Journal of Agricultural and Resource Economics 28(2):364–373

Using Both Sociological and Economic Incentives to Reduce Moral Hazard

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Economists tend to focus on monetary incentives. In the model developed here, both sociological and economic incentives are used to diminish the apparent moral hazard problem existing in commodity grading. Training that promotes graders' response to sociological incentives is shown to increase expected benefits. The model suggests this training be increased up to the point where the marginal benefit due to training equals its marginal cost. It may be more economical to influence the grader's behavior by creating cognitive dissonance through training and rules rather than by using economic incentives alone.

Key words: grading, incentives, moral hazard, norms, social sanctions

Introduction

Today more than ever, agricultural processors demand commodities that meet strict quality standards and, furthermore, commodities that have been accurately graded by quality. Processors seem more aware of the detriments of quality uncertainty. In a study of international grain markets, Wilson and Dahl found quality uncertainty can increase costs for buyers, processors, and grain handlers. Quality grades can also affect sorting and blending strategies.

Recent studies by Kenkel and Anderson in wheat and Pebe Diaz in peanuts have reported inaccuracy in grading due to graders not following directions. Brorsen, Grant, and Rister also found that hedonic prices for rice varied across locations due to differences in graders. Some graders do not follow official grading procedures because their individual incentives differ from those of the grading agency.

Economists have focused mainly on whether grading standards accurately measure the economic value of the commodity (e.g., Hennessy and Wahl; Adam, Kenkel, and Anderson). Scientists in other disciplines have examined the physical measurement of quality factors (Powell, Sheppard, and Dowell), but no research has been conducted on the incentives faced by individual graders.

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Review coordinated by Gary D. Thompson.

A principal-agent model is developed here to explain how both economic and sociological incentives can lead to improving the grading procedure. Principal-agent models are commonly used to determine the form of optimal contracts (e.g., Wu and Babcock; Lajili et al.; Allen and Lueck). The power of sociological incentives can be increased by training programs emphasizing the cost of not following directions and by administering psychological tests designed to identify graders who are prone to rule-following behavior.

The grader is assumed to be motivated by sociological incentives such as recognition and praise which add to the subjective or psychic income (increasing self-esteem) arising from doing a good job. According to neoclassical theory, the grader maximizes expected utility. The grader, as a rational economic agent, is motivated by economic incentives such as increased wage income and more hours of leisure. In addition to the economic incentives, nonmonetary, sociological incentives may also influence the grader's utility.

Moral Hazard in Grading

Standard agency theory deals with asymmetries of information that develop after the signing of a contract. Two types of informational problems arise: those resulting from hidden actions, and those resulting from hidden information (Mas-Colell, Whinston, and Green). Hidden action is the problem considered here. An example of the hidden action case, also known as moral hazard,[1] is illustrated by the inability of U.S. Department of Agriculture's Federal/State Inspection Service (hereafter denoted simply as USDA) to know the real capabilities of the grader or to observe whether the grader precisely follows grading procedures—i.e., the grader's effort levels are not observable. Hence, the USDA has an informational disadvantage. This problem is referred to as "nonobservability" in contract theory (Strausz).

The primary difficulty within the grading procedure is the existence of a moral hazard problem, which involves an incentive conflict between the USDA (principal) and the grader (agent). The grader is assumed to control an action that is normally interpreted as effort level. Following Strausz, the incentive problem is characterized as follows. The grader dislikes performing effort, but the USDA may need the grader to apply high effort because it tends to improve grading accuracy. While output, or grading accuracy, depends on the grader's effort, it is not solely determined by this effort. Consequently, the USDA and the grader can only contract on general grading services, and the need for monitoring arises.

Under the USDA operational structure for peanut grading, the Federal/State Area Supervisor is responsible for monitoring the grader's actions in an assigned territory. At any time, the supervisor can analyze a nongraded sample from a lot that has been graded, and track the individual graders who worked on the lot. However, the process of monitoring and supervision is costly—a factor likely explaining why monitoring is not used extensively.

[1] Mas-Colell, Whinston, and Green (see p. 477, footnote) point out that the literature's use of the term "moral hazard" is not entirely uniform. Also, for earlier moral hazard models, see Holmstrom; Shavell; Mirrless; and Grossman and Hart. For more information on recent developments in moral hazard models, see Prescott.

