The Welfare Comparison of Alternative Broiler Production Tournaments

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Abstract:
We present the first comparison between the conventional one-flock tournament and a previously unexamined T-week tournament, in which performance is averaged over multiple weeks. Our analysis uncovers key differences in incentives, risks, and welfare outcomes between the two schemes. We show that effort and income depend on the incentive parameter in both settings, and additionally on the grower's discount factor in the T-week format. We identify a trade-off between common production risk in the T-week tournament and group composition risk in the one-flock tournament. Using empirical data, we estimate structural parameters and conduct counterfactual simulations with $T = 52$. We find that the 52-week tournament reduces income volatility, but its welfare effects vary with growers' ability and the incentive parameter, indicating that it could serve as a viable alternative.

Keywords: One-flock tournament, T-week tournament, Broiler industry

1 Introduction

In the broiler industry, contract farming is governed by principal-agent (PA) relationships between integrators and growers. Integrators retain ownership of key inputs and final output, while growers are responsible for the daily management of chicken growout, including feeding, housing, and monitoring bird health, creating asymmetries in information about grower attributes (e.g., ability) and actions (e.g., effort). These asymmetries give rise to two canonical PA problems: selection, where the principal must contract with agents whose types are unobservable, and incentive, where the agent's effort is hidden but crucial for performance (Stiglitz, 1987). One widely used contractual response to these frictions is the tournament-type settlement, which compensates agents based on how their performance compares to others within the same group (Lazear and Rosen, 1981).

Tournament contracts address the incentive problem by tying rewards to relative performance. This structure enhances effort incentives without requiring costly monitoring and automatically filters out common shocks, making it appealing to risk-averse growers by reducing income volatility (Bull et al., 1987; Knoeber and Thurman, 1994; Zheng and Vukina, 2007; Marinakis and Tsoulouhas, 2012; Agranov and Tergiman, 2013). Additionally, the base pay component can serve as a screening device for selection, as only growers who expect to achieve at least their reservation income will find participation worthwhile at a given base pay level. From the integrator's perspective, this combination of relative incentives and selective participation is effective.

However, contrary to these theoretical findings, criticisms of broiler tournaments have been present among unhappy contract growers for almost as long as the tournaments themselves and so were the attempts to regulate them. The literature on these topics is substantial, see for example Wang and Vukina (2017) and the references therein. In June 2022, the USDA solicited public comments on tournament-type contracts in the poultry industry due to "numerous complaints from poultry growers" about the use of tournament systems (USDA, 2022). After that, in June 2024, the USDA proposed a rule, which was finalized in January 2025, requiring integrators not to penalize growers based on their performance relative to other growers. This context serves as the main motivation for studying the welfare properties of alternative payment schemes that could be adopted in the broiler industry.

Exposed to frequent regulatory initiatives and growers' complaints, the industry itself would occasionally try to find effective replacements for traditional tournament schemes. One particular experiment being considered in the industry circle is the new payment scheme, similar to the conventional tournament, which calculates the benchmark for performance comparison based on the difference between individual and group-average performance based on a T-weeks moving average, rather than only based on one (current) flock. T-weeks moving average means that the comparison will be based on all flocks produced by an individual grower and other growers in the complex within a specified T-weeks time period, where T is typically set to one year (52

weeks) but could be shorter.[1]

The use of moving average comparisons is interesting because it increases common production risk, such as weather or disease shocks commonly shared by growers during the same period, while reducing group composition risk, which refers to uncertainty about future competitors. The increase in common shock is a result of the much longer time periods of measured performance, encompassing also the periods when the individual grower was not in the tournament but some of her competitors could have been. This results in the situation where the common shock is not canceled out, whereas it is consistently the case in a conventional tournament. The decrease in the group composition risk comes from the fact that over a longer time horizon, any individual grower will be compared against a much larger number of other contestants (possibly all) than during a single flock tournament.

Using moving averages also changes how effort influences outcomes in the presence of moral hazard. In a conventional tournament, a grower's effort affects only the performance of the current flock. In a T-week tournament, effort in the current flock contributes to measured performance across multiple subsequent flocks within the T-week period.

This study contributes to the literature by introducing and analyzing the welfare properties of the T-week tournament, a format not previously studied in the academic literature. We compare growers' effort, payments, and welfare under the traditional one-flock and T-week tournaments using a structural model estimated from individual-level contract settlement data.

Our results show that while the 52-week tournament generally reduces income volatility relative to the one-flock tournament, its welfare effects vary with growers' ability and the incentive parameter. These findings offers evidence that could be relevant to industry and regulatory discussions on alternative tournament designs.

