The Welfare Effects of Banning Tournaments When Commitment Is Impossible: Some Results from the Broiler Sector

We consider the social efficacy of banning relative performance contracts in a multi-period model where parties cannot commit to future contract parameters. A ban can increase total surplus by mitigating the ratchet effect. Calibrating the model to published data from the broiler sector, we find a ban on use of all relative performance data does not improve total surplus under most circumstances but could increase total surplus in a few instances of low wealth and unitary relative risk aversion. Such a ban also impedes the formation of grower reputation, which may help explain the popularity of tournament bans among some growers. More practically implemented bans that forbid only the use of contemporary relative performance data are less likely to be welfare enhancing and have no effect on the speed of reputation formation. We also derive results concerning the impact of serial correlation of common production shocks on the strength of the ratchet effect and potential welfare gains from tournament bans.

Key Words: Broiler Chickens, Compensation, Contracts, Piece Rates, Regulation, Relative Performance Indicators, Tournaments, Welfare

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There has been much discussion about banning the use of relative performance (RP) schemes in the agricultural sector as pressure from producers involved in these tournament-type contracts increases. Such tournament-type contracts shield growers from systemic risks, i.e., provide insurance against shocks common to all agents, but expose growers to the heterogeneity of abilities found within the group whose performance determines the benchmark, i.e., expose agents to group composition risk (Tsoulouhas and Vukina). We consider a case in which the principal is involved in two periods of contracting and contracts are only enforceable for a single period; i.e., the principal cannot commit to the parameters of second-period contracts during the first period. This is quite common in agricultural contracting. For example, standard broiler contracts cover only one grower period at a time while many hog finishing contracts explicitly note that quality standards used in compensation formulae may be altered in the future if the contracted standards significantly deviate from industry standards.

The introduction of multiple periods without the ability of the principal to commit to future actions may introduce implicit incentives that can impede efficient outcomes. By commitment, we mean that the principal writes contracts where the parameters governing agent compensation during latter periods are independent of information revealed during earlier periods. Consequently, agents' optimal choices of effort for the entire sequence of periods can be determined with initial information. Without this ability to commit to future contract parameters, implicit incentives may emerge to alter early period effort to gain more favorable terms of trade later in the time horizon.

One type of implicit incentive is the *ratchet effect*, in which agents reduce effort in early periods to lower the principal's expectations concerning future performance and, hence, set contract terms more favorable for the agent in later periods (Olsen and Torsvik, Weitzman). *Career concerns* or *reputation effects* refer to a class of implicit incentives that may heighten agent effort in early period's in order to improve the principal's expectations concerning future performance and gain more favorable contract terms for subsequent periods (Gibbons and Murphy).

Previous analyses of banning tournaments in an agricultural context consider only a static framework, i.e., a single period (Tsoulouhas and Vukina 1999, 2001), or multiple periods with commitment (Levy and Vukina). In each case the authors make convincing arguments that, for the case of broiler chicken production, banning contracts with RP measures would reduce social welfare (principal's plus agents' surplus) because the production variance attributable to common production shocks is substantially larger than the variance attributable to agents' heterogeneous abilities, i.e., the positive insurance provision effect outweighs the negative group composition risk effect. Furthermore, for the dynamic case with commitment, Levy and Vukina argue that the league composition effect (i.e., the changing mix of competitors' abilities across periods) in combination with large common shocks undermines the social efficacy of a ban on RP measures.

Lueck and Allen and Leegomonchai and Vukina have studied implicit incentives in agricultural contracting situations, though not in the context of exploring the efficacy of a ban on tournaments. Allen and Lueck's empirical search for ratchet effects in agricultural land rental markets revealed little affirmative evidence, though such markets do not commonly employ RP measures for determining compensation.

Leegomonchai and Vukina's research is directly relevant to our work as they draw stylized facts and data from the broiler chicken sector, which commonly employs tournament compensation. The authors develop a theoretical model in which a principal may induce implicit incentives by allocating high and low quality inputs according to perceived agent ability. Whether the principal allocates high quality inputs to high ability agents (i.e., induces career concerns) or to low ability agents (i.e., induces ratchet effects) in their model depends upon the underlying production technology.

The authors analyze data from broiler chicken tournament contracts and look for instances where higher quality inputs are differentially allocated across growers according to ability, where bird mortality during the first week of growth (normalized to account for ability differences across growers) serves as the measure of input quality. Their analysis rejects differential allocation in 73 percent of the cases analyzed, fails to reject career concerns in 17 percent of the cases, and fails to reject ratchet effects in 10 percent of the cases (their Table 5). They conclude that implicit incentives do not appear to dominate in such contracting situations, but that further empirical work is required.

The current research explores how implicit incentives alter the social efficacy of proposed bans on RP contracts. To the authors' knowledge, the only previous research on this nexus of issues is by Meyer and Vickers. In their theoretical and numerical analysis, they find that a ban of RP measures could improve total surplus when the ratchet effect is large enough and that reputation effects have no impact on social welfare.

The purpose of this paper is to explore whether banning relative performance measures could increase total surplus when commitment is not possible and, if so, to see if the situations in which welfare could be improved correspond to the empirical regularities of the broiler chicken market. We begin by developing a two-period model similar to that of Meyer and Vickers (MV) in which a single principal contracts with two agents. The risk neutral principal values output created by the risk-averse agents. The agents create output via a production function that is linear in their own costly effort, in their own ability, in a common production shock and in an idiosyncratic production shock. We then consider the welfare effects of a policy that bans the principal from comparing one agent's performance to that of another agent.

The model and analysis extend MV in two non-trivial ways. First, it allows for serial correlation in common production shocks to accommodate the empirical regularities of such shocks in many agricultural contexts including broiler production. The generalization turns out to be important as serial correlation often exacerbates the ratchet effect. Second, we consider a more feasible same-period ban of tournament contracts. MV analyze a ban that forbids the principal from using current or past performance of other agents to set contract parameters, which we argue would be difficult to enforce in realistic settings. Furthermore, the current effort is one of the few analyses to consider ratchet effects in an agricultural context and to consider the implications of banning tournaments in a setting where commitment is not possible.

Model

In the spirit of Meyer and Vickers, consider a principal (P) who contracts with two agents (A_i, A_j) over two periods, t = 1, 2. In period t A_k produces output, x_{it}, according to:

(1) $$x_{kt} = a_k + e_{kt} + z_t + u_{kt}$$

where a_k is the time invariant ability level of agent k, e_{kt} is the effort put forth by agent k in period t, z_t is a common shock experienced by both agents in period t and u_{kt} is an idiosyncratic shock experienced by agent k in period t. Agents know their own ability level while all agents and the principal are aware of the distributions that contain agents' ability levels and the distributions from which the common and idiosyncratic shocks are drawn. Agents observe random shocks after choosing effort but are not directly informed of the other agent's ability. The principal is never made aware of the realized shocks. The random and unknown elements are distributed as follows:

(2) $$\begin{pmatrix} a_i \\ a_j \end{pmatrix} \sim N\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \sigma^2 \begin{pmatrix} \tau_1 & \eta\tau_1 \\ \eta\tau_1 & \tau_1 \end{pmatrix}\right],$$

(3) $$\begin{pmatrix} z_1 \\ z_2 \end{pmatrix} \sim N\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \sigma^2 \begin{pmatrix} \tau_2 & \rho\tau_2 \\ \rho\tau_2 & \tau_2 \end{pmatrix}\right] \text{ and}$$

(4) $$u_{t,k} \sim N[0, \tau_3\sigma^2] \ \forall\ t, k,$$

where $\tau_i \geq 0$ $i = 1, 2, 3$ and $\tau_1 + \tau_2 + \tau_3 = 1$. The correlation between agents' ability levels equals η while ρ is the serial correlation of the common shock. We assume no correlation between ability, common shock and idiosyncratic shock, i.e., $E[a_k z_t] = E[a_k u_{tk}] = E[z_t u_{tk}] = 0 \ \forall\ k, t$. Together, this yields and unconditional distribution for production of

(5) $$\begin{pmatrix} x_{1i} \\ x_{2i} \\ x_{1j} \\ x_{2j} \end{pmatrix} \sim N\left[\begin{pmatrix} \hat{e}_{1i} \\ \hat{e}_{2i} \\ \hat{e}_{1j} \\ \hat{e}_{2j} \end{pmatrix}, \sigma^2 \begin{pmatrix} 1 & R & C & K \\ R & 1 & K & C \\ C & K & 1 & R \\ K & C & R & 1 \end{pmatrix}\right]$$

where $\hat{e}_{tk}$ denotes the conjecture (which is correct in equilibrium) concerning agent k's effort in period t, $R = \tau_1 + \rho\tau_2$ is the time series correlation between production levels for the same agent, $C = \eta\tau_1 + \tau_2$ is the cross sectional correlation between agents' production levels during the same time period, and $K = \eta\tau_1 + \rho\tau_2$ is the correlation between output of different agents in different periods.

