) - \beta_1 \equiv g_1,$$

$$(16.4) \quad \frac{dp_2}{d\gamma} = \frac{-\beta_1 \beta_2}{D} [(2 - \beta_2) \delta + 2\beta_0 + \delta^2] \equiv g_2.$$

Thus,  $p_1$  and  $p_2$  vary linearly in  $\gamma$  and  $\theta$ .

We can, therefore, write

$$(17.1) \quad p_1 = \bar{p}_1 + e_1 \theta + g_1 \gamma$$

$$(17.2) \quad p_2 = \bar{p}_2 + e_2\theta + g_2\gamma.$$

From (9),  $E(\theta) = E(\gamma) = 0$ , so  $E(p_i) = \bar{p}_i$ ,  $i = 1, 2$ .

Equations (17.1) and (17.2) imply that

$$(18.1) \quad \sigma_{ii} = e_i^2 \sigma_{\theta\theta} + g_i^2 \sigma_{\gamma\gamma} + 2e_i g_i \sigma_{\theta\gamma}, \quad i = 1, 2,$$

$$(18.2) \quad \sigma_{12} = e_1 e_2 \sigma_{\theta\theta} + g_1 g_2 \sigma_{\gamma\gamma} + (e_1 g_2 + g_1 e_2) \sigma_{\theta\gamma} = \sigma_{21},$$

$$(18.3) \quad \rho = \frac{e_1 e_2 \sigma_{\theta\theta} + g_1 g_2 \sigma_{\gamma\gamma} + (e_1 g_2 + g_1 e_2) \sigma_{\theta\gamma}}{\sqrt{(e_1^2 \sigma_{\theta\theta} + g_1^2 \sigma_{\gamma\gamma} + 2e_1 g_1 \sigma_{\theta\gamma}) (e_2^2 \sigma_{\theta\theta} + g_2^2 \sigma_{\gamma\gamma} + 2e_2 g_2 \sigma_{\theta\gamma})}}.$$

Thus, normality of  $\theta$  and  $\gamma$  do imply  $p_1$  and  $p_2$  are normally distributed.

If, for example,  $\gamma = 0$ , then  $\sigma_{\gamma\gamma} = 0$ ,  $\rho = 1$ , and (11) becomes

$$(19) \quad E(p_2 | p_1) = \bar{p}_2 + \frac{e_2}{e_1} (p_1 - \bar{p}_1) = \bar{p}_2 + e_2 \theta.$$

In this case, B firms shift their predictions of  $p_2$  linearly with  $\theta$ .

In contrast, when  $\sigma_{\gamma\gamma}$  and  $\sigma_{\theta\theta}$  are both positive, an increase in  $p_1$  could reflect either a low harvest ( $\gamma$  small) or large demand for  $x$  ( $\theta$  large). B firms will not know why  $p_1$  shifted; and, hence, their predictions of  $p_2$  will reflect a weighted averaging of  $\theta$  and  $\gamma$ .

#### B. Implications of Improved Information

In this model, the A firm has asymmetric information about  $\theta$  (we only assume the B firms do not know  $\gamma$  so that  $\theta$  will not be revealed through price

information). One way to model the effect of improved information is to ask what happens as  $\sigma_{\theta\theta}$  diminishes (all else the same).

Differentiating (12) with respect to  $\sigma_{\theta\theta}$  [using the definitions in equation (18)]:

$$(20) \quad \frac{d\phi}{d\sigma_{\theta\theta}} = \frac{e_1}{\sigma_{11}} (e_2 - \phi e_1).$$

Since  $e_1 > 0$ , but  $e_2 \gtrless 0$ , the sign of (20) is ambiguous. If we make the reasonable assumption that  $\phi \leq 1$  (an increase in  $p_1$  over its average value causes B firms' expectations about  $p_2$  to rise less than in proportion), after some tedious derivations it can be shown that  $d\phi/d\sigma_{\theta\theta} > 0$ . By differentiating equation (14), we know that the reaction of B firms to a change in A or x varies with information (uncertainty):

$$(21) \quad \frac{d\delta}{d\sigma_{\theta\theta}} = \frac{d\phi}{d\sigma_{\theta\theta}} \frac{nc_B\beta_1}{(c_B - n[\phi - 1]\beta_1)^2} > 0.$$

That is, a reduction in information (an increase in  $\sigma_{\theta\theta}$ ) raises  $\delta$ , causing B firms to be less accommodating.