The remainder of the paper is organized as follows. Section 2 reviews the related literature, Section 3 introduces the theoretical framework, Section 4 details the data, Section 5 explains the empirical strategy, Section 6 presents the results, and Section 7 offers concluding remarks.

2 Literature Review

Tournaments, which are compensation schemes based on relative rather than absolute performance, have been extensively studied as mechanisms to incentivize effort in environments where output is influenced by noise. In their seminal work, Lazear and Rosen (1981) formalize the tournament model, showing that rank-based reward structures can effectively eliminate the influence of common shocks on compensation while inducing high effort levels. This insight has led to a broad literature exploring how tournaments perform under various informational, behavioral, and institutional conditions.

[1] A simple way to understand the nature of the new scheme, imagine the performance bonus/malus for the above/below average performance calculated based on the last 3-flocks moving average rather than only one. For an analytical model of this type see Appendix A.

Subsequent studies examine what determines observed performance in tournaments and how contract design affects participant incentives and welfare. Some focus on the components of performance, such as individual effort, idiosyncratic shocks, and common shocks, and how these interact within competitive settings. Others investigate the institutional application of tournaments, notably in the broiler industry, where relative-performance contracts are prevalent and growers are compensated based on their rank within settlement groups. A key issue in that context is the role of heterogeneous ability and group composition, which affect both performance and perceived fairness.

Contrary to the academic perspective, in the real world, there is a significant amount of discontent with tournaments among growers, which has driven the government (USDA) to regulate or even prohibit the tournament scheme. Addressing this issue, more recent work challenges the assumption that tournaments are always well-received by agents, showing that fairness concerns may reduce participant satisfaction. In response, scholars have proposed alternative contract forms, such as hybrid or truncated tournaments, to balance incentives, fairness, and risk-sharing.

This review synthesizes these strands of research along four key themes:

(1) the determinants of agent performance;

(2) the theoretical and empirical rationale for tournament contracts;

(3) behavioral critiques and grower dissatisfaction with tournament schemes; and

(4) proposed alternatives that modify or complement tournament incentives.

2.1 The Determinants of Agent Performance

In the standard tournament framework, an agent's observed performance is typically modeled as the sum of the agent's chosen effort, common shocks affecting all participants, and idiosyncratic shocks unique to each agent (Lazear and Rosen, 1981). This decomposition is especially important in empirical settings where environmental and stochastic factors are hard to isolate.

Levy and Vukina (2004) extend this structure by introducing heterogeneity in grower type through an additive ability term, which represents grower-fixed effects derived from characteristics such as skill, experience, or facility features.[2] The authors also show that variation in ability distribution within settlement groups can lead to substantial payment variation across growers, termed the "league composition effect," or the "group composition effect." Moreover, they derive the grower's optimal effort level under tournament contracts and show that the resulting behavior constitutes a pure strategy Nash equilibrium that is uniform across all growers and time periods.

[2]Other literature, such as McLaughlin et al. (1988) and Tsoulouhas (2010), introduces ability as a factor affecting marginal cost, implying that higher ability leads to lower effort cost. We follow Levy and Vukina (2004), specifying ability as an additive term in performance. As we discuss later, this structural assumption allows us to directly estimate ability in the empirical work.

2.2 Rationale for Tournament Contracts in Broiler Industry

Tournaments provide a compelling solution to the problem of common shocks by rewarding only relative performance. As Lazear and Rosen (1981) demonstrate, this eliminates the need to contract on absolute output and allows firms to design high-powered incentives even in noisy environments.

Tournaments can take two principal forms: rank-order tournaments, where prizes are assigned strictly based on ordinal rank (e.g., first place, second place), and cardinal tournaments, where compensation is based on how much better or worse an agent performs relative to the group average. In cardinal tournaments, the payout is a continuous function of relative performance, commonly referred to as the "settlement cost" in broiler contracts, which allows for finer distinctions between performances.

The organization of broiler production is peculiar in two aspects: first, it is mostly composed of individual contracts rather than spot markets or vertical integration. Second, most of the contracts follow a cardinal tournament scheme rather than a pure rank-order tournament.