Given that production levels are normally distributed, one can deduce the following condition variances and expectations, which will be of use later in the analysis:

(6) $\text{var}(x_{ti} \mid x_{tj}) = \sigma^2\nu_1$

(7) $\text{var}(x_{2i} \mid x_{1i}) = \sigma^2\nu_2$

(8) $\text{var}(x_{2i} \mid x_{1i}, x_{1j}, x_{2j}) = \sigma^2\nu_3$

(9) $\text{var}(x_{2i} \mid x_{1i}, x_{1j}) = \sigma^2\nu_4$

(10) $E[x_{2i} \mid x_{1i}, x_{1j}, x_{2j}] = \hat{e}_{2i} + \gamma(x_{1i} - \hat{e}_{1i}) + \delta_1(x_{1j} - \hat{e}_{1j}) + \delta_2(x_{2j} - \hat{e}_{2j})$

where detailed expressions for ν_1 - ν_4, γ, δ_1 and δ_2 are provided in the Appendix.

The principal forms a contract with both agents at the beginning of each period with a wage, w_{it}, paid in the form

(11) $w_{it} = \alpha_t + \beta_t x_{it} + \in_t x_{jt}$

where α_t is a fixed payment, β_t is a piece-rate reward based upon agent i's production and $\in_t$ is a payment based upon the performance of the other agent. The agent's cost of exerting effort is $C(e_{it}) = ½(e_{it})^2$, which is a strictly increasing, convex function of e_{it}. The risk-averse agents have utility

(12) $U_i = -\exp\{-r[w_{i1} - ½(e_{i1})^2 + w_{i2} - ½(e_{i2})^2]\}$

where r is the Pratt-Arrow coefficient of absolute risk aversion. Given the normality assumptions for the random and unknown elements and the linear form of the payment scheme, agent i's expected utility has the certainty equivalent of

(13) $CE_i \equiv E(w_{i1}) - ½(e_{i1})^2 + E(w_{i2}) - ½(e_{i2})^2 - ½\, r\, \text{var}(w_{i1} + w_{i2})$.

The risk-neutral principal's objective with respect to agent i is to choose payment parameters α_t, β_t and $\in_t$ to maximize

(14) $E(x_{i1}) - E(w_{i1}) + E(x_{i2}) - E(w_{i2})$.

The principal faces several constraints. First, incentive compatibility constraints require the agent to choose effort levels to maximize expected utility. In the second period this merely requires the marginal effort cost equate with marginal return from effort or that $e_{2i} = \beta_2$. In the first period, however, the choice will be more complex as effort exerted in period one may alter the principal's choice of wage parameters and, hence, marginal returns to effort in period two.

Second, because pre-commitment is not possible, time consistency constraints require the principal to utilize first-period information to optimally alter second-period contract parameters.

Third, participation constraints require the principal to offer a contract with expected utility greater than or equal to each agent's reservation utility; i.e., $CE_i \geq \bar{u}$, where agents are assumed to have identical reservation utilities. Following MV we will later consider instances in which an agent's bargaining power may increase over time with perceived ability level.

Incorporating these constraints transforms the principal's objective yields

(15) $e_{1i} - ½\,(e_{1i})^2 + e_{2i} - ½\,(e_{2i})^2 - ½\,r\ \mathrm{var}(w_{1i} + w_{2i}) - \bar{u} \equiv W - \bar{u}$.

Under a first-best situation, the principal entices agents to exert $e_{ti}^* = 1$ and, because effort is observable, the payments offered by the principal would be fixed (no wage risk); hence $W^* = 1$. We formulate a welfare loss function as the value of social welfare at the first-best less the value of social welfare under asymmetric information structure

(16) $L = 1 - W = ½\,[(1 - e_{1i})^2 + (1 - e_{2i})^2 + r\ \mathrm{var}(w_{1i} + w_{2i})]$.

Static Losses from Banning Relative Performance Incentives

To begin we analyze a restricted, single-period version of the model. With no dynamic consequences of an agent's effort choice, an agent satisfies the incentive compatibility constraint by choosing effort equal to the marginal incentive, β. After some manipulation, this substitution yields a welfare loss function of

(17) $l = ½ [(1 – β)^2 + rσ^2 (β^2 + ∈^2 + 2β∈C)]$.

The principal chooses β and ∈ to minimize l and, assuming for the moment that the agent has no bargaining power, the principal chooses α such that the agent's participation constraint is met with equality. Note that the ∈ only appears in the variance term; hence, eliminating ∈ from the principal's control, as would occur if RP contracts were eliminated, will increase payment variance and reduce welfare. Optimal values are

(18) $∈ = –βC$ and

(19) $β^{RP} = 1/[1 + rσ^2ν_1]$,

where the superscript '*RP*' stands for the optimal parameter under a relative performance contract. The minimized loss function is

(17') $l^{RP} = ½ (1 – β^{RP}) = ½ rσ^2ν_1 /[1 + rσ^2ν_1] = λ(ν_1)$

where we define the strictly increasing function

(20) $λ(ν) ≡ ½ rσ^2ν /[1 + rσ^2ν]$,

and where λ(0) = 0 and λ(∞) = ½. If RP indicators are banned, the principal is restricted to a contract in which ∈ = 0; the principal would optimize via the choice of β only. Denote the outcome of this optimization as

(19') $β^B = 1/[1 + rσ^2]$,

where the superscript '*B*' denotes a ban. The accompanying loss function is

(17'') $l^B = ½ (1 – β^B) = ½ rσ^2/[1 + rσ^2]$.

The per period welfare loss from banning tournaments in a static framework is

$$(21) \qquad l^B - l^{RP} = \lambda(1) - \lambda(\nu_1) = (1 - \nu_1)\frac{r\sigma^2}{2(1+r\sigma^2)(1+r\sigma^2\nu_1)} \geq 0.$$

Banning tournaments can never be welfare improving in a static setting. If agent abilities were uncorrelated ($\eta = 0$) and there was no common shock ($\tau_2 = 0$), ν_1 would equal one and, hence there would be no welfare loss from banning tournaments. However, in such a situation, the principal would never optimally choose to institute a tournament, i.e., that $\nu_1 = 1$ implies $\beta = \beta^B$.

As agents' abilities become uncorrelated ($\eta = 0$) and as idiosyncratic shocks disappear ($\tau_3 = 0$), ν_1 tends toward zero and the welfare loss associated with banning tournament compensation increases. This confirms the results derived by Tsoulouhas and Vukina (2001) in a static model with *n* agents.

Dynamic Model Results

To begin the dynamic analysis, we begin in the final period. The principal solves the problem as in the static case only she now has additional information from period one output from both agents and, because she cannot commit to ignoring this information, it is used to formulate final period incentives. Hence the problem for the principal is to choose α, β and $\in$ to minimize

$$(22) \qquad l_2 = \tfrac{1}{2}\,[(1 - \beta_2)^2 + r\,\text{var}(w_{2i} \mid x_{1i}, x_{1j})]$$

$$= \tfrac{1}{2}\,[(1 - \beta_2)^2 + r\,\{\beta_2^2\,\text{var}(x_{2i} \mid x_{1i}, x_{1j}) + \in_2^2\,\text{var}(x_{2j} \mid x_{1i}, x_{1j})$$

$$+ 2\beta_2 \in_2 \text{cov}(x_{2i}, x_{2j} \mid x_{1i}, x_{1j})\}]$$

As before, $\in_2$ only appears in the variance term and is dependent upon the choice of β_2; hence, $\in_2$ is chosen to minimize the conditional variance of w_{2i}, which occurs when

(23) $\in_2 = -\beta_2 \operatorname{cov}(x_{2i}, x_{2j} \mid x_{1i}, x_{1j})/\operatorname{var}(x_{2j} \mid x_{1i}, x_{1j}) = -\beta_2\delta_2$

where the latter equality follows from (A7). Plugging this back into (22) yields

(22') $$l_2 = 1/2\left((1-\beta_2)^2 + r\left\{(\beta_2)^2\left[\operatorname{var}(x_{2i} \mid x_{1i}, x_{1j}) - \frac{\{\operatorname{cov}(x_{2i}, x_{2j} \mid x_{1i}, x_{1j})\}^2}{\operatorname{var}(x_{2j} \mid x_{1i}, x_{1j})}\right]\right\}\right)$$

where the term in square brackets is equal to $\operatorname{var}(x_{2i} \mid x_{1i}, x_{1j}, x_{2j}) = \sigma^2\nu_3$ (equation (8)). Minimizing the loss with respect to β_2 yields

(24) $$\beta_2^{RP} = \frac{1}{1 + r\sigma^2\nu_3}.$$

Agents, who are following incentive compatibility constraints, set $e_2 = \beta_2^{RP}$ and the loss of social welfare in period 2 compared to first best equals $\lambda(\nu_3)$.

