Using Both Sociological and Economic Incentives to Reduce Moral Hazard

Francisca G.-C. Richter

Edgar F. Pebe Diaz

B. Wade Brorsen (Corresponding Author)
Department of Agricultural Economics
Oklahoma State University
526 Ag Hall
Stillwater, OK 74078
Phone: (405)-744-6084
Email: **brorsen@okstate.edu**

Kevin Currier

Selected Paper prepared for presentation at the
Southern Agricultural Economics Association Annual Meeting, Mobile, Alabama, February 1-5, 2003

- Francisca G.-C. Richter is a former Post Doctoral Fellow in the Department of Agricultural Economics at Oklahoma State University. Edgar F. Pebe Diaz is an economist with the Ministry of Economy and Finance in Peru. B. Wade Brorsen is a regents professor and Jean and Patsy Neustadt Chair in the Department of Agricultural Economics at Oklahoma State University. Kevin Currier is an associate professor in the Department of Economics at Oklahoma State University. This research was partially supported with a grant from the Targeted Research Initiative Program at Oklahoma State University. The authors thank Kim Anderson, and Phil Kenkel for their considerable assistance.

Using Both Sociological and Economic Incentives to Reduce Moral Hazard

Abstract

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 that 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

Agricultural processors today, more than ever, 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. Wilson and Dahl have shown that 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 found inaccuracy in grading due to graders not following directions. Brorsen, et al. 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 mainly focused on whether grading standards accurately measure the economic value of the commodity (eg. Hennessy and Wahl; Adam, Kenkel, and Anderson). Scientists in other disciplines have focused on the physical measurement of quality factors (Powell, Sheppard, and Dowell), but there has been no research on the incentives of individual graders.

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 (eg. Wu and Babcock; Lajili et al.; Allen and Lueck). The power of sociological incentives can be increased by training programs that emphasize the cost of not following directions and by giving psychological tests that help select graders that are prone to rule-following behavior.

We assume that the grader can be motivated by sociological incentives (recognition and praise) that add to the subjective or psychic income (increasing self-esteem) that arises 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, we hypothesize that certain nonmonetary 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. There are two types of informational problems that arise: those resulting from hidden actions and those resulting from hidden information (Mas-Colell, Whinston, and Green). An example of the hidden action case, also known as moral hazard[4], is illustrated by the USDA's inability to know the real capabilities of the grader or to observe whether the grader precisely follows grading procedures. That is, 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 hidden information case arises when the grader often ends up having better information than the USDA about the technicalities of the grading process that could be used to improve the grading system.

The main problem existing in grading is a moral hazard problem, which involves an incentive conflict between the USDA (principal) and the grader (agent). The grader is

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

assumed to control an action that is normally interpreted as effort level. Following Strausz, the incentive problem is depicted as follows: the grader dislikes performing effort, but the USDA wants the grader to apply high effort, as it tends to improve grading accuracy. Output, or grading accuracy, depends on the grader's effort, but it is not solely determined by it. So, 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 non-graded sample from a lot that has been graded, and track the graders that worked on that lot. However, it is costly to monitor and supervise, which is probably why monitoring is not used extensively.

Social Norms Rewards, and Internal and External Sanctions

Coleman argues that tools such as social norms and internal and external sanctions could be useful to explain micro-level social problems. With an internal sanction, the grader must internalize a norm such as following grading manuals exactly. Formal training programs (workshops, seminars, conferences) are important means of internalizing the norm in the grader[2]. Internal sanctions can be either positive or negative, so that the grader will feel internally rewarded for generating precise grades and internally punished 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

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

grader a verbal reprimand if observed using improper sampling procedures, the USDA is using 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 Varian's moral hazard model to include training and social norms. Implications for grading accuracy are derived.

The Model

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 will be a measure of the level of grading *inaccuracy*, so less output will be preferred to more.

The fact that USDA is unable to observe the grader's effort creates a moral hazard situation and brings about a welfare loss. We want to analyze whether or not psychic income, along with current monetary incentives may reduce this welfare loss.

For this, let us clearly define how psychic income enters in the model. For simplicity, we assume the grader can only take one of two effort levels, e_L being the low effort level and e_H the high effort level, with $e_H > e_L$ USDA can direct a training program aimed at strengthening in graders an internal sanctioning system, induces an increase in 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. Since effort creates disutility in the agent, $d^H(t) > d^L(t)$. In our model, training directly affects the grader's disutility of effort, by strengthening the graders' 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 USDA's benefit function, let *f(θ)* be the monetary value of grading accuracy; and *p(θ)* 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 function is $u(p(\theta)) + d(t)$, where *u* is a von Neumann-Morgenstern utility function with u'(p(θ)) strictly decreasing in *p*.