Social Norms Rewards, and Internal and External Sanctions

Coleman argues that tools such as social norms and internal and external sanctions could be useful in explaining micro-level social problems. With an internal sanction, the grader must internalize a norm, such as following grading manuals precisely. Formal training programs (workshops, seminars, conferences) are important means for convincing graders to internalize the norm.[2] Internal sanctions can be either positive or negative—the grader will feel internally rewarded for generating precise grades, or will feel internally punished (i.e., feel guilty) for not following directions. External sanctions can range from those damaging or enhancing prestige to those providing economic benefits. These sanctions directly affect the grader's utility. For example, when the USDA supervisor gives the grader a verbal reprimand for using improper sampling procedures, the USDA is employing an external sanction.

The nonmonetary effects on utility from both external and internal sanctions are called "psychic income." The USDA may decide to implement a strategy based on training, auditing, and incentives deriving from internal and/or external sanctions to induce the grader to apply high effort levels. The model presented below extends the classical moral hazard model to include training and social norms.

The Model

The USDA, acting as a risk-neutral principal in the model, wants to maximize benefits. A grader (the agent) is temporarily hired to perform grading services, and produces output θ. In this model, output is a measure of the level of grading *inaccuracy*, so less output is preferred to more.

As a consequence of the USDA's inability to observe the grader's effort, a moral hazard situation is created, bringing about a welfare loss. Our objective is to analyze whether or not psychic income, in combination with current monetary incentives, may reduce this welfare loss.

For simplicity, assume the grader can only take one of two effort levels: e_L the low effort level, and e_H the high effort level, with $e_H > e_L$. The USDA can implement a training program aimed at strengthening in graders an internal sanctioning system which induces an increase in graders' psychic income whenever they do a good job. Training at level t is performed at the beginning of the season and carries a one-time cost of $c(t)$. Denote by $d^H(t)$ the disutility of high effort, and by $d^L(t)$ the disutility of low effort. Effort creates disutility in the agent, $d^H(t) > d^L(t)$.

In the model, training directly affects the grader's disutility of effort by strengthening the grader's internal sanctioning (positive and negative) system. The higher the training level, the lower the disutility of exerting a high effort level, $\partial d^H(t)/\partial t < 0$. Also, training increases the disutility of exerting low effort levels, so $\partial d^L(t)/\partial t > 0$.

To construct the USDA's benefit function, let $f(\theta)$ be the monetary value of grading inaccuracy, and $p(\theta)$ be the monetary payment to the grader, where $\partial f(\theta)/\partial\theta < 0$ and $\partial p(\theta)/\partial\theta < 0$. The USDA's benefit function is then $f(\theta) - p(\theta) - c(t)$, and the grader's utility

[2] In conversations with graders, some told us they considered following certain details of grading manuals to be unimportant. This suggests some training programs have failed to convince graders of the importance of internalizing the norm.

function is $u(p(\theta)) + d(t)$, where u is a von Neumann-Morgenstern utility function with $u'(p(\theta))$ strictly decreasing in p.

To further simplify the model, assume output θ, the inaccuracy-in-grading measure, can take only discrete values in a finite range. The set of possible values for θ is $\{\theta_1, ..., \theta_n\}$. Also, recall that the USDA cannot precisely infer from the value of θ the effort level exerted by the grader. However, by monitoring and supervising, the USDA can estimate the probability distribution of outcome θ given a certain effort level. Let $\{\pi_{iH}\}$ be the probability distribution of θ given H (high effort), and $\{\pi_{iL}\}$ be the probability distribution of θ given L (low effort). Also, because θ is discrete, the monetary payment to the grader, $p(\theta)$, and the function, $f(\theta)$, will also be discrete. The following notation is used: $p_i = p(\theta_i)$ and $f_i = f(\theta_i)$, $i = 1, ..., n$.

When Effort Is Observable

With these variables defined, the problem is formulated where effort can be observed and graders are not trained, because the solution to this problem will be used to solve for the nonobservability-of-effort case with training. The USDA is assumed risk neutral, and thus its goal is to maximize expected benefits. One alternative to the risk-averse, effort-averse grader is to not accept the contract. If so, the grader gets utility $\bar{u}$. Hence, the grader must receive at least his/her reservation utility level $\bar{u}$ to accept the contract. This is known as the participation or individual rationality constraint.

The optimization problem, which is denoted Problem 1, is written as:

$$\max_{e, p_i} \sum_{i=1}^{n} [f_i - p_i]\Pi_{ie}, \qquad \text{s.t.: } \sum_{i=1}^{n} u(p_i)\Pi_{ie} - d^e \geq \bar{u}, \quad e \in \{L, H\}, \tag{1}$$

where Π_{ie} is the probability of θ_i occurring when effort e is applied, d^e is the disutility of effort level e, and e can take values H (high) and L (low).