The agent's certainty equivalent in period 2 is

(25) $ACE_2 = \alpha_2 + \beta_2^{RP}E[x_{2i} - \delta_2 x_{2j} \mid x_{1i}, x_{1j}] - ½\,(e_{2i})^2 - ½r\sigma^2(\beta_2^{RP})^2\nu_3$,

where δ_2 is defined in (A7). Assume that the agent's participation constraint in period 2 requires $ACE_2 \geq \bar{u} + bTCE_2$ where

(26) $TCE_2 = E[a_i \mid x_{1i}, x_{1j}] + \hat{e}_{2i} - ½(e_{2i})^2 - ½\,r(\beta_2^{RP})^2\nu_3\sigma^2$

is the total certainty equivalent to be bargained over before the beginning of the second period and $0 \leq b \leq 1$ is the agent's exogenous bargaining power for negotiating incentives in the second period.

Using this participation constraint to solve for α_2 yields

(27) $\alpha_2 = \bar{u} + bTCE_2 + ½\,(e_{2i})^2 + ½r(\beta_2^{RP})^2\nu_3\sigma^2 - \beta_2^{RP}E[x_{2i} - \delta_2 x_{2j} \mid x_{1i}, x_{1j}]$

Plugging this into the wage contract for period 2 yields

(28) $w_{2i} = \text{constant} + bE[a_i \mid x_{1i}, x_{1j}] + \beta_2^{RP}\{x_{2i} - \delta_2 x_{2j} - E[x_{2i} - \delta_2 x_{2j} \mid x_{1i}, x_{1j}]\}$

$= \text{constant} + bE[a_i \mid x_{1i}, x_{1j}] + \beta_2^{RP}\{x_{2i} - E[x_{2i} \mid x_{1i}, x_{1j}, x_{2j}]\}$

where constant = $\bar{u} + b(\hat{e}_{2i})^2 + (1 - b)[½(e_{2i})^2 + ½\, r(\beta_2^{RP})^2 \nu_3 \sigma^2]$ which is independent of all output levels. Bargaining power adjusts agent payment according to the principal's expectation of agent ability contingent upon first-period performance of both agents. If an agent's ability is below average (<0), then the agent's wage will be lowered in proportion to the exogenous bargaining power coefficient, b.

We define

$$(29) \qquad \tilde{\beta}_1 = \beta_1 + b(\partial/\partial x_{1i})E[a_i \mid x_{1i}, x_{1j}] - \beta_2^{RP}(\partial/\partial x_{1i})E[x_{2i} \mid x_{1i}, x_{1j}, x_{2j}]$$

$$= \beta_1 + b\Psi - \beta_2^{RP}\gamma,$$

where γ is defined in equation (A5) and

$$(30) \qquad \Psi = \frac{\tau_1(1-\eta C)}{1-C^2}.$$

The term $\tilde{\beta}_1$ is the coefficient on agent i's first period output, x_{1i}, and is composed of the explicit incentive from period 1 (β_1), a reputation incentive ($b\Psi$) and a ratchet incentive ($\beta_2^{RP}\gamma$). Higher reputation incentives and lower ratchet incentives increase the agent's incentive to provide effort in the first period.

In period one the agent's effort level will be set equal to $\tilde{\beta}_1$. Define $\tilde{\in}_1$ as the first-period coefficient on agent j's output and $\tilde{\alpha}_1$ as the first-period fixed payment. The principal minimizes equation (16)

$$L = ½\,[(1 - \tilde{\beta}_1)^2 + (1 - \beta_2^{RP})^2 + r\,\mathrm{var}(w_{1i} + w_{2i})].$$

Expanding the variance expression yields

$$\mathrm{var}(\tilde{\beta}_1 x_{1i} + \tilde{\in}_1\, x_{1j} + \beta_2^{RP} x_{2i} + \in_2 x_{2j})$$

$$= \mathrm{var}((\tilde{\beta}_1 + \beta_2^{RP}\gamma)x_{1i} + (\tilde{\in}_1 + \beta_2\delta_1)\, x_{1j}) + \mathrm{var}(\beta_2^{RP}[x_{2i} - E(x_{2i} \mid x_{1i}, x_{1j}, x_{2j})]),$$

where we utilize $\in_2 = -\delta_2 x_{2j}$. Minimization of L with respect to $\tilde{\in}_1$ requires minimizing variance of payments with respect to $\tilde{\in}_1$; this yields

$$\tilde{\in}_1^* = -(\tilde{\beta}_1 + \beta_2^{RP}\gamma)\frac{\text{cov}(x_{1i}, x_{1j})}{\text{var}(x_{1j})} x_{1j} - \beta_2^{RP}\delta_2.$$

Plugging this back into the variance expression yields

$$= \text{var}([\tilde{\beta}_1 + \beta_2^{RP}\gamma][x_{1i} - \frac{\text{cov}(x_{1i}, x_{1j})}{\text{var}(x_{1j})} x_{1j}]) + \text{var}(\beta_2^{RP}[x_{2i} - E(x_{2i} \mid x_{1i}, x_{1j}, x_{2j})])$$

$$= (\tilde{\beta}_1 + \beta_2^{RP}\gamma)^2 \nu_1\sigma^2 + (\beta_2^{RP})^2\nu_3\sigma^2,$$

where we utilize the definition of conditional variances for the multivariate normal and the definitions from equations (6) and (8). The loss function is

$$L = ½ [(1 - \tilde{\beta}_1)^2 + (1 - \beta_2^{RP})^2 + r(\tilde{\beta}_1 + \beta_2^{RP}\gamma)^2 \nu_1\sigma^2 + (\beta_2^{RP})^2\nu_3\sigma^2].$$

Minimizing the loss function with respect to $\tilde{\beta}_1$ and solving yields

$$\tilde{\beta}_1^{RP} = \frac{1 - \beta_2^{RP}\gamma r\sigma^2\nu_1}{1 + r\sigma^2\nu_1}.$$

Plugging this into the loss function and using the definition of $\lambda(\nu)$ from eq. (20) yields:

$$L = \lambda(\nu_1)(1 + \beta_2^{RP}\gamma)^2 + \lambda(\nu_3) = \lambda(\nu_1)\left[1 + \frac{\gamma}{1 + r\sigma^2\nu_3}\right]^2 + \lambda(\nu_3).$$

The first term is the loss associated with the static outcome of the model, $\lambda(\nu_1)$, multiplied by the squared term in square brackets, which is strictly greater than one for strictly positive ratchet effects ($\gamma > 0$). This means the welfare loss during the first period in the dynamic model is greater than a single-period loss in a static model for positive ratchet effects. That is, because exerting effort in the first period increases the principal's expectation of performance during the second period the agent has an incentive to lower effort, and this causes the loss above that experienced in the static model. The size of this loss diminishes as the magnitude of the conditional variance of x_{2i} increases. The last term is simply the welfare loss incurred during the second period.

Two Types of Bans

To consider the welfare impacts of banning RP indicators we consider two restricted cases of the previous analysis. First is what we call a same-period ban, which restricts the principal from using player *j*'s contemporaneous performance in devising contract parameters for player *i*. Contrast this to an all-periods ban like that analyzed by MV, which disallows the principal from using information concerning player *j* from either period to develop contract parameters for player *i*.

In practice banning same-period relative performance measures is more practically implemented than is banning all-periods relative performance measures because updating of general benchmark parameters is seemingly insidious. That is, it might be quite simple to document in court that a firm had an explicit policy that compared one agent's performance to the performance of others or, even via statistical analysis of payment by performance, to show a firm held an implicit relative pay policy in a given period. However, unless a firm had an explicit policy of updating benchmarks over time using all agents' performance levels, it may be more difficult to prove that a firm altered its expectations for a particular agent due to past performance of all agents, particularly if agents' abilities were correlated and common shocks were sizable.[1]

[1] Furthermore, judges and juries may be less sympathetic to all-period bans because adjusting performance standards to meet 'emerging industry standards' seems like a logical and progressive practice, i.e., it may be cruel and cutthroat to pit agent against agent in any particular period, but it only seems right that agents alter performance to keep up with average changes in industry-wide performance.