To determine how information affects the average values of A, B, and x, we start by taking expectations (indicated by a "-") in equation (13),

$$(22.1) \quad \bar{B} = \frac{n\alpha_2 - \alpha_1 + \beta_1 Q - (\beta_1 + \beta_2) \bar{A} - \beta_1 \bar{x}}{c_B + n(\beta_1 + \beta_2)} \equiv Z_1 - Z_2 \bar{A} - Z_3 \bar{x}.$$

Taking expectations on both sides of (8.3) and substituting for  $\bar{B}$  from (21.1): we obtain

$$(22.2) \quad \bar{x} = \frac{\alpha_0 - \alpha_2 + \beta_2 Z_1 + \beta_2(2 - Z_2) \bar{A}}{2\beta_0 + \beta_2 Z_3} \equiv Z_4 + Z_5 \bar{A}.$$

Using (22.2), we can rewrite (22.1) as

$$(22.3) \quad \bar{B} = Z_1 - Z_3 Z_4 - (Z_2 + Z_3 Z_5) \bar{A} \equiv Z_6 - Z_7 \bar{A}.$$

Next, taking expectations on both sides of (8.2) and substituting for  $\bar{B}$  and  $\bar{x}$  from (22.2) and (22.3), we find that:

$$(23) \quad \bar{A} = \frac{[\alpha_0 - \alpha_1 + \beta_1 Q] - \beta_1 Z_6 - [2\beta_0 + \beta_1(2 + \delta) + c_A] Z_4}{[\beta_1(2 + \delta) + \beta_2 \delta + c_A] - \beta_1 Z_7 + [2\beta_0 + \beta_1(2 + \delta) + c_A] Z_5} \equiv \frac{Z_8}{Z_9},$$

where  $Z_5$  and  $Z_6$  are negative constants which depend on  $\phi$  since  $\delta$  does [see (14)].

Differentiating,

$$(24) \quad \frac{d\bar{A}}{d\sigma_{\theta\theta}} = \frac{-d\delta}{d\sigma_{\theta\theta}} \frac{1}{Z_9} \left[ \beta_1 Z_4 + \bar{A}(\beta_1 + \beta_2 + \beta_1 Z_5) \right].$$

All the variables in the brackets are positive except  $Z_4$ . As a result, the sign of (24) is ambiguous:  $d\bar{A}/d\sigma_{\theta\theta} \gtrless 0$ . As B firms face less uncertainty ( $\sigma_{\theta\theta}$  falls), they become more accommodating ( $\delta$  falls), but  $\bar{A}$  may rise or fall. Further, from (22.2) and (22.3),  $\bar{x}$  moves with  $\bar{A}$  and  $\bar{B}$  moves in the opposite direction. Thus, a decrease in  $\sigma_{\theta\theta}$  may cause  $\bar{A}$  and  $\bar{x}$  to fall and  $\bar{B}$  to rise, or  $\bar{A}$  and  $\bar{x}$  to rise and  $\bar{B}$  to fall.

Moreover,



$$(25.1) \quad \frac{d\bar{p}_1}{d\sigma_{\theta\theta}} = \frac{d\bar{A}}{d\sigma_{\theta\theta}} \beta_1 \left[ \frac{2\beta_0 c_B + \beta_2(2c_B + n\beta_2)}{2\beta_0[c_B + n(\beta_1 + \beta_2)] + n\beta_1\beta_2} \right]$$

$$(25.2) \quad \frac{d\bar{p}_2}{d\sigma_{\theta\theta}} = \frac{-d\bar{A}}{d\sigma_{\theta\theta}} \beta_2 \frac{2\beta_0 c_B - \beta_1\beta_2 n}{2\beta_0[c_B + n(\beta_1 + \beta_2)] + n\beta_1\beta_2}$$

and

$$(26) \quad \frac{d\bar{p}_x}{d\sigma_{\theta\theta}} = -\beta_0 \frac{d\bar{A}}{d\sigma_{\theta\theta}} Z_5.$$

That is, as  $\sigma_{\theta\theta}$  rises,  $p_1$  moves with  $\bar{A}$ ,  $p_x$  moves in the opposite direction, and  $p_2$  may move in the same or opposite direction.

Consumer surplus in each market is

$$(27) \quad s_i = \frac{1}{2} \beta_i q_i^2, \quad i = x, 1, 2.$$

Obviously,  $ds_i/d\sigma_{\theta\theta}$  moves in the opposite direction of  $dp_i/d\sigma_{\theta\theta}$ . Since farmers sell their entire harvest at price  $p_1$ , their incomes move in the same direction as  $p_1$ .

Similarly, by differentiating, we can show that  $\bar{\pi}_A$  changes in the same and  $\bar{\pi}_B$  move in the opposite direction as  $\bar{A}$ . Table 1 summarizes who wins and who loses as information improves.

The table clearly shows that, regardless of whether  $\bar{A}$  rises or falls, as B firms' information improves, there are both winners and losers. For example, when the farmers gain, the B firms lose and vice versa.

The results suggest that more information, under certain circumstances, may harm the B firms. One possible scenario is that, as B firms' information

Table 1. The Change in Various Welfare and Other Measures as B Firms' Information Improves Relative to the A firm's ( $\sigma_{\theta\theta}$  falls)

	If $\bar{A}$ falls	If $\bar{A}$ rises
$\delta$	falls	falls
$\bar{B}$	rises	falls
$\bar{x}$	falls	rises
$\bar{p}_1$	falls	rises
$\bar{p}_2$	?	?
$\bar{p}_x$	rises	falls
$s_1$	rises	falls
$s_2$	?	?
$s_x$	falls	rises
Farmers' Income	falls	rises
$\bar{\pi}_A$	falls	rises
$\bar{\pi}_B$	rises	falls

improves, A increases its allocation to the second-period market, and B firms accommodate by lowering their<sup>4</sup> output with a resulting decrease in their market share. Since the per unit profit ( $p_2 - p_1$ ) falls with improved information and B's output is lower, B becomes worse off. A contrasting scenario is that A reduces its allocation to the second-period market and the B firms increase their sales in that market. Here, the B firms "free ride" on the dominant firms' ability to increase  $p_2$  by unloading some of the stored crop in the x market.

