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

Brian Roe and Steven Wu

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We consider the implications of banning tournament contracts and replacing them with fixed performance standard contracts in a multi-period model where the principal cannot commit to future contract parameters. A ban cannot increase total surplus in a static model. In a dynamic model, however, a ban of tournaments can increase total surplus by mitigating the ratchet effect. Calibrating our model to published data from the broiler sector, we find that a ban on use of contemporaneous and lagged 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. A more enforceable, period-by-period ban is even less likely to be welfare enhancing and does not hinder the principal from redistributing a fixed compensation pool from low ability growers to high ability growers.

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The Welfare Effects of Banning Tournaments When Commitment Is Impossible

There has been much discussion about banning the use of relative performance schemes in the agricultural sector as pressure from producers involved in these tournament-type contracts increases. Fixed performance standards are often suggested as the alternative form of remuneration for contracts, where producer rewards are tied to performance relative to a predetermined standard rather than performance relative to the contemporaneous performance of other producers.

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. 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, 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 while broiler contracts cover only one grower period at a time (Levy and Vukina).

The introduction of multiple periods without the ability of the principal to commit to future actions introduces a potential source of inefficiency known as the ratchet effect. 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). By commitment, we mean that the principal

writes contracts where the parameters of latter contracts are independent of information revealed during the course of contracts written in earlier periods and, consequently, agents' optimal choices of effort for the entire sequence of contracts can be determined with initial information. Without this ability to commit to future contract parameters, implicit incentives to alter early period effort to gain more favorable terms of trade later in the time horizon may emerge.

Previous comparisons of tournaments versus fixed performance standards 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, static models and dynamic models with commitment predict that banning contracts with relative performance measure would reduce total surplus (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.

Using a dynamic model in which the principal cannot commit, however, Meyers and Vickers find that a ban of relative performance measures could improve total surplus when the ratchet effect is large enough. The only empirical investigation of ratchet effects in agricultural markets reveals little affirmative evidence (Allen and Lueck), however this investigation focused on agricultural land rental markets, which do not commonly employ comparative performance measures.

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 Meyers 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 during the same period.

The model and analysis extend MV in two fundamental 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. 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. 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 to future contract parameters is not possible.

Model

In the spirit of Meyers and Vickers, consider a principal (P) who is contracting 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) $\begin{pmatrix} z_1 \\ z_2 \end{pmatrix} \sim N\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \sigma^2 \begin{pmatrix} \tau_2 & \rho\tau_2 \\ \rho\tau_2 & \tau_2 \end{pmatrix} \right]$ 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.[1] 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 expectations and variances, which will be of use later in the analysis:

(6) $\mathrm{var}(x_{ti} \mid x_{tj}) = \sigma^2(1 - C^2) \equiv \sigma^2 v_1$

(7) $\mathrm{var}(x_{2i} \mid x_{1i}) = \sigma^2(1 - R^2) \equiv \sigma^2 v_2$

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

$$\equiv \sigma^2 v_3$$

(9) $\mathrm{var}(x_{2i} \mid x_{1i}, x_{1j}) = \sigma^2[1 - \dfrac{R^2 - 2CKR + K^2}{1 - C^2}] \equiv \sigma^2 v_4$

(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

(10a) $\gamma = \mathrm{cov}(x_{2i}, x_{1i} \mid x_{1j}, x_{2j})/\mathrm{var}(x_{1i} \mid x_{1j}, x_{2j}) = \dfrac{R(R^2 - C^2 - 1 - K^2) + 2CK}{R^2 + C^2 + K^2 - 2CKR - 1}$,

(10b) $\delta_1 = \mathrm{cov}(x_{2i}, x_{1j} \mid x_{2j}, x_{1i})/\mathrm{var}(x_{1j} \mid x_{1i}, x_{2j}) = \dfrac{K(K^2 - C^2 - 1 - R^2) + 2CR}{R^2 + C^2 + K^2 - 2CKR - 1}$, and