MV argue that the parameters chosen under an all-period ban would be the same parameters chosen by the principal if agent *j*'s performance held no information concerning agent *i*'s performance, i.e., if $\eta = \tau_2 = 0$. For these restrictions (denoted by superscript *AB*), the key variance terms simplify as follows: $\nu_1^{AB} = 1$ and $\nu_3^{AB} = (1 - \tau_1^2)$.

Key contract parameters are $\beta_2^{AB} = 1/[1 + r\sigma^2(1 - \tau_1^2)]$ and $\tilde{\beta}_1^{AB} = (1 - \beta_2^{BA}\tau_1 r\sigma^2)/(1 + r\sigma^2)$, the ratchet and reputation incentives are $\gamma^{AB} = \Psi^{AB} = \tau_1$, and the resulting loss function is:

$$L^{AB} = \lambda(\nu_1^{AB})[1 + \gamma^{AB}\nu_3^{AB}]^2 + \lambda(\nu_3^{AB}) = \lambda(1)\left[1 + \frac{\tau_1}{1 + r\sigma^2(1-\tau_1^2)}\right]^2 + \lambda(1-\tau_1^2)\,.$$

Analytically, the same-period ban is equivalent to $\tilde{\in}_1 = \in_2 = 0$. The optimal second period piece-rate is

$$(24') \quad \beta_2^{SB} = \frac{1}{1 + r\sigma^2\nu_4}$$

where $\nu_4\sigma^2 = \text{var}(x_{2i} \mid x_{1i}, x_{1j})$ and the superscript '*SB*' refers to a same-period ban. This reflects that wage parameters in the second period cannot incorporate same-period results from agent *j,* but can incorporate previous period results from agent *j*. The second-period piece rate with a same-period ban will be smaller than the piece rate with out the ban because ν_4 is larger than ν_3 as ν_4 is conditioned on less information than ν_3.

Following the same procedures as before, the effective second period wage is

$$w_{2,i}^{SB} = \text{constant}^{SB} + bE(a_i \mid x_{1i}, x_{1j}) - \beta_2^{SB}\,[x_{2i} - E(x_{2i} \mid x_{1i}, x_{1j})]$$

where $\text{constant}^{SB} = s + b\hat{e}_{2i} + (1 - b)[\frac{1}{2}\,(\hat{e}_{2i})^2 + \frac{1}{2}\,(\beta_2^{SB})^2\, r\sigma^2\nu_4]$. The effective coefficient on first-period effort by agent *i* equals

$$\tilde{\beta}_1^{SB} = \beta_1^{SB} + b(\partial/\partial x_{1i})E(a_i \mid x_{1i}, x_{1j}) - \beta_2^{SB}\,(\partial/\partial x_{1i})E(x_{2i} \mid x_{1i}, x_{1j})$$

$= \beta_1{}^{SB} + b\Psi^{SB} - \beta_2{}^{SB}\gamma^{SB}$

where the reputation incentive is $\Psi^{SB} = \Psi^{RP}$ and where ratchet incentive is $\gamma^{SB} = (R - CK)/(1 - C^2)$. The reputation incentive is unchanged for a same period ban because the other agent's performance is used only to formulate the principal's expectations regarding agent i's ability, which is then utilized in the following period.

The loss function under a same period ban is

$$L^{SB} = ½ \, [\, (1 - \tilde{\beta}_1{}^{SB})^2 + (1 - \beta_2{}^{SB})^2 + r \,\mathrm{var}(w_{1i} + w_{2i})]$$

$$= ½ \, [\, (1 - \tilde{\beta}_1{}^{SB})^2 + (1 - \beta_2{}^{SB})^2 + r \,\mathrm{var}(\tilde{\beta}_1{}^{SB} x_{1i} + \beta_2{}^{SB} x_{2i})].$$

The variance term can be restated as

$$\mathrm{var}\{(\tilde{\beta}_1{}^{SB} + \gamma^{SB}\beta_2{}^{SB})\, x_{1i} + \delta^{SB} x_{1j} + \beta_2{}^{SB}(x_{2i} - \gamma^{SB} x_{1i} - \delta^{SB} x_{1j})\}$$

$$= \sigma^2\{(\tilde{\beta}_1{}^{SB} + \gamma^{SB}\beta_2{}^{SB})^2 + (\delta^{SB})^2 + 2C(\tilde{\beta}_1{}^{SB} + \gamma^{SB}\beta_2{}^{SB})\delta^{SB} + (\beta_2{}^{SB})^2 \nu_4\}$$

where C is the covariance of $x_{1,i}$ and $x_{1,j}$. Minimizing L^{SB} with respect to $\tilde{\beta}_1^{SB}$ yields

$$\tilde{\beta}_1{}^{SB} = (1 - r\sigma^2[\beta_2\gamma^{SB} + C\delta^{SB}]) \,/\, (1 + r\sigma^2).$$

The resulting loss function is:

$$L^{SB} = ½\{\, (1 - \tilde{\beta}_1{}^{SB})^2 + r\sigma^2[(\tilde{\beta}_1{}^{SB} + \gamma^{SB}\beta_2{}^{SB})^2 + (\delta^{SB})^2 + 2C(\tilde{\beta}_1{}^{SB} + \gamma^{SB}\beta_2{}^{SB})\delta^{SB}\,]\} + \lambda(\nu_4).$$

Ratchet and Welfare Effects: General Results

We now derive several theoretical and numeric results that highlight the importance of altering MV's original framework to account for serial correlation and implementation of same-period bans. Recall, MV's model assumes no serial correlation and only analyzes bans that forbid the use of RP information from all periods. We first introduce the following assumption that ensures a positive definite covariance matrix:

(S1) $\quad -1 < R + C + K < 1.$

Proposition 1. For $\eta = \rho = 0$ and (S1), $\gamma^{RP} \geq \gamma^{SB} \geq \gamma^{AB} \geq 0$.

Proof. Under the restrictions, $\gamma^{SB} \geq \gamma^{AB}$ implies $\tau_1/(1 - \tau_2^2) \geq \tau_1$ which holds for all allowable τ_2. $\gamma^{RP} \geq \gamma^{SB}$ implies $\tau_1(1 - \tau_1^2 + \tau_2^2)/(1 - \tau_1^2 - \tau_2^2) \geq \tau_1/(1 - \tau_2^2)$, which simplifies to $\tau_1^2 - \tau_2^2 \geq - 1$, which holds for all allowable τ_1 and τ_2.

Proposition 2. For $\eta = \rho = 0$, $\tau_1 = \tau_2 = \tau$, and (S1), $\partial\gamma^{SB}/\partial\rho \geq \partial\gamma^{RP}/\partial\rho \geq \partial\gamma^{AB}/\partial\rho = 0$.

Proof. Obvious from each definition under the given restrictions.

Proposition 1 provides a ranking of the severity of the ratchet effect under the three compensation schemes and establishes that it is non-negative for all three schemes when ability correlation and serial correlation are zero. As information concerning the performance of the other agent is excluded by banning RP schemes, an agent's first period effort has less impact on how the principal formulates her expectations concerning that agent's second period performance. This provides the genesis for potential welfare gains from banning relative performance information: banning the use of RP incentives reduces the ratchet effect and allows for more powerful second-period incentives.

Proposition 2 establishes, for a restricted set of parameters, that serial correlation of common shocks exacerbates the ratchet effect more intensely when a same-period ban of RP incentives is in place than when RP incentives are used and that the ratchet effect is independent of serial correlation when an all period ban is in place. To our knowledge, it is the only analysis of the impact of serial correlation on ratchet effects.

Taken together propositions 1 and 2 suggest that when ability correlation and serial correlation are negligible, ratchet effects are most intense when RP incentives are used and, hence, a ban might minimize this welfare-reducing implicit incentive. As serial correlation strengthens, however, the ratchet effect intensifies for unfettered use of RP incentives and even more rapidly for same-period bans of RP incentives.

In the absence of RP incentives and serial correlation the principal implicitly penalizes an agent with high output in the first period by raising the performance bar the following period; this implicitly mutes the agent's incentive to exert first-period effort. RP measures exacerbate this implicit incentive to reduce effort by providing the principal with more information with which to formulate next period's incentives; i.e., higher effort is now more tightly tied to an increase in the height of next period's bar because the principal is better informed. Adding serial correlation further heightens this incentive because higher effort in the first period can be construed by the principal as an element of common shock and, in the presence of positive serial correlation, this further increases the principal's expectation of next period's common shock and output. When RP incentives are in place, the principal can use a broader set of information to filter out effort from common shock, but when a same period ban is in place, this is not possible. Hence, this leads to the result in Proposition 2 that serial correlation has a stronger impact on the ratchet effect under a same period ban.