One possible explanation for the second point is that cardinal tournaments are more efficient than rank-order tournaments. Lazear and Rosen (1981) highlight the problem of adverse selection in rank-order tournaments when worker abilities are heterogeneous. When low-ability workers are pooled with high-ability workers, incentive misalignment arises between the principal and agents: high-ability workers may under-exert, knowing they can win with minimal effort against weaker competitors. Conversely, low-ability workers may exert no effort at all, expecting little chance of winning, yet still earning more than they would in a league composed only of other low-ability workers (a minor league). To address this, Lazear and Rosen propose that principals introduce handicaps if worker ability is observable, allowing both types to exert efficient effort. However, this solution entails higher transaction costs, as it requires the principal to observe individual abilities and calibrate handicap levels accordingly.

Knoeber and Thurman (1994) argue that cardinal tournaments avoid this issue, as rewards are directly and linearly tied to individual performance rather than rank. This removes the strategic inefficiency induced by ability mixing in rank-based systems.

In a related discussion, Knoeber (1989) emphasizes that contract production and tournament-style compensation in the broiler industry are interrelated and mutually reinforcing. He discusses that cardinal tournaments reduce growers' income risk by filtering out common shocks, which account for nearly half the total income variance. They also minimize transaction costs, as compensation need not be renegotiated when exogenous conditions (e.g., technological change, disease outbreaks, or weather shocks) change, which is an especially valuable feature in broiler production.

From the principal's perspective, tournaments are also attractive because they generate strong performance incentives, particularly when combined with the grower's obligation to invest in relationship-specific capital (i.e., broiler houses). Contracts often include performance-

contingent termination clauses. Since broiler houses have little value outside of this specific relationship, contract termination imposes a severe penalty on underperforming growers. Although reselling to another grower is theoretically possible, a buyer may not exist.

Knoeber also explains why individual contracts are common in broiler production compared to other industries. First, broiler production involves large investments in relationship-specific assets, making spot markets less viable. Second, requiring growers to provide housing creates a powerful incentive to exert effort, which is an incentive that vertical integration cannot replicate as houses would be supplied by the integrator rather than the grower.

2.3 Grower Resistance to Tournaments

Despite their incentive benefits, tournaments are not universally embraced. A substantial number of growers report dissatisfaction, often due to perceived unfairness and outcome uncertainty.[3] Wu and Roe (2006) show through lab experiments that agents often exhibit inequity aversion, leading to dissatisfaction under tournament pay even when the expected monetary payoff is higher. When individuals perceive outcome differences as unfair due to noise or ability heterogeneity, they may reduce effort or opt out of the contract entirely.

The presence of effort cost asymmetry further exacerbates the issue. In Wu and Roe's framework, low-cost individuals tend to win repeatedly, while high-cost individuals are discouraged from participating. This dynamic raises concerns about both efficiency and fairness, especially in markets like broiler production where participants cannot easily exit the system.

2.4 Alternative tournament designs

To address these limitations, there have been proposals for alternative tournament designs that preserve incentives while improving fairness and risk-sharing. Tsoulouhas (2010) suggests hybrid (cardinal) tournaments, which include both absolute and relative performance elements with different weights.[4] The author theoretically shows that hybrid tournaments induce higher effort from agents and increase the principal's expected profit compared to the standard cardinal tournament, provided that common shock risk exists.

However, in practice, such schemes are not observed, at least in broiler contracts. Tsoulouhas conjecture that this is because transaction costs (e.g., determining optimal parameters) may compel the principal to adopt a simpler scheme, making standard tournaments the dominant choice.

[3]Growers claim unfairness in various aspects, including the biased distribution of production inputs of differing quality by integrators, frequent mandatory upgrade requests for housing facilities and equipment, lack of transparency in contract dispute resolution, and retaliatory actions against outspoken producers (Wang and Vukina, 2017).

[4]For a formal illustration and its comparison with the standard cardinal tournament, see Section 3 in Tsoulouhas (2010).

Another alternative payment scheme is the truncated tournament, proposed by the USDA[5] and examined by Wang and Vukina (2017). It adjusts the prize structure by capping losses at the base payment level. Growers who underperform relative to their group do not receive penalties, while only those who outperform receive bonuses. Wang and Vukina analyze the company's optimal contract design under both standard cardinal and truncated tournament scenarios. The results show that principals can significantly mitigate potential welfare losses due to the regulation by adjusting the payment scheme. The optimal adaptation to tournament truncation leads to a situation where both high- and low-ability players benefit from the policy, while average-ability players lose.

In this study, we examine another alternative tournament design that exists in the industry but has not yet been examined in academia: the T-week tournament. This tournament differs from the standard cardinal tournament in that individual and group-average performance are based on a T-week moving average, rather than just one (current) flock. The T-week moving average means that comparisons are based on all flocks produced by an individual grower and others in the complex within a specified T-week period, typically set to one year (52 weeks) but possibly shorter.