(10c) $\delta_2 = \mathrm{cov}(x_{2i}, x_{2j} \mid x_{1i}, x_{1j})/\mathrm{var}(x_{2j} \mid x_{1i}, x_{1j}) = \dfrac{C(C^2 - R^2 - K^2 - 1) + 2KR}{R^2 + C^2 + K^2 - 2CKR - 1}$

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

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

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 $C(e_{it}) = \frac{1}{2}(e_{it})^2$, which is a strictly increasing, convex function of e_{it}. The risk-averse agents have utility

$$(12) \quad U_i = -\exp\{-r[w_{i1} - \frac{1}{2}(e_{i1})^2 + w_{i2} - \frac{1}{2}(e_{i2})^2]\}$$

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

$$(13) \quad CE_i \equiv E(w_{i1}) - \frac{1}{2}(e_{i1})^2 + E(w_{i2}) - \frac{1}{2}(e_{i2})^2 - \frac{1}{2} r \, \text{var}(w_{i1} + w_{i2}).$$

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

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

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

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

Static Losses from Banning Comparative 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. This substitution yields a welfare loss function of

(17) $l = \frac{1}{2}[(1 - \beta)^2 + r \, \text{var}(w_{1i})]$

$= \frac{1}{2}[(1 - \beta)^2 + r\sigma^2 (\beta^2 + \epsilon^2 + 2\beta\epsilon C)]$.

The principal chooses β and ϵ 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 ϵ only appears in the variance term; hence, eliminating ϵ from the principal's control, as would occur if relative performance

contracts were eliminated, will increase payment variance and reduce welfare. Optimal

values are

(18) $\in = -\beta C$ and

(19) $\beta^{RP} = 1/[1 + r\sigma^2 v_1]$,

where the superscript 'RP' stands for the optimal parameter under a relative performance

contract. The minimized loss function is

(17') $l^{RP} = \frac{1}{2}(1 - \beta^{RP}) = \frac{1}{2} r\sigma^2 v_1 /[1 + r\sigma^2 v_1] = \lambda(v_1)$

where we define the strictly increasing function

(20) $\lambda(v) \equiv \frac{1}{2} r\sigma^2 v /[1 + r\sigma^2 v]$,

and where $\lambda(0) = 0$ and $\lambda(\infty) = \frac{1}{2}$. If relative performance indicators are banned, the

principal is restricted to a contract in which $\in = 0$; the principal would optimize via the

choice of β only. Denote the outcome of this optimization as

(19') $\beta^B = 1/[1 + r\sigma^2]$,

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

(17'') $l^B = \frac{1}{2}(1 - \beta^F) = \frac{1}{2} r\sigma^2/[1 + r\sigma^2]$.

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

(21) $l^B - l^{RP} = \lambda(1) - \lambda(v_1) = (1 - v_1)\dfrac{r\sigma^2}{2(1+r\sigma^2)(1+r\sigma^2 v_1)} \geq 0$.

Banning tournaments can never be welfare improving in a static setting. If agent abilities

were uncorrelated ($\eta = 0$) and there was no common shock ($\tau_2 = 0$), v_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

$v_1 = 1$ 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) $l_2 = \frac{1}{2} [(1 - \beta_2)^2 + r \, \text{var}(w_{2i} \mid x_{1i}, x_{1j})]$

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

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

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

where the latter equality follows from (10c). Plugging this back into (22) yields

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

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

(24) $\quad \beta_2{}^{RP} = \dfrac{1}{1 + r\sigma^2 v_3}$.

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 $\lambda(v_3)$.

The agent's certainty equivalent in period 2 is

(25) $\quad ACE_2 = \alpha_2 + \beta_2{}^{RP}E[x_{2i} - \delta_2 x_{2j} \mid x_{1i}, x_{1j}] - \tfrac{1}{2}(e_{2i})^2 - \tfrac{1}{2}r\sigma^2(\beta_2{}^{RP})^2 v_3$,

where δ_2 is defined in (10c). Assume that the agent's participation constraint in period 2 requires $ACE_2 \geq \bar{u} + bTCE_2$ where

(26) $\quad TCE_2 = E[a_i \mid x_{1i}, x_{1j}] + \hat{e}_{2i} - \tfrac{1}{2}(e_{2i})^2 - \tfrac{1}{2} r(\beta_2{}^{RP})^2 v_3 \sigma^2$