Propositions 1 and 2 are limited because they depend on several restrictions concerning the covariance of various sources of production risk. Figure 1 provides the same qualitative analysis as Proposition 1, only for a broad spectrum of possible parameter combinations. Specifically, the solid (dashed) lines reveal the boundary between the parameter combinations in which the ratchet effect from a same-period (all-period) ban of RP incentives is larger than the ratchet effect from RP incentives.

The middle graph in the top row of the visual array in Figure 1 coincides with the assumptions of Propositions 1 and 2 ($\rho = \eta = 0$) and, as predicted, in all areas the ratchet effect associated with ban is smaller than the ratchet effect from RP incentives. For positive serial correlation the all-period ban continues to feature a smaller ratchet effect while the same-period ban is less effective in mitigating the ratchet effect. Also, as correlation among agent abilities increases (visually, moving down the graphical array), bans become less effective in mitigating the ratchet effect. Increasing correlation across abilities sharpens the information gathered by the principal: as information reveals one agent's ability, so it reveals all agents' ability.

A similar graphical approach in Figure 2 relays numerical results from an analysis of the two types of bans affect overall welfare for a producer when $r\sigma^2 = 0.1$.[2] Several qualitative features become evident upon inspection.

First, confirming most previous research, as common shocks dominate the source of production risk (as $Z \rightarrow 0$ and $\tau_3 \rightarrow 0$ or, visually, in the bottom left portion of each square), any type of ban on RP contracts reduces surplus. The intuition follows previous accounts: banning tournaments removes a source of insurance for producers against common shocks. Second, as serial correlation increases, all-period (same-period) bans are more likely (less likely) to increase welfare. Finally, as correlation across abilities increases (growers become more homogeneous), bans are unlikely to improve welfare.

Welfare Effects: The Case of Broilers

The general analysis provides some situations in which a ban may improve total surplus. To explore the implications of banning RP measures in a policy relevant setting, we

[2] A similar graphic was constructed for $r\sigma^2 = 0.5$ and reveals similar qualitative results. It is omitted for brevity but available upon request.

calibrate the loss functions defined above to Levy and Vukina's empirical results, which are based on data from more than 7,000 broiler flocks grown under tournament contracts from 1995 to 1997. Levy and Vukina (LV) model the performance of five types of growers as a two-way fixed effects model. Performance is measured as the unit cost of producing chickens, which covers chick, feed, medicine and other flock costs.

Their estimates of the percentage of variance attributable to ability, τ_1, common shocks, τ_2, and idiosyncratic shocks, τ_3, are listed in table 1. LV also publish estimates of total variance, which they express on a per pound of production basis. We use the midpoint of per bird weight ranges provided by LV in their footnote 15 and a birds-per-flock estimate of 22,000 taken from broiler production enterprise budgets (Vukina) to project the total production variance per flock figures in the right-hand column.

LV do not publish an estimate of serial correlation, ρ, but do present a graph of common shocks over time (their figure 2) that is consistent with positive autocorrelation; we assume serial correlation equals ¼. LV do not present estimates of correlation among abilities, only the total variance of grower ability; hence we assume $\eta = 0$.[3] Finally, we have no data on grower risk aversion and, indeed, little empirical evidence is published on coefficients of absolute risk aversion (r), which is critical to our analysis, so we examine a broad range of possible values.

Figure 3 graphs the welfare loss from implementing a same-period ban (dashed line) and an all-periods ban (solid line) of relative performance indicators as a function of $r\sigma^2$, where the amount of the welfare loss is expressed relative to the loss from no ban, e.g., $L^{SB} - L^{RP}$. The model is calibrated to the proportional variance parameters from the

[3] The qualitative nature of our results is similar for a range of mildly positive values of serial correlation and ability correlation.

pooled broiler contract results in LV, in which about 31 percent of variance is attributable to grower ability and 63 percent to common shocks. Line segments below zero represent regions in which a ban is welfare enhancing.

The all-periods ban increases total surplus when $r\sigma^2$ rises above 0.6 or, given the calculated total production variance of 4,670, when the coefficient of absolute risk aversion rises above 0.0001285. If grower wealth were low, say $50,000 (about half the cost of constructing and equipping a single broiler unit or about two-thirds the 1998 average net worth of limited resource farmers as defined by US Department of Agriculture's Economic Research Service), this would equate to a coefficient of relative risk aversion of about 6.4. Antle reports estimates of relative risk aversion coefficients from US agricultural producers in the range of 0.19 to 1.77 while Neilson and Winter summarize empirical estimates of relative risk aversion coefficient for moderate risks taken by consumers in the range of 0.07 to 4.2. Hence, a relative risk aversion coefficient of 6.4 could be considered extremely risk averse. If grower wealth were similar to the average US farmer, say around $750,000, this would equate to a relative risk aversion coefficient of 96.4, which is greater than published any published estimates of risk aversion by nearly an order of magnitude. Scenarios that feature positive η and higher or lower ρ are less favorable to the proposition that an all-period ban increases welfare.

Figures 4 and 5 decompose the welfare loss and help provide some intuition behind the results presented in figure 3. The top panel of figure 4 graphs the second-period piece rate under a relative performance contract (dotted line) and under an all-periods (solid line) and same-period (dashed line) ban of relative performance indicators. The piece rate under a RP contract is larger for all levels of $r\sigma^2$ because the principal can use the contemporaneous performance of the other agent to insulate the agent from common shock risk, the dominant source of risk, during the second period. This translates to the lowest welfare loss during the second period (graphed in the bottom panel). In other words, the RP contract allows for the sharpest effort incentives because it provides the most positive insurance effect. Note the same period ban contract can provide marginally stronger piece rate levels during the second period than the all periods ban because the principal can utilize lagged relative performances to formulate second period parameters and, hence, provide some insurance against common shocks. While not pictured, we note that as serial correlation becomes stronger lagged performance becomes more informative and β^{SB} will grow.

The top panel of figure 5 graphs the ratchet effect ($\beta_2\gamma$) for each of the three arrangements over the range $r\sigma^2$. This clearly reveals that the ratchet effect is strongest, i.e., reduces welfare the most, when RP measures are in place. This stems from the fact that second period piece rate incentives are the sharpest for RP contracts, i.e., $\beta_2^{RP} > \beta_2^{SB} > \beta_2^{AB}$, and from the fact that first period alterations of effort have the largest impact on the principal's expectation for output by that agent during the second period when RP contracts are in place, i.e., $\gamma^{RP} > \gamma^{SB} > \gamma^{AB}$.

The graphs in the bottom panel balance the welfare loss associated with the ratchet effect, which is least favorable to the RP contract, against the first period insurance effect, which is most favorable for RP contracts. The insurance effect is most favorable for the RP contracts because contracts with either a same period ban or an all periods ban on RP indicators can provide no insurance against common shocks in the first period and, hence, weaken piece rates and, correspondingly, individual effort incentives.

The curvature presented in figures 4 and 5 helps provide some intuition for the curvature of the relative benefits from banning in figure 3. When risk aversion is zero, the bans have no impact on welfare as all piece rates are set to 1 regardless of any ban that might be in place because the principal makes the risk neutral agents the residual claimant and allow agents to bear all risk. As risk aversion is introduced welfare initially decreases due to the bans because the principal cannot use the RP indicators to provide the agents any insurance against common shocks and the benefit welfare boost from mitigating the ratchet effect has not fully taken hold. At higher levels of risk aversion the benefit from mitigating the ratchet effect gains the most traction and can increase welfare.

To reiterate, the model calibrated to the estimates for the pooled broiler contract data from LV are supportive of welfare gains only for levels of risk aversion not typically reported in the literature. Table 2 lists the minimum relative risk aversion coefficients at which growers with two different wealth levels operating under each of the six contracts explored by LV would benefit from a same-period and all-periods ban on RP indicators. A same-period ban realistically could increase welfare under only one contract, Roasters with Female Fillers #1, and then only for strongly risk averse, lower wealth growers. An all-periods ban under that same contract could improve welfare for lower wealth growers near unitary relative risk aversion. Bans under the remainder of contracts either are not welfare enhancing at any level of risk aversion or are not welfare enhancing at levels of risk aversion commonly estimated in empirical studies.