To further simplify the model, assume that output *θ*, the inaccuracy in grading measure, can only take discrete values in a finite range. The set of possible values for θ is: $\{\theta_1, \ldots, \theta_n\}$. Also, recall that USDA cannot precisely infer from the value of θ the effort level exerted by the grader. However by monitoring and supervising, 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, since θ is now discrete, the monetary payment to the grader, *p(θ)* and the function *f(θ)* will also be discrete. We use the following notation: $p_i = p(\theta_i)$ and $f_i = f(\theta_i)$, i=1, …, n. Note, however, that in reality USDA will only be able to *estimate* θ, and that the higher the monitoring level (more samples per period), the better the estimator of grading inefficiency will be.

When Effort Is Observable

With these variables defined, we proceed to formulate the problem when effort can be observed and graders are not trained, because the solution to this problem will be used to solve for the non-observability of effort-case with training. We have assumed the USDA is 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 $\overline{u}$. Hence, the grader has to receive at least his reservation utility level $\overline{u}$ to accept the contract. This is the participation or individual rationality constraint.

The optimization problem, which shall be called Problem 1, is:

$$(1) \qquad \max_{e,\,P_i} \sum_{i=1}^{n} \left[f_i - p_i \right] \Pi_{ie}$$

$$\text{s.t.} \sum_{i=1}^{n} u(p_i) \Pi_{ie} - d^e \geq \overline{u}$$

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: Solve the problem first with low and then with high effort. Then compare maximized benefits for these two problems and choose the effort level accordingly[3].

Note that the participation constraint will be binding at the optimum. To see this, let $\{ p_i \}$ be any set of payments that satisfies the constraint but is not binding. Then there will always exist a value $\varepsilon > 0$, no matter how small it needs to be, such that $\{ p_i - \varepsilon \}$ also satisfies the constraints and increases the profit function as compared to $\{ p_i \}$.

With a fixed level of effort, the Lagrangian for this problem and the first order conditions for all i=1, ..., n are:

$$(2) \qquad \max_{p_i} \; L = \sum_{i=1}^{n} \left(f_i - p_i \right) \Pi_{ie} - \lambda \left(\sum u(p_i) \Pi_{ie} - d^e - \overline{u} \right)$$

$$(3) \qquad \frac{1}{u'(p_i)} = \lambda \qquad\qquad i = 1, \ldots, n$$

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

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

(4) $$u\left[p^*\right] - d^{e^*} = \bar{u} \ ,$$

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

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

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

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

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 let us introduce training and assume effort is not observable.

The problem can be stated as:

(7)
$$\max_{p_i} \sum_{i=1}^{n} \left(f_i - p_i\right) \Pi_{ie*} - c(t)$$
$$\text{s.t.} \sum_{i=1}^{n} u\left(p_i\right) \Pi_{ie*} - d^{e*}(t) \geq \bar{u}$$
$$e^* \text{ solves } \max_{e} \sum_{i=1}^{n} u\left(p_1\right) \Pi_{ie} - d^{e}(t)$$

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

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

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

To show this, note that (8) is the payment a grader would receive for the low effort case when effort is observable (see (5)). Since 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 lets him earn his reservation utility. Also note that Problem 2 is Problem 1 with an added restriction. So 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 we were to add training (t>0), payments and costs would only increase (recall that the disutility of low effort increases with training), and thus, zero training with (8) solves the low-effort-case problem.

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 to this is to have only p as a choice variable, leave t as a parameter and then perform comparative statics on the optimized function varying t. This latter approach was chosen since it allows a more intuitive understanding of the problem. So, for a fixed training level t, the model can be formulated as follows:

(9) $$\max_{p_i} \sum_{i=1}^{n} \left[f_i - p_i\right] \pi_{iH} - c(t)$$

st.

$$\sum_{i=1}^{n} u(p_i)\,\pi_{iH} - d^H(t) \geq \bar{u}$$

$$\sum_{i=1}^{n} u(p_i)\,\pi_{iH} - d^H(t) \geq \sum_{i=1}^{n} u(p_i)\,\pi_{iL} - d^L(t)$$

That is, find the optimal payment scheme that will maximize USDA's expected profit 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:

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

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

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

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

The set of equations in (11) indicates that the optimum monetary payment will depend on the likelihood ratio π_{iL} / π_{iH}. Note that this value 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 that it 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 since a large amount of errors in grading should be associated with low as compared to high effort. Monitoring will allow obtaining a better estimate of this ratio, and thus, it will determine how closely we approximate the solution.

Let us see why both Lagrangian multipliers are greater than zero. If λ_2 were zero, we would have a fixed wage solution so the grader would perform at low effort, which is undesirable. If λ_1 were zero we could have, for a large number of errors in grading (represented by θ_i) that $\pi_{iL} / \pi_{iH} > 1$, and thus, $u'(p)$ would be negative, which violates our assumption about the grader's utility function.

If in fact the likelihood ratio is small for small i's (less errors in grading) and large for large *i*'s (more grading errors), from (11) and the fact that *u'(p)* is decreasing, we can be assured that payments to the grader will be larger for fewer errors and smaller for more errors. This variability in payments translates into higher expected payments to the grader as compared to the fixed wage case.

So far, results can be summarized as follows: When USDA finds it optimal to induce low effort, payments to the grader will be fixed and equal to the payments that 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 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 him to perform high effort than when effort is observable. Thus, there will be a welfare loss as compared to the effort-observable case.