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) $\quad \alpha_2 = \bar{u} + bTCE_2 + \tfrac{1}{2}(e_{2i})^2 + \tfrac{1}{2}r(\beta_2{}^{RP})^2 v_3 \sigma^2 - \beta_2{}^{RP}E[x_{2i} - \delta_2 x_{2j} \mid x_{1i}, x_{1j}]$

Plugging this into the wage contract for period 2 yields

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

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

where constant $= \bar{u} + b(\hat{e}_{2i})^2 + (1 - b)[\tfrac{1}{2}(e_{2i})^2 + \tfrac{1}{2} r(\beta_2{}^{RP})^2 v_3 \sigma^2]$ 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) $\quad \tilde{\beta}_1 = \beta_1 + b(\partial/\partial x_{1i})E[a_i \mid x_{1i}, x_{1j}] - \beta_2{}^{RP}(\partial/\partial x_{1i})E[x_{2i} \mid x_{1i}, x_{1j}, x_{2j}]$

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

where γ is defined in equation (10a) and

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

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)

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

Expanding the variance expression yields

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

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

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

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

Plugging this back into the variance expression yields

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

$$= (\tilde{\beta}_1 + \beta_2{}^{RP}\gamma)^2 \, v_1\sigma^2 + (\beta_2{}^{RP})^2 v_3\sigma^2,$$

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

$$L = \tfrac{1}{2}\,[(1 - \tilde{\beta}_1)^2 + (1 - \beta_2{}^{RP})^2 + r\,(\tilde{\beta}_1 + \beta_2{}^{RP}\gamma)^2 \, v_1\sigma^2 + (\beta_2{}^{RP})^2 v_3\sigma^2].$$

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

$$\tilde{\beta}_1{}^{RP} = \frac{1 - \beta_2{}^{RP}\gamma r \sigma^2 v_1}{1 + r\sigma^2 v_1}.$$

Plugging this back into the loss function and recalling the definition of $\lambda(v)$ from equation (20) yields:

$$L = \lambda(v_1)(1 + \beta_2{}^{RP}\gamma)^2 + \lambda(v_3) = \lambda(v_1)\left[1 + \frac{\gamma}{1 + r\sigma^2 v_3}\right]^2 + \lambda(v_3).$$

The first term is the loss associated with the static outcome of the model, $\lambda(v_1)$, 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 CPI Restrictions

To consider the welfare impacts of banning relative performance 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 what we call a full or all-periods ban, which disallows the principal from using information concerning player j from either period to develop contract parameters for player i. Static analyses of banning comparative performance incentives are implicitly restricted to same period bans as is the ban analyzed by MV.

In practice banning same-period comparative performance measures is more practically implemented than is banning all-periods comparative 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 comparative 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.[2]

Analytically, 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, which are

denoted by the superscript letters *AB*, the key variance terms simplify as follows: $v_1^{AB} = 1$

and $v_3^{AB} = (1 - \tau_1^2)$.

In this case the relevant 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:

$$L^{AB} = \lambda(v_1^{AB})[1 + \gamma^{AB}v_3^{AB}]^2 + \lambda(v_3^{AB}) = \lambda(1)\left[1 + \frac{\tau_1}{1 + r\sigma^2(1-\tau_1^2)}\right]^2 + \lambda(1-\tau_1^2).$$

Analytically, the same-period ban is equivalent to $\tilde{\epsilon}_1 = \epsilon_2 = 0$. The optimal

second period piece-rate is

(24') $\beta_2^{SB} = \dfrac{1}{1 + r\sigma^2 v_4}$

where $v_4\sigma^2 = \mathrm{var}(x_{2i} \mid x_{1i}, x_{1j})$ 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 v_4 is larger than v_3 as v_4 is conditioned on less information than v_3.