So far we have discussed the impact of banning RP contracts on total surplus rather than welfare effects for growers in particular even though growers are the impetus for much of the proposed legislation efforts to curb tournament contracts. As Tsoulouhas and Vukina (2001) point out, in the absence of grower bargaining power or policies that essentially mandate a shift in bargaining power from the principal to the growers (explicitly modeled as b in this paper), growers receive the reservation utility level regardless of the type of contract issued. Hence, the issue of grower welfare is a moot point in many analyses that use a principal-agent model.

When $b > 0$, or when growers have strictly positive bargaining power, distributional effects do arise in our model.[4] The presence of bargaining power allows growers to recover their ability level, a_i, in proportion to their bargaining power, as part of the second period wage. Because a_i is assumed to be distributed normally with zero mean, this suggests that, on average, growers fare no better, but the distribution among growers is now correlated with ability level. That is, in the presence of bargaining power, grower remuneration grows more dispersed, with above (below) average grower's compensation rising above (falling below) first period ex ante expected returns.

This dispersion of grower wages occurs more quickly in the presence of RP information than if RP information is banned. Particularly, in both unfettered RP contracts and contracts featuring same-period bans of RP data, the principal uses lagged RP data to formulate expectations concerning agent ability. Under an all periods ban, the principal can only use the agent's own lagged performance information to formulate expectations concerning ability.

An agent's ability to shape this key figure, ψ, is calculated for each of the six sets of parameters (table 3). Under an all-period ban, this parameter reduces to τ_1, the fraction

[4] Meyer and Vickers note that the bargaining power coefficient has no impact on total surplus; the same holds for this extended version of their model. This is apparent as *b* does not appear in the welfare loss functions.

of variance attributable to agent ability.[5] In each case the ability to use lagged RP data greatly enhances agents' capacity to signal ability and causes greater dispersion in grower payments, in some contracts by as much as four times. Hence, in the presence of some bargaining power by growers, such a finding might provide motivation for low ability growers to lobby for bans of RP contracts. However, the ban would have to be an all-periods ban because a principal's expectations concerning agent ability is most rapidly formed using lagged RP data, which continues to be utilized under a same-period ban.

Conclusions and Extensions

We show that the introduction of dynamic contracts where the principal cannot commit to future contract parameters sparks implicit incentives that can reduce total welfare via ratchet incentives and that the use of relative performance indicators can exacerbate these incentives. Such welfare reducing implicit incentives can, in theory, offset the welfare enhancing insurance and incentive effects provided by RP indicators, i.e., the ability to induce grower effort while shielding growers from common production shocks. This leads to the possibility that, even in the presence of dominating common shocks, bans on RP indicators could enhance total surplus.

When the model is calibrated to parameters from a sector that features dynamic contracts without long-term commitment to payment parameters – the broiler chicken contract market (Levy and Vukina) – there appear to be very few circumstances under which a simple ban of RP indicators would enhance aggregate welfare: for production processes with relatively large variance in grower ability and highly risk averse growers. If policies could somehow be formulated to disallow a principal from comparing agents'

[5] Intuitively, when only the agent's own lagged performance can be used to infer ability, the weight used is the proportional to the amount of variance attributable to agent ability.

relative performances from any previous period (an all-periods ban), the parameter space in which a ban is welfare enhancing marginally expands.

When growers have any degree of bargaining power in their negotiations with the principal, we show that grower compensation changes in proportion to their ability but that average compensation does not improve nor is aggregate welfare altered. Furthermore, a ban on the use of same-period RP data does not impede the pace at which grower compensation disperses to reward or penalize relative abilities, as the principal uses lagged RP to infer grower ability and distribute compensation. Only banning the use of both contemporary and lagged RP data would slow the pace at which growers' compensation disperses and, hence, provide welfare improvement for low ability growers at the expense of high ability growers.

The model considered features several important extensions of the model introduced by Meyer and Vickers, including the ability to account for serial correlation of common production shocks and the introduction of a more realistic ban on RP indicators. We show both extensions to be crucial for properly analyzing proposed bans of tournaments as serial correlation is shown to impact the magnitude of the ratchet effect while the analysis of the more realistic ban of same-period relative performance information is less positive concerning potential welfare gains from implementing bans.

However, several characteristics of the broiler contracting situation are not accommodated. For example, our model features only two agents while LV report that broiler integrators base grower compensation on the performance of a league of nine to 30 growers. Moreover, we do not consider a model in which the principal may provide differential quality inputs to agents as in Leegomonchai and Vukina. Meyer and Vickers comment that the strength and relative welfare impact of the ratchet effect remains in the presence of more agents so long as risk aversion is not too small. This suggests that generalizing our results to include more agents would be even less likely to reveal a beneficial effect from banning tournaments.

Our model also restricts dynamics to two periods while broiler contracts often feature long contract sequences. Future research featuring longer time horizons may provide additional clarity. For example, the ratchet effect induces agents to lower initial effort to drive down the principal's expectation of future performance. With expectations lowered, average effort in later periods allows the agent to exceed expectations and to collect higher compensation for the given level of effort. Over a longer time horizon, incentives may arise to further reduce initial efforts, as this data would be used to derive expectations in many future periods. However, there are now more periods in which agents may 'harvest' lower expectations. Effort levels during these harvest periods would then ratchet the principal's expectation back up. Furthermore, as more periods are added, our implicit assumption of no discounting of future utility becomes less tenable, and, hence, harvesting lowered expectations comes during periods that are discounted while the lowered efforts and compensation required to set up this harvest occur during more highly valued early periods.

Beyond these issues, there are a suite of issues from which the current effort abstracts, including the impact of banning tournaments on technology transfer between principal and agent and on implicit incentives for agents to invest in long-term learning and capital augmentation. Future research that incorporates these issues would enhance our view of the true welfare impacts of restrictions on contractual form.

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Table 1. Estimated Variance Parameters from Levy and Vukina.

	% Variance Attributable to ….			
Contract Group	Ability (τ_1)	Common Shock (τ_2)	Idiosyncratic Shock (τ_3)	Per Flock Std. Dev. (σ)
Regular Broilers	0.12	0.74	0.14	2,097
Large Broilers	0.21	0.73	0.06	4,315
Roasters w/ Female Fillers #1	0.44	0.52	0.03	5,382
Roasters w/ Female Fillers #2	0.06	0.89	0.06	3,506
Roasters w/ Straight Run	0.24	0.69	0.07	4,850
Pooled Results	0.31	0.63	0.06	4,670

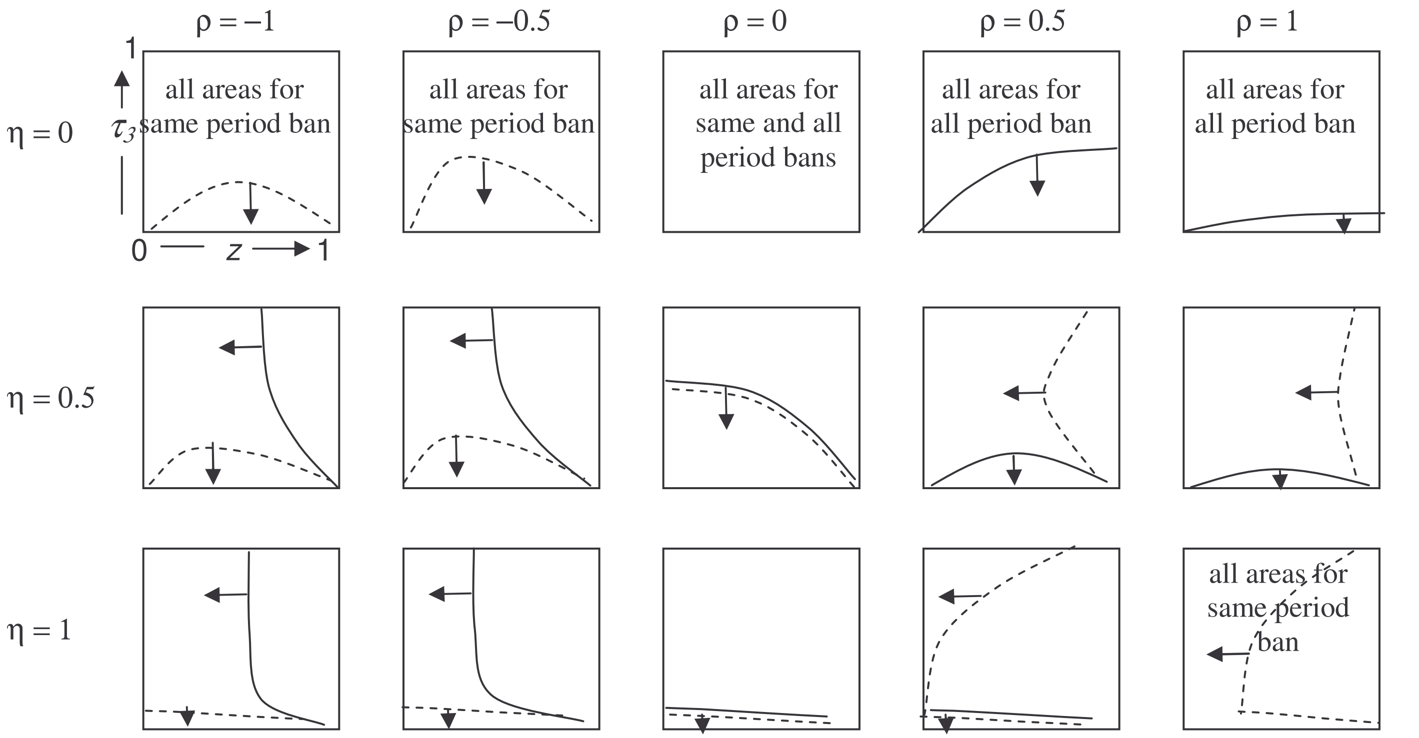
Table 2. Lowest Relative Risk Aversion Coefficients for Which Banning Tournaments is Welfare Enhancing.