Thus, depending on the measure used, an increase in B firms information (reduction in their uncertainty) can raise or lower welfare. For example, the sum of consumer surplus in the three output markets can rise or fall (even if one assumes  $\bar{A}$  must rise as information improves).

### III. Conclusion

For the model presented here, an increase in information known to the competitive fringe firms can increase or decrease the distortions in various agricultural markets. This ambiguous result should not be surprising. It simply reflects the general principle that, in moving from one second-best world to another, there is no assurance that societal welfare is enhanced. What at first may seem a paradox--improved information may be harmful--is a general result that should be expected.

Whether increasing information proves of value depends upon the relationship between prices in harvest and postharvest markets. It can be shown that many of the ambiguous comparative statics results depend on the parameter  $\phi$  which can be determined through a simple linear regression. A number of other potential implications of the model formulation require further investigation. In this sense, the results presented here are only preliminary.

Under certain circumstances, it can be shown that it is in the dominant firm's interests to reveal information to the competitive fringe B firms. Further research is necessary to examine the implications of this possibility. In future research, we propose to identify precisely parameter regimes for which improved information is beneficial or harmful to dominant type A firms, competitive fringe type B firms, consumers, farmers, and to society as a whole. The identification of these parameter regimes will allow us to determine under what conditions the collection and reporting by the government of better information will improve intertemporal allocations and reduce monopoly distortions. Isolating the conditions for revealing information is particularly valuable and could, of course, lead to improving the function of agricultural markets.

Finally, it is our expectation that the model structure presented here has much to offer in explaining the evolution of thin cash markets that have arisen for many agricultural commodities (Raikes). The distortions that arise in this model formulation from monopoly power and asymmetric information under certain conditions provide incentives for farmers to form cooperatives and for dominant firms and competitive fringe firms to engage in vertical integration (cf. Arrow and Carlton) and forward contracting. Attempts to gain information or to offset the information advantage or monopoly power of others through vertical integration, forward contracting, or the formation of cooperatives can (and has) resulted in thin cash markets (Garoyan and Armbruster). In future research we hope to isolate the relationship between the basic model structure proposed here, the role of information, and their collective implications for the thin spot markets that have arisen in many agricultural commodity systems.

Footnotes

\*Giannini Foundation Paper No. 675 (reprint identification only).

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<sup>1</sup>Hirshleifer concluded that there is an overinvestment in information collection in a market in which production is immutable (information cannot lead to a more efficient allocation of resources) and the private information held by a single agent has negligible impacts on prices. In his model, information cannot lead to a more efficient allocation of resources; rather, the impact is purely redistributive whereby the gains to one informed agent are made at the expense of others.

<sup>2</sup>Grossman and Stiglitz have argued that, in a market in which information acquisition is competitive, the market price must reveal just enough of the costly information so that the market participants are indifferent between incurring the cost of becoming informed or remaining uninformed and simply using market prices to guide their decisions.

<sup>3</sup>An alternative view has been expressed by Caves who argues that "there appear to be scale economies in coordination and risk bearing that are due to the characteristics of information as an input. Information is a fixed cost which can be spread over varying amounts of transactions, and information about trading locations is subject to increasing returns in the trading possibilities that it reveals."

<sup>4</sup>A farmer who stores his crop until period 2 is called a speculator and is considered to have sold his crop to himself at the going market price,  $p_1$ .

<sup>5</sup>We assume the processor stores it until the second period where it is converted into the processed form at no cost. It would make little qualitative difference to the analysis if it were also sold in the first period or if there was a costly Leontief conversion process.

<sup>6</sup>If firm A can only estimate  $\theta$  better than B firms, the qualitative story we tell below holds. We assume that firm A knows  $\theta$  with certainty to simplify the algebra. Given firm A knows  $\theta$ , it can infer  $\gamma$  from observing  $p_1$  and B.

<sup>7</sup>We assume that it does not pay firm A to destroy part of  $A + x$  in order to drive up  $p_2$  and  $p_x$ .

<sup>8</sup>Since B is a function of  $p_1$  and  $p_1$  is a function of  $A + x$ , B shifts equally given a change in either A or x. Heuristically, until period 2, whether firm A plans to use its purchases in the fresh or processed markets is irrelevant; its further purchases for either reason increases  $p_1$  all else the same.

<sup>9</sup>Cf., Newbery and Stiglitz on additive error terms.

<sup>10</sup>We are making use of a consistent conjectures assumption (analogous to Breshnahan) that about the equilibrium the slope of the B firms' reaction function equals the actual change. This assumption is used to obtain the expression to the right of the second equality sign.

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