Problems of this type may be solved in two stages. The problem is solved first with low, and then with high effort. Then maximized benefits are compared for these two solutions, and the effort level is chosen accordingly.[3]

Note that the participation constraint is binding at the optimum. To see this, assume the payment scheme $\{p_i\}$ is a solution to (1), but the constraint is not binding (the expected utility is strictly larger than the reservation utility). Then, a slightly smaller expected utility (p_j', smaller than p_j for some j) would also satisfy the constraint and at the same time yield a higher expected benefit for the USDA. This outcome contradicts the fact that $\{p_i\}$ solves (1).

With a fixed level of effort, the Lagrangian for this problem and the first-order conditions are:

$$\max_{p_i} L = \sum_{i=1}^{n} (f_i - p_i)\Pi_{ie} - \lambda \left(\sum_{i=1}^{n} u(p_i)\Pi_{ie} - d^e - \bar{u} \right), \tag{2}$$

[3] For a complete treatment of the typical principal-agent problem, see Mas-Colell, Whinston, and Greene (chapter 14, section B).

$$\frac{1}{u'(p_i)} = \lambda, \quad i = 1, \dots, n; \ \lambda > 0. \tag{3}$$

The grader is risk averse, and $u'(p_i)$ is strictly decreasing in p for all i. Therefore, (3) implies payments to the grader are constant for all i. With fixed payments, the participation constraint at the optimum becomes:

$$u[p^*] - d^{e^*} = \bar{u}, \tag{4}$$

where p^* denotes the fixed optimum payment, and e^* is the optimum effort level. This participation constraint leads to payments of the form:

$$p^* = u^{-1}(d^{e^*} + \bar{u}). \tag{5}$$

USDA's maximum expected benefits, as a function of effort, are:

$$\sum_{i=1}^{n} f_i \Pi_{ie^*} - u^{-1}(d^{e^*} + \bar{u}). \tag{6}$$

Thus, the solution to this problem is obtained by finding the effort level e^* that maximizes (6) and pays the grader a fixed wage p^*. Intuitively, fixed wages, or no incentives, make sense because of the attitudes toward risk of both parties, and because effort is observable and can be specified in the contract.

When Effort Is Not Observable

Now introduce training and assume effort is not observable. The problem can be stated as follows:

$$\begin{aligned} &\max_{p_i} \sum_{i=1}^{n} (f_i - p_i)\Pi_{ie^*} - c(t), \\ &\text{s.t.: } \sum_{i=1}^{n} u(p_i)\Pi_{ie^*} - d^{e^*}(t) \geq \bar{u}, \\ &\qquad e^* \text{ solves } \max_{e} \sum_{i=1}^{n} u(p_i)\Pi_{ie} - d^{e}(t). \end{aligned} \tag{7}$$

The second constraint is called the incentive compatibility constraint because, if satisfied, the grader's incentives become compatible with those of the USDA. The grader finds it optimal to exert the effort level desired by the USDA.

Again, the problem is analyzed in two stages. First, consider the problem with low effort and zero training ($t = 0$), denoted Problem 2. The solution to this problem will be to pay the grader a fixed wage of

$$p = u^{-1}\left(\bar{u} + d^{L}(0)\right). \tag{8}$$

To show this, note that (8) is the payment a grader would receive for the low-effort case when effort is observable [see (5)]. Because payments do not depend on the effort level (they are fixed), the grader will choose the level of effort that brings about the lowest disutility, while at the same time allowing the grader to earn his/her reservation utility. Also note that Problem 2 is actually Problem 1 with an added restriction. Therefore, a solution to Problem 2 can never obtain a higher maximum than a solution to Problem 1. Thus, payments as in (8) solve Problem 2. If training were added ($t > 0$), payments and costs would only increase (recall the disutility of low effort increases with training), and so zero training with (8) solves the low-effort case.

Now, consider the high-effort case with training. The problem was initially formulated with two choice variables, the monetary payment schedule (p) and the training level (t). An alternative is to have only p as a choice variable, leaving t as a parameter, and then perform comparative statistics on the optimized function by varying t. This latter approach was chosen because it allows a more intuitive understanding of the problem. So, for a fixed training level t, the model can be formulated as maximizing expected net benefit (EB):

$$\text{(9)} \qquad \begin{aligned} \max_{p_i} EB &= \sum_{i=1}^{n} [f_i - p_i]\pi_{iH} - c(t), \\ \text{s.t.: } &\sum_{i=1}^{n} u(p_i)\pi_{iH} - d^H(t) \geq \bar{u}, \\ &\sum_{i=1}^{n} u(p_i)\pi_{iH} - d^H(t) \geq \sum_{i=1}^{n} u(p_i)\pi_{iL} - d^L(t). \end{aligned}$$

Specifically, find the optimal payment scheme that will maximize the USDA's expected net benefit by inducing the grader to exert high effort. The first constraint is the participation constraint and the second is the incentive compatibility constraint.