The use of moving average comparisons is interesting because it increases common shock risk but reduces group composition risk. Common shock increases because the longer performance window includes periods when the individual grower was inactive while some competitors were active. As a result, common shocks are not canceled out, unlike in conventional tournaments. Group composition risk decreases because, over a longer time horizon, each grower is compared against a larger and more stable set of competitors.

Additionally, from a contract design perspective, using a moving average fundamentally changes the incentive compatibility constraint in moral hazard problems faced by broiler integrators (principals). In conventional tournaments, unobserved grower effort affects only their one-period (flock) performance. In T-week tournaments, effort exerted during the current flock influences measured performance in multiple flocks grown during the future T weeks.

In the following section, we present a theoretical model comparing the standard cardinal tournament with the T-week tournament. For clarity, we refer to the standard cardinal tournament as the "one-flock" tournament.

3 Theoretical Framework

3.1 Basic Setup

Consider a broiler complex with a total of N growers under contract, where $n_t < N$ denotes the number of growers settling their contracts each week. The individual performance of grower i is defined as $x_{i,t} = -\frac{C_{i,t}}{q_{i,t}}$, where $C_{i,t}$ represents the settlement cost incurred during the growing

[5]The rule was finalized in January 2025 and will take effect on July 1, 2026.

period, and $q_{i,t}$ denotes the live weight of chickens produced. The settlement cost includes production inputs provided by the integrator to grower i, such as chicks, feed, and veterinary services. Therefore, the performance metric $x_{i,t}$ captures the integrator's average live production cost for that grower.

The tournament operates as a two-margin contest, where growers compete to maximize live weight and minimize production costs. Following Knoeber and Thurman (1994), and to keep subsequent analyses tractable, we adopt the following assumption:

Assumption 1 (Additive structure of performance) *The live weight of chickens produced is constant across growers and normalized as* $q_{i,t} = \bar{q} = 1$.[6] *Under this assumption, grower performance* $x_{i,t}$ *is given by:*

$$x_{i,t} = e_{i,t} + a_i + u_t + w_{i,t} \tag{1}$$

With $q_{i,t} = 1$, the tournament reduces to a single-margin contest in which each grower competes by reducing the production cost of a pound of live chicken. In this setting, $x_{i,t}$ serves as the performance metric used to compare growers, and growers choose the amount of effort to exert, which entails a cost. Since the integrator cannot observe individual effort, the framework constitutes a classic hidden-action moral hazard problem.

On the right-hand side of Equation (1), $e_{i,t} \geq 0$ denotes the effort exerted by grower i, and $a_i \leq 0$ represents his inherent ability, assumed constant over time.[7] Abilities vary across growers in the complex, with variance σ_a^2. The term u_t captures common stochastic shocks that affect all growers equally, including factors such as weather or disease outbreaks. These shocks are independent over time, with u_1 normalized to 0, a mean of 0, and finite variance σ_u^2. The term $w_{i,t}$ denotes grower- and time-specific idiosyncratic shocks, which are independently distributed across growers and time, with a mean of 0 and finite variance σ_w^2.

Most contracts are flock-based, meaning that chicks are delivered to growers at the beginning of each contract, and the contract is settled once the birds are raised to the target broiler weight and returned to the company. The growing period typically lasts 5 to 7 weeks, depending on the target weight, during which the grower raises the birds under standardized conditions. Upon settlement, the grower's final performance $x_{i,t}$ is recorded, and the contract concludes. In this context, we define a tournament at time t as the competition among growers whose contracts are settled in week t, with n growers participating based on their relative performance.

Following settlement, growers typically enter an intermission period, which lasts 3 to 4 weeks before the next contract begins. The length of this period may vary depending on market conditions (such as demand for chicken meat) and logistical constraints. Together, the growing

[6] This assumption is justified because output is primarily determined by housing density, number of houses, and livability, factors that are generally unaffected by growers' endogenous effort within a short time frame. Housing density is standardized and unalterable by growers, the number of houses is fixed in the short run, and livability depends mainly on chick quality beyond the grower's control. Differences in production scale are treated as part of grower ability, which captures persistent productivity heterogeneity.

[7] The term "ability" includes innate characteristics, acquired skills, and time-invariant factors such as location, production scale, or facility attributes. Empirically, this is interpreted as a grower fixed effect.

and intermission periods constitute a production cycle, generally spanning 8 to 11 weeks. Variation in cycle lengths across growers introduces randomness into the weekly composition of tournament participants (see Figure 1). As a result, neither the integrator nor the growers know or control the exact group composition of each tournament in advance. Nonetheless, a specific cycle length (for example, 9 weeks) is commonly observed in practice due to the homogeneity in production goals and standardized management protocols within each complex.