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

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

where $\mathrm{constant}_{SB} = s + b\hat{e}_{2i} + (1 - b)[\frac{1}{2}(\hat{e}_{2i})^2 + \frac{1}{2}(\beta_2^{SB})^2 r\sigma^2 v_4]$. The effective

coefficient on first-period effort by agent *i* equals

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

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

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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

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

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

The variance term can be restated as

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

$$= \sigma^2\{(\tilde{\beta}_1^{\,SB} + \gamma^{SB}\beta_2^{\,SB})^2 + (\delta^{SB})^2 + 2C(\tilde{\beta}_1^{\,SB} + \gamma^{SB}\beta_2^{\,SB})\delta^{SB} + (\beta_2^{\,SB})^2 v_4\}$$

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:

$$L^{SB} = \tfrac{1}{2}\{(1 - \tilde{\beta}_1^{\,SB})^2 + r\sigma^2[(\tilde{\beta}_1^{\,SB} + \gamma^{SB}\beta_2^{\,SB})^2 + (\delta^{SB})^2 + 2C(\tilde{\beta}_1^{\,SB} + \gamma^{SB}\beta_2^{\,SB})\delta^{SB}]\} + \lambda(v_4).$$

Welfare Effects: The Case of Broilers

To explore the implications of banning relative performance measures we calibrate the loss functions defined above to Levy and Vukina's empirical results, which are based on data from more than 7,000 flocks of broiler chickens grown under tournament contracts over a period of about two years. 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 1 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 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 2 and 3 decompose the welfare loss and help provide some intuition behind the results presented in figure 1. The top panel of figure 2 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 relative performance 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 relative performance 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 3 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 relative performance measures are in place. This stems from the fact that second period piece rate incentives are the sharpest for relative performance 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 relative performance 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 relative performance contract, against the first period insurance effect, which is most favorable for the relative performance contracts. The insurance effect is the most favorable for the relative performance contracts because contracts with either a same period ban or an all periods ban on relative performance 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 2 and 3 helps provide some intuition for the curvature of the relative benefits from banning in figure 1. 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 relative performance 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 relative traction and can lead to welfare gains.

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 would benefit from a same-period and all-periods ban on relative performance 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 relative performance 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 relative performance information than if relative performance information is banned. Particularly, in both unfettered relative performance contracts and contracts featuring same-period bans of relative performance data, the principal uses lagged relative performance 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 and presented in table 3. When an all periods ban is in effect this parameter reduces to τ_1, the fraction of variance attributable to agent ability.[5] In each case the ability to use lagged relative performance 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 relative performance 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 relative performance 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 the welfare of agents 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 relative performance 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 relative performance 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 appears to be very few circumstances under which a simple ban of relative performance 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' 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 ban of relative performance data does not impede the pace at which grower compensation disperses to reward or penalize relative abilities, as the principal uses lagged relative performance to infer grower ability and distribute compensation. Only banning the use of both contemporary and lagged relative performances data would slow the pace at which growers' compensation disperses and, hence, provide welfare improvement for low ability growers.

The model considered features several important extensions of the model introduced by Meyers and Vickers, including the ability to account for serial correlation of common production shocks and the introduction of a more realistic ban on relative performance indicators. 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. Meyers 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 does not grow 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 occur over just two periods while broiler contracts often feature long sequences of potentially renegotiated contracts. Future research that focuses on longer time horizons would be a benefit here because there are

seemingly competing issues. The ratchet effect induces agents to lower initial effort (and expected initial compensation) to drive down the principal's expectation of future performance. With expectations lowered, standard 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, there may be an incentive to further reduce initial efforts, as this data is now used by the principal to derive expectations in many future periods. However, there are now more periods in which an agent may 'harvest' lower expectations. Effort levels during these periods of harvest will then have the effect of ratcheting the principal's expectation back up. Furthermore, as more periods are added beyond two, 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 balances these issues with those considered here would enhance our view of the true welfare impacts of restrictions on contractual form.

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Endnotes

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[1] Homogenous agent ability could be parameterized in two ways: $\tau_1 = 0$ or $\tau_1 > 0$ and $\eta = 1$. In the either case both the agents and principal are exactly aware of agent ability. In the former case there is no variance associated with ability and, hence, the mean ability level prevails. In the latter all ability levels are perfectly correlated; hence, the only way to maintain the mean is for each agent's ability to be equal to the mean ability.