	Same-Period Ban		All-Periods Ban	
	Wealth = $50,000	Wealth = $750,000	Wealth = $50,000	Wealth = $750,000
Regular Broilers	None	None	None	None
Large Broilers	None	None	23.0	345.7
Roasters w/ Female Fillers #1	5.4	81.4	1.0	15.3
Roasters w/ Female Fillers #2	None	None	None	None
Roasters w/ Straight Run	None	None	15.0	224.7
Pooled Results	17.9	268.8	6.4	96.7

*All calculations assume $\eta = 0$ and $\rho = 1/4$.

Table 3. Effect of Banning Tournaments on Reputation Effect.

Contract	$\psi^{RP} = \psi^{SB}$	ψ^{AB}	% Reduction from All-Periods Ban
Regular Broilers	0.27	0.12	56
Large Broilers	0.45	0.21	53
Roasters w/ Female Fillers #1	0.60	0.44	27
Roasters w/ Female Fillers #2	0.29	0.06	79
Roasters w/ Straight Run	0.46	0.24	48
Pooled Results	0.51	0.31	39



- - - - - - - - - - Boundary between areas in which the ratchet effect from an all period ban on RP incentives is greater than the ratchet effect from RP incentives

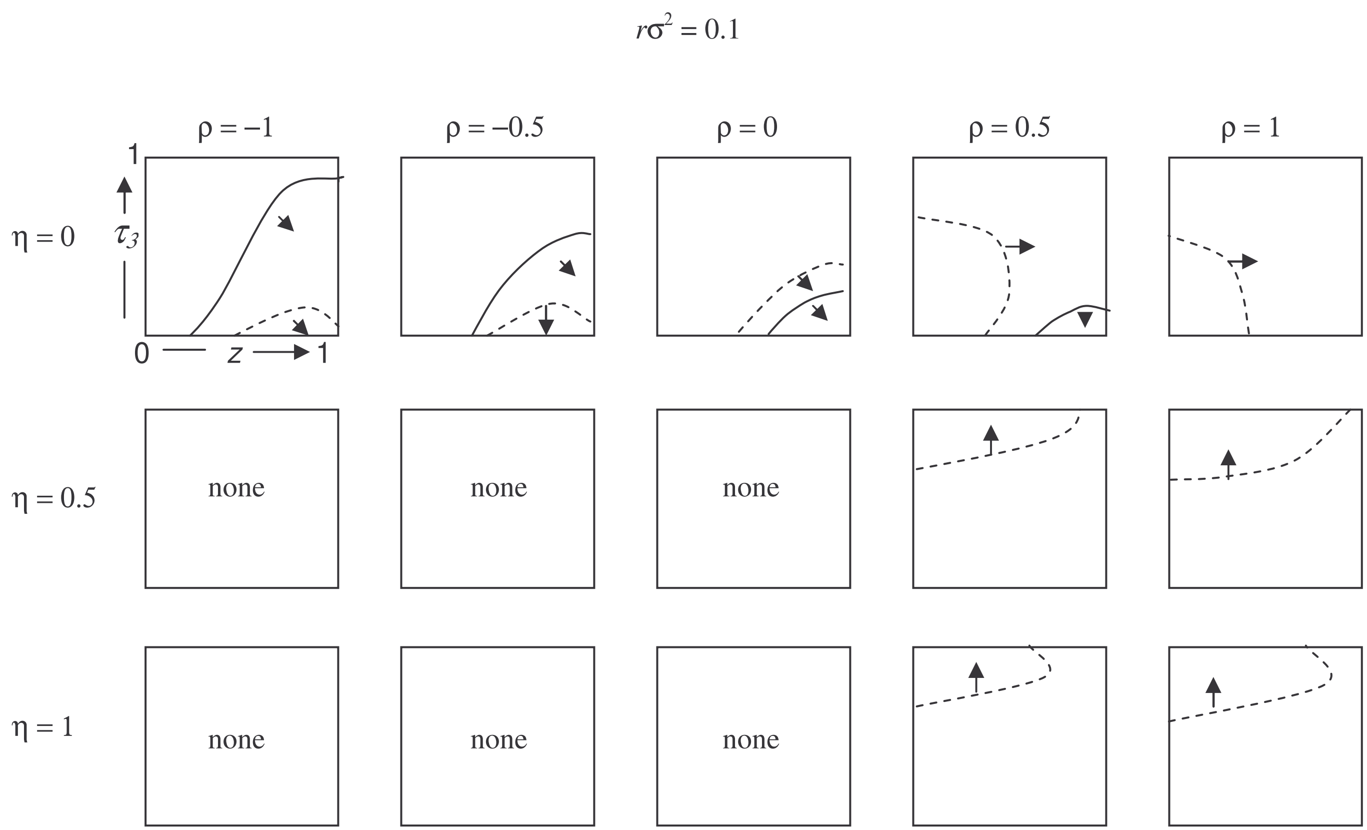
———— Boundary between areas in which the ratchet effect from a same period ban on RP incentives is greater than the ratchet effect from RP incentives

* Arrows point to regions in which a the ratchet effect from the ban is smaller

η– correlation of agent ability; *Z* – % systematic variance from variance in agent ability;

τ_3 - % variance from idiosyncratic sources

Figure 1. Ratchet Effect of All Period and Same Period Bans of Relative Performance Incentives



- - - - - - - - Boundary between areas where an all period ban on RP incentives is welfare enhancing/reducing

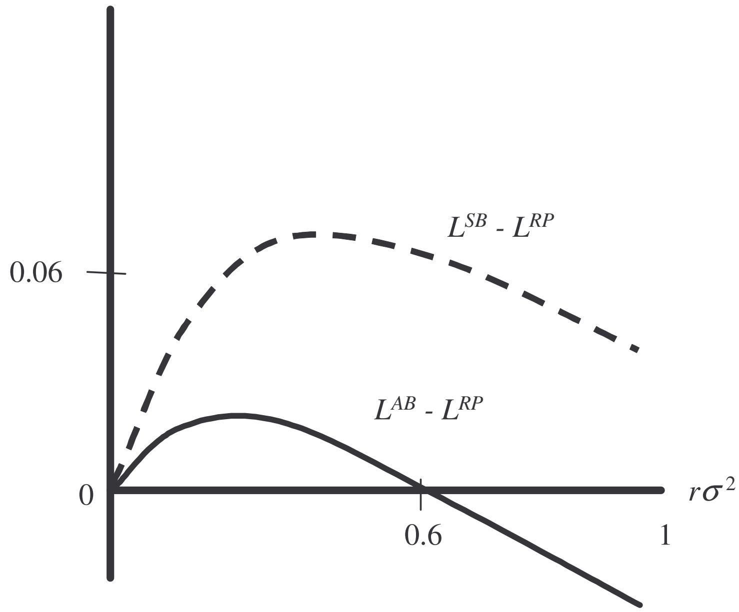
———— Boundary between areas where a same period ban on RP incentives is welfare enhancing/reducing

* Arrows point to regions in which a ban is welfare enhancing

r – relative risk aversion; η – correlation of agent ability; *Z* – % systematic variance from variance in agent ability; τ_3 - % variance from idiosyncratic sources, σ^2 – production variance