The Lagrangian for this problem is expressed as:

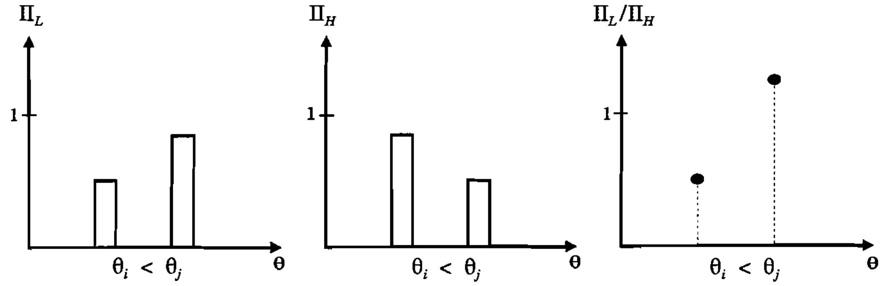
$$\text{(10)} \qquad \begin{aligned} L = \sum_{i=1}^{n} [f_i - p_i]\pi_{iH} - c(t) - \lambda_1 \left[\bar{u} + d^H(t) - \sum_{i=1}^{n} u(p_i)\pi_{iH} \right] \\ - \lambda_2 \left[d^H(t) - d^L(t) - \sum_{i=1}^{n} u(p_i)(\pi_{iH} - \pi_{iL}) \right]. \end{aligned}$$

The Kuhn-Tucker first-order conditions are obtained by differentiating (10) with respect to each p to obtain:

$$\text{(11)} \qquad \frac{1}{u'(p_i)} = \lambda_1 + \lambda_2(1 - \pi_{iL}/\pi_{iH}), \quad i = 1, \ldots, n,$$

where $\lambda_1^* > 0$, $\lambda_2^* > 0$.

The set of equations in (11) indicates the optimum monetary payment will depend on the likelihood ratio π_{iL}/π_{iH}. The likelihood ratio is the ratio of probabilities of obtaining outcome (error in grading) i, given low and high efforts. Thus, for low outcome levels, it is desirable that the likelihood ratio be small. This would imply the grader is more likely to make only a few errors when exerting high as compared to low effort. Likewise, a large outcome level should be associated with a large likelihood-ratio value because a large amount of errors in grading should be associated with low effort as compared to high effort (figure 1). Monitoring will allow obtaining a better estimate of this ratio, and thus it will determine how closely the solution is approximated.



Note: Although it is desirable that Π_L/Π_H be monotonic (monotonic likelihood-ratio property), this may not always be the case.

Figure 1. The likelihood ratio as an increasing function of grading inaccuracy

Let us examine why both Lagrangian multipliers are greater than zero. If λ_2^* were zero, a fixed-wage solution would result and the grader would perform at low effort, which is undesirable. On the other hand, λ_1^* equal to zero could lead to $u'(p)$ being negative (if $\pi_{iL}/\pi_{iH} > 1$), which violates our assumption about the grader's utility function.

If in fact the likelihood ratio is small for small i's (fewer errors in grading) and large for large i's (more grading errors), from (11) and because $u'(p)$ is decreasing, payments to the grader will be larger with fewer errors and smaller with more errors. This variability in payments and a risk-averse grader translate into higher expected payments to the grader as compared to the observable case, in order to achieve the same expected utility level of $\bar{u}$. In other words, because the payment scheme introduces risk, the grader will need to be compensated with higher average payments.

To observe this, note that for the risk-averse grader, the utility of expected payments ($u(\mathrm{E}p)$) is strictly greater than the expected utility of payments: $u(\mathrm{E}p) > \Sigma_{i=1}^n u(p_i)\pi_{iH}$. Because λ_1 is binding, $\Sigma_{i=1}^n u(p_i)\pi_{iH} = \bar{u} + d^H(t)$ holds. Therefore, $\mathrm{E}p > u^{-1}(\bar{u} + d^H(t))$, where the last term is the fixed optimum payment when effort is observable as in (5).

So far, results can be summarized as follows. When the USDA finds it optimal to induce low effort, payments to the grader will be fixed and equal to the payments graders would receive if efforts were observable and low effort were optimal. No training would be necessary, and no welfare loss would occur. However, if the USDA finds it optimal to induce high effort in graders, payments will no longer be fixed; rather, they will be characterized by (11). Higher expected payments to the grader are needed to induce high-effort performance when effort is nonobservable. Thus, there will be a welfare loss as compared to the effort-observable case.