[2] 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.

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

[4] Meyers 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.

[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.

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	15.0	224.7	None	None
Pooled Results	6.4	96.7	17.9	268.8

*All calculations assume $\eta = 0$ and $\rho = \frac{1}{4}$.

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
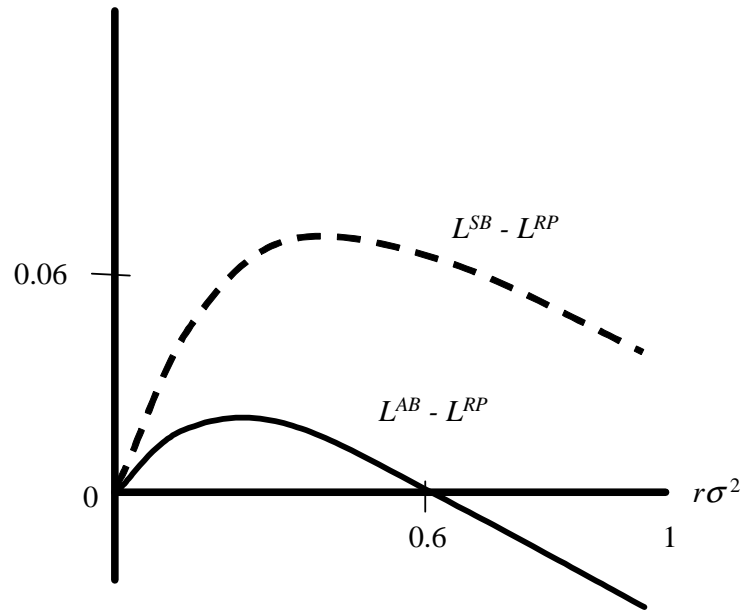
*Parameters are τ_1=0.31 and τ_2=0.63 are calculated from Levy and Vukina; η=0 and $\rho = \frac{1}{4}$ are assumed. Line segments below zero represent welfare gains from imposing an all period ban (solid line) or a same period ban (dashed line). Total variance for the contract is calculated as $\sigma^2 = 4,670$

Figure 1. Welfare Loss From Banning Tournaments: Pooled Broiler Contracts
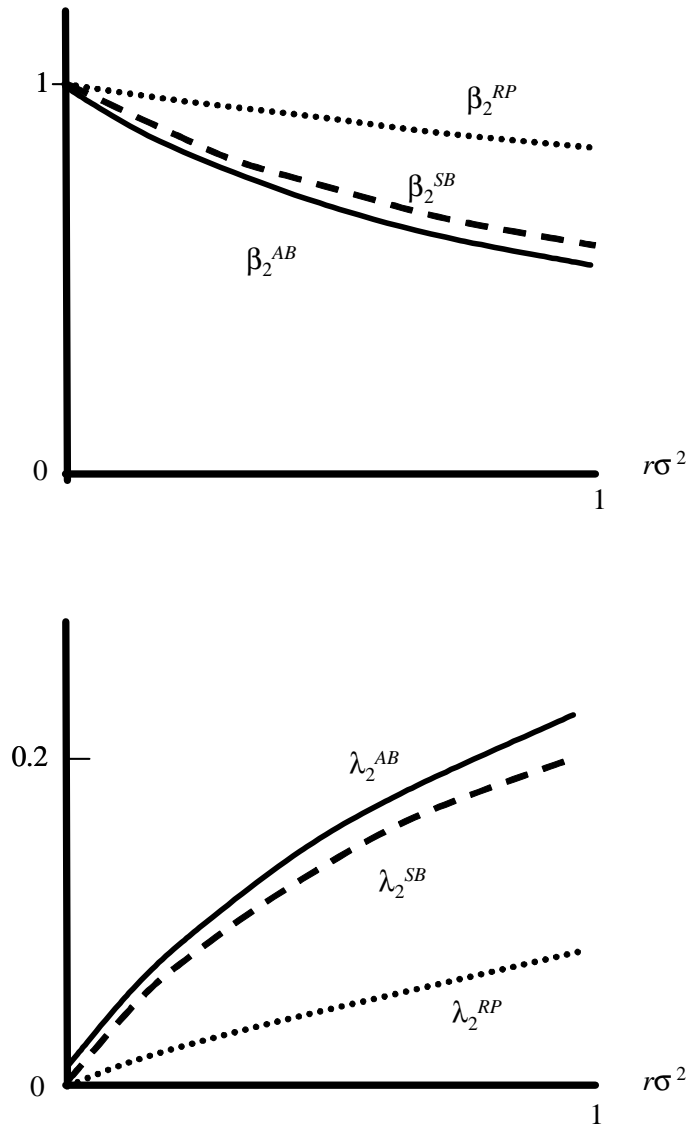
*Parameters are the same as figure 1. The top panel represents the piece-rate parameters for relative performance contracts (dotted line) and contracts under which relative performance measures are banned during the same period (solid line) and all periods (dashed line). The bottom panel features the welfare losses for each contract associated with the inability of contracts to provide insurance against common shocks during the second period.