Now, to see if training can decrease this loss, let us analyze how training affects the USDA's optimized level of expected profit, *EP**. For this, we perform comparative statics on the optimized Lagrangian, using the envelope theorem:

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

From this, training will increase the optimized expected profit for USDA as long as the expression in (12) is positive. By our assumptions on the disutility functions, the first term is negative, and the second and third terms are positive. To interpret (12) let us first look at the following comparative statics:

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

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

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 profit. More explicitly, if we are able to decrease the disutility of high effort (possibly through training), expected profit to USDA will increase (see (13)). Likewise, if the disutility of performing low effort increases (through training), expected profit will also increase (see (14)). A first look at the these expressions might suggest that it is more profitable to invest in training that will positively reinforce the norm (13), than to train towards strengthening internal sanctions in the grader (14). However the cost of both types of training ought to be considered as well as the relative magnitude of the multipliers.

Now, going back to expression (12), replace (13) and (14) in (12). We can say that training will increase maximized profit as long as:

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

This gives 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 USDA, the welfare loss that occurs due to non-observability 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 terms of the above model, the incentive compatibility constraint seems not to hold. This could mean that the USDA finds low effort optimal or it could mean that the USDA is operating inefficiently. In peanuts, the USDA is relying heavily on internal sanctions to get the desired result and in some cases this has not been sufficient. Designing training programs that strengthen internal sanctions as well as increased monitoring are possible solutions to the incentive problems in peanut grading. Pebe Diaz et al. argue that the peanut grading procedure could be redesigned so that the disutility of high effort would be less.

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

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 was the principal and the grader was the agent. Nonmonetary incentives or psychic income due to praise, internal, or external sanctions in the grader's expected utility function were included.

The model suggested that 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 and it is suggested that training be increased up to the point where the marginal benefit due to training equals its marginal cost. USDA may find it more economical to influence the grader's behavior by creating cognitive dissonance through training and rules rather than by using economic incentives alone. Formal training programs for graders should aim at internalizing sanctions and thus creating awareness of the problems derived from not following instructions.

---

[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.).

References

Adam, B.D., P. Kenkel, and K. Anderson. "Economics of Cleaning Wheat." *Journal of Agricultural and Resource Economics* 19(1994):280-98

Brorsen, B.W., W.R. Grant, and M.E. Rister. "Economic Values of Rice Quality Factors." The Texas Agriculture Experiment Station, Texas A&M University, PR-4202, June 1984.

Coleman, James S. *Foundations of Social Theory*. Cambridge: The Belknap Press of Harvard University Press, 1990.

Grossman, S.J. and O.D. Hart. "An Analysis of the Principal-Agent Problem." *Econometrica* 51(1983): 7-46.

Hennessy, D.A., and T. Wahl. "Discount Schedules and Grower Incentives in Grain Marketing." *American Journal of Agricultural Economics* 79(August 1997):888-901.

Holmstrom, Bengt. "Moral Hazard and Observability." *Bell Journal of Economics* 10(1979):74-91.

Kenkel, P., and K. Anderson. "Who Wins, Who Loses? Report on OSU Study on Grain Grading Accuracy." *Oklahoma Current Farm Economics* 69(1996):27-36.

Mas-Colell, Andrew, Michael D. Whinston, and Jerry R. Greene. *Microeconomic Theory*. New York: Oxford University Press, Inc., 1995.

Mirrless, J. "The Implications of Moral Hazard for Optimal Insurance." Mimeo, Bergen, 1979.

Pebe Diaz, E.F. "Refining the U.S. Peanut Grading System." Unpublished Ph.D. diss., Okla. State Univ., December 1999.

Pebe Diaz, E.F., B.W. Brorsen, K.B. Anderson, and Phil Kenkel, 2001. "Effects of Overweight Samples and Rounding of Grade Percentages on Peanut Grades and Prices." *Peanut Science*, 28:9-12.

Powell, Jr., J. H., H. T. Sheppard, and F. E. Dowell. "An Automated Data Collection System for Use in Grading of Farmers' Stock Peanuts." Paper presented at the 1994 International Winter Meeting sponsored by American Society of Agricultural Engineers (ASAE), Atlanta, Georgia, December 13-16, 1994.

Prescott, Edward S. "A Primer on Moral-Hazard Models." *Federal Reserve Bank of Richmond Economic Quarterly* 85(1999):47-77.

Shavell, S. "Risk Sharing and Incentives in the Principal and Agent Relationship." *Bell Journal of Economics* 10(1979):55-73.

Strausz, Roland. *On Incentives and Asymmetric Information in Organizations*. Aachen, Berlin: Shaker Verlag, 1998.

Varian, Hal R. *Microeconomic Analysis*. Third Edition. New York: W.W. Norton & Company, Inc., 1992.

Wilson, W.W., and B.L. Dahl. "Quality Uncertainty in International Grain Markets: Analytical and Competitive Issues." *Review of Agricultural Economics* 21 (Spring/Summer 1999):209-224.