Now, to determine if training can decrease this loss, we analyze how training affects the USDA's optimized level of expected net benefit, EB^*. Comparative statics are obtained on the optimized Lagrangian, using the envelope theorem:

$$(12) \qquad \partial EB^*/\partial t = \partial L^*/\partial t = -\partial c/\partial t - (\lambda_1 + \lambda_2)d_t^H(t) + \lambda_2 d_t^L(t).$$

Training will increase the optimized expected net benefit for the USDA as long as the expression in (12) is positive. Given the assumptions on the disutility functions, the first term is negative, and the second and third terms are positive. To interpret (12), consider the following comparative statics:

(13) $$\partial EB^*/\partial d^H = \partial L^*/\partial d^H = -(\lambda_1 + \lambda_2)$$

and

(14) $$\partial EB^*/\partial d^L = \partial L^*/\partial d^L = \lambda_2.$$

Derivatives (13) and (14) may be interpreted as the "ceteris paribus" effect of a change in the disutility functions at high and low effort levels, respectively, on the optimized expected net benefit. More explicitly, if the disutility of high effort can be decreased (possibly through training), expected net benefit to the USDA will increase [see (13)]. Likewise, if the disutility of performing low effort increases (through training), expected net benefit will also increase [see (14)].

A first look at these expressions might suggest it is more beneficial to invest in training that will positively reinforce the norm, as in (13), than to train toward strengthening internal sanctions in the grader, as in (14). However, the cost of both types of training ought to be considered, as well as the relative magnitude of the Lagrange multipliers.

Returning to expression (12), replace (13) and (14) in (12). Training will increase maximized net benefit as long as:

(15) $$\partial c/\partial t < (\partial EB^*/\partial d^H)d_t^H(t) + (\partial EB^*/\partial d^L)d_t^L(t),$$

giving the classical result that training should be increased up to the point where the marginal cost of training equals the expected marginal benefit from training. Hence, *when high effort is optimal* for the USDA, the welfare loss occurring due to nonobservability of effort might be lessened with training as defined here.

In peanut grading, where monitoring is limited, graders have been observed to exert low effort levels (Pebe Diaz). In the context of the above model, the incentive compatibility constraint seems not to hold. This result could mean the USDA finds low effort optimal, or it could indicate the USDA is operating inefficiently. In peanut grading, the USDA is relying heavily on internal sanctions to obtain the desired result, and in some cases this has not been sufficient. Implementing training programs that strengthen internal sanctions and increased monitoring in combination with external sanctions are possible solutions to the incentive problems in peanut grading. Also, Pebe Diaz et al. argue that the peanut grading procedure could be redesigned whereby the disutility of high effort would be less.

The reasons for inaccurate grading in wheat are different from those observed in peanut grading. In wheat, the principals (elevators) have developed an asymmetric objective function which has large penalties for underestimating quality. In Oklahoma, an extension education program directed to farmers and elevator managers regarding the importance of accurate grading resulted in a change in the objective function, which in turn has caused more accurate grading of wheat. Because the sampling and grading rules for wheat are easier to follow than those for peanuts,[4] the incentive compatibility constraint appears to be violated rarely.

[4] With peanuts, proper sampling takes about 15 minutes, and the grader is to rotate among a set of sampling patterns. A peanut grader also has an incentive to start with an overweight sample to reduce the probability of having to regrade (Pebe Diaz et al.).

Conclusions

A theoretical framework was developed to explain the incentives faced by graders. Previous moral hazard models have not considered both sociological and economic incentives. A training-monitoring strategy was analyzed under a moral hazard setting where the USDA (Federal/State Inspection Service) was the principal and the grader was the agent. Nonmonetary incentives or psychic income due to praise, and internal or external sanctions in the grader's expected utility function were included. Payments to the grader are dependent on the likelihood of inefficiency at different effort levels, which is estimated through monitoring.

Results of the model suggest the USDA should consider using training to create internal sanctions as an alternative to using monetary incentives alone. Training is shown to increase optimal expected benefits. The model indicates training should be increased to the point where the expected marginal benefit due to training equals its marginal cost. The USDA may find it more economical to influence the grader's behavior through training and rules rather than by using economic incentives alone. Formal training programs for graders should aim at having graders internalize grading norms, thereby creating awareness of the problems derived from not following instructions.

[*Received September 2001; final received February 2003.*]

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