Figure 2. Second period effects of banning tournaments for pooled broiler contracts
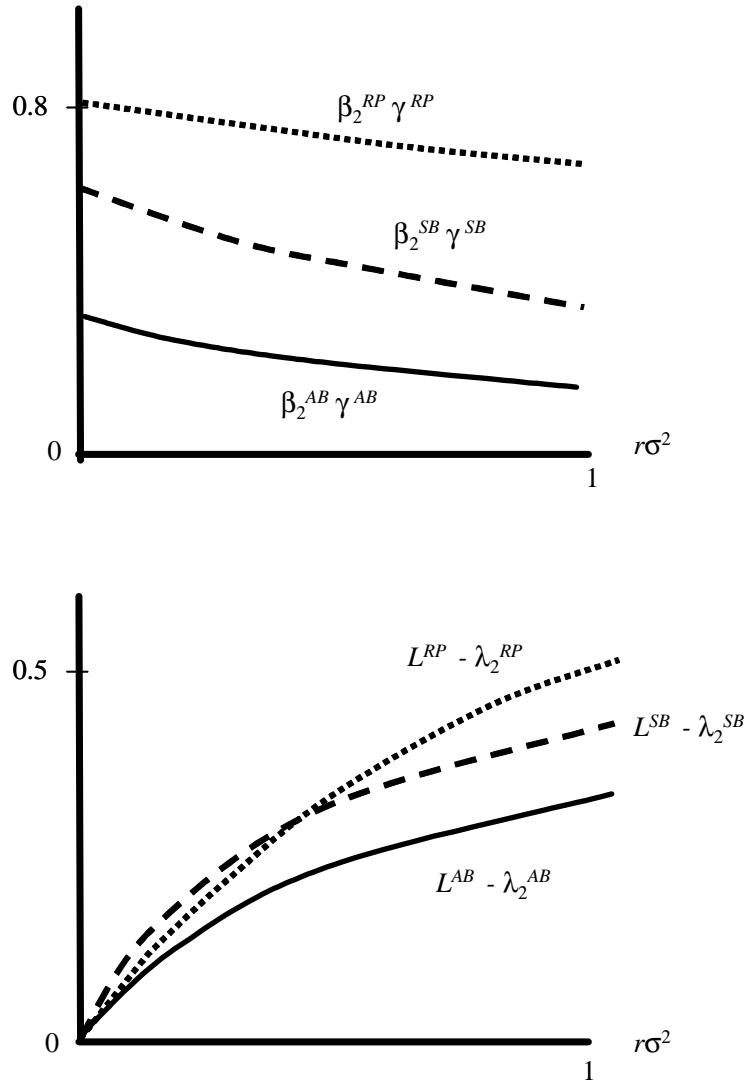
*Parameters are the same as figure 2. The top panel represents the ratchet effect for relative performance contracts (dotted line) and contracts under which relative performance measures are banned during the same period (solid line) and all periods (dashed line). The bottom panel features the first-period 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 3. First period effects of banning tournaments for pooled broiler contracts