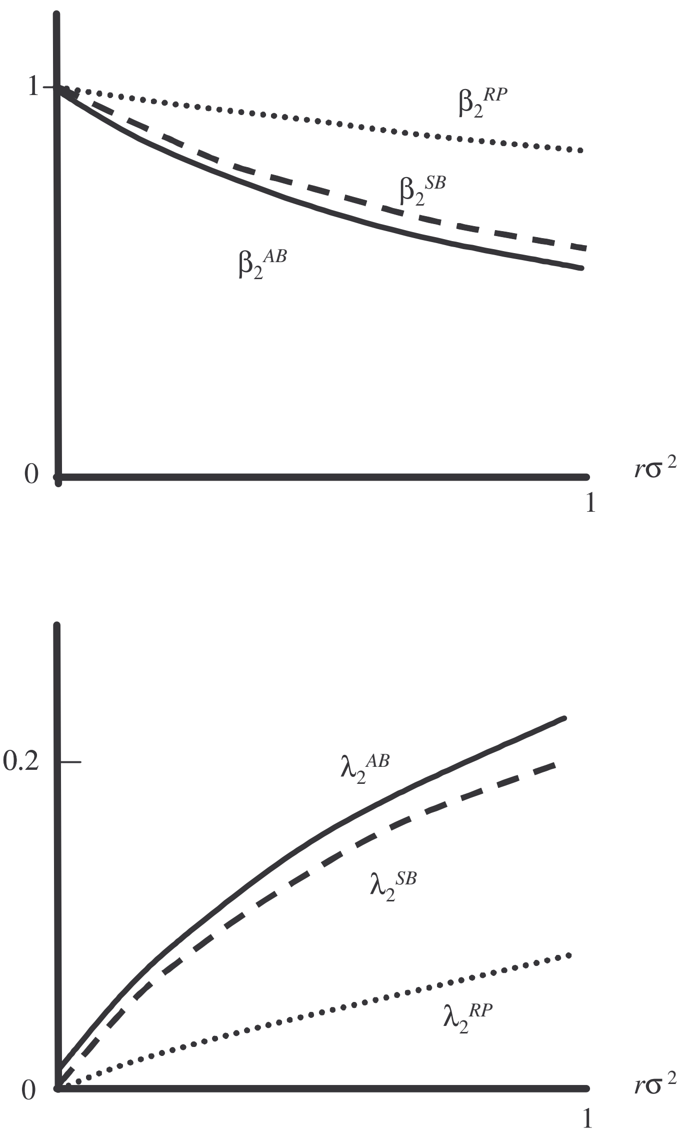
Figure 2. Welfare Effect of All Period and Same Period Bans of Relative Performance Incentives

35



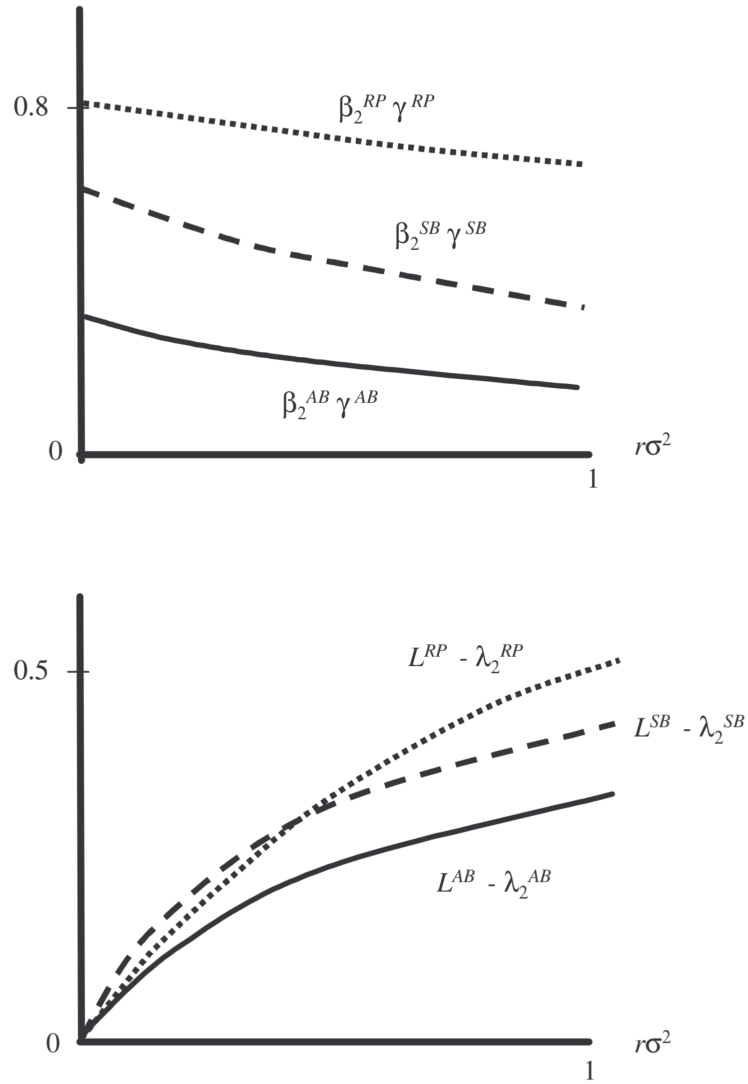
*Parameters are τ_1=0.31 and τ_2=0.63 are calculated from Levy and Vukina; η=0 and ρ = ¼ are assumed. Line segments below zero represent welfare gains from imposing an all period ban (solid line) or a same period ban (dashed line). Total variance for the contract is calculated as σ^2 = 4,670

Figure 3. Welfare Loss From Banning Tournaments: Pooled Broiler Contracts



*Parameters are the same as figure 3. The top panel represents the piece-rate parameters for relative performance contracts (dotted line) and contracts under which relative performance measures are banned during the same period (solid line) and all periods (dashed line). The bottom panel features the welfare losses for each contract associated with the inability of contracts to provide insurance against common shocks during the second period.

Figure 4. Second period effects of banning tournaments for pooled broiler contracts



*Parameters are the same as figure 4. The top panel represents the ratchet effect for relative performance contracts (dotted line) and contracts under which relative performance measures are banned during the same period (solid line) and all periods (dashed line). The bottom panel features the first-period welfare losses for each contract associated with the inability of contracts to provide insurance against common shocks and the ratchet effect's dulling of effort.

Figure 5. First period effects of banning tournaments for pooled broiler contracts

Appendix

The detailed expressions for the variance components listed in equations six through nine are:

(A1) $\mathrm{var}(x_{ti} \mid x_{tj}) = \sigma^2(1 - C^2) \equiv \sigma^2\nu_1$

(A2) $\mathrm{var}(x_{2i} \mid x_{1i}) = \sigma^2(1 - R^2) \equiv \sigma^2\nu_2$

(A3) $$\mathrm{var}(x_{2i} \mid x_{1i}, x_{1j}, x_{2j}) = \sigma^2\left[\frac{R^4 + C^4 + K^4 + 4CKR - 2(R^2C^2 + R^2K^2 + C^2K^2) - 1}{R^2 + C^2 + K^2 - 2CKR - 1}\right]$$

$$\equiv \sigma^2\nu_3$$

(A4) $$\mathrm{var}(x_{2i} \mid x_{1i}, x_{1j}) = \sigma^2[1 - \frac{R^2 - 2CKR + K^2}{1 - C^2}] \equiv \sigma^2\nu_4 .$$

Detailed expressions for γ, δ_1 and $\delta_2$are

(A5) $$\gamma = \mathrm{cov}(x_{2i}, x_{1i} \mid x_{1j}, x_{2j})/\mathrm{var}(x_{1i} \mid x_{1j}, x_{2j}) = \frac{R(R^2 - C^2 - 1 - K^2) + 2CK}{R^2 + C^2 + K^2 - 2CKR - 1},$$

(A6) $$\delta_1 = \mathrm{cov}(x_{2i}, x_{1j} \mid x_{2j}, x_{1i})/\mathrm{var}(x_{1j} \mid x_{1i}, x_{2j}) = \frac{K(K^2 - C^2 - 1 - R^2) + 2CR}{R^2 + C^2 + K^2 - 2CKR - 1},$$

(A7) $$\delta_2 = \mathrm{cov}(x_{2i}, x_{2j} \mid x_{1i}, x_{1j})/\mathrm{var}(x_{2j} \mid x_{1i}, x_{1j}) = \frac{C(C^2 - R^2 - K^2 - 1) + 2KR}{R^2 + C^2 + K^2 - 2CKR - 1}$$