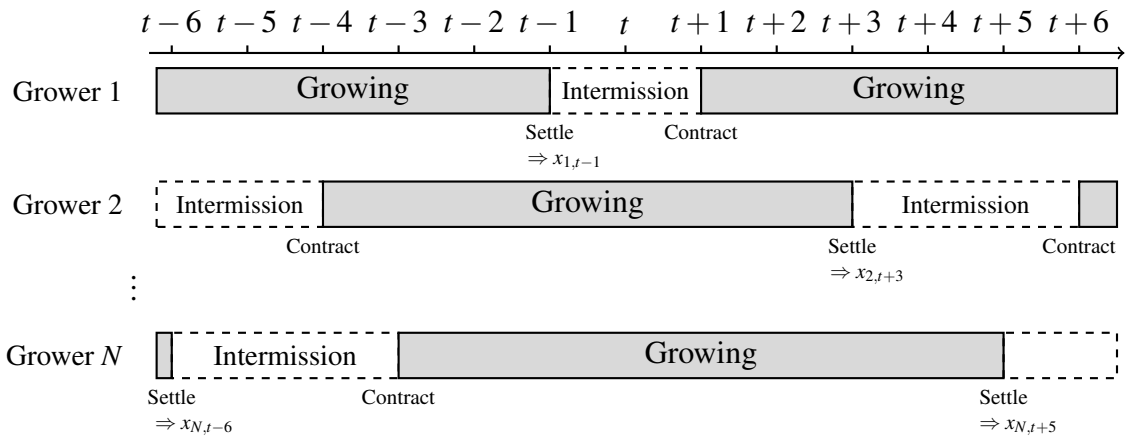


Figure 1: Illustration of growing and intermission stages for multiple growers

We model growers as maximizing their utility, where utility is a function of income net of effort cost. In line with Levy and Vukina (2004), we adopt a common utility function:

Assumption 2 (Common utility and quadratic effort cost) *All growers share a common utility function of the form $U[y_{i,t} - c(e_{i,t})]$, where $U' > 0$ and $U'' \leq 0$. The term $c(e_{i,t})$ denotes the cost of effort, which enters directly into the utility function. The cost of effort is assumed to take the quadratic form:*

$$c(e_{i,t}) = \frac{Ke_{i,t}^2}{2}$$

where $K > 0$ is a parameter representing the disutility of effort.

Under this specification, $c(e_{i,t})$ is strictly convex in effort, satisfying $c'(e_{i,t}) > 0$ and $c''(e_{i,t}) > 0$. The assumption $U'' \leq 0$ rules out the possibility of risk-loving preferences.

These assumptions form the basis for analyzing growers' strategic behavior under two payment schemes: the one-flock tournament and the T-week tournament.

3.2 One-flock Tournament

Under the one-flock tournament, grower i's income per flock ($y_{i,t}^{1f}$) is given by:

$$y_{i,t}^{1f} = b^{1f} + \beta(x_{i,t} - \bar{x}_t) \tag{2}$$

where b^{1f} is the base payment, and β is the incentive parameter, representing the slope of the bonus/malus component. In most empirically observed contracts, β is fixed at 1. The term $\bar{x}_t$ denotes the average performance of the n growers who settled their flocks in the tournament at time t, and is calculated as:

$$\bar{x}_t = \frac{\sum_{j=1}^{N} \mathbb{D}_{j,t} x_{j,t}}{\sum_{j=1}^{N} \mathbb{D}_{j,t}}$$

where $\mathbb{D}_{j,t}$ is a dummy variable equal to 1 if grower j settled their flock in period t, and 0 otherwise. By construction, $\sum_{j=1}^{N} \mathbb{D}_{j,t} = n_t$.

Combining equations (1) and (2) the grower's income under the one-flock tournament is rewritten as:

$$y_{i,t}^{1f} = b^{1f} + \beta \left[\left(e_{i,t} - \frac{\sum_{j=1}^{N} \mathbb{D}_{j,t} e_{j,t}}{n_t - 1} \right) + \left(a_i - \frac{\sum_{j=1}^{N} \mathbb{D}_{j,t} a_j}{n_t - 1} \right) + \left(w_{i,t} - \frac{\sum_{j=1}^{N} \mathbb{D}_{j,t} w_{j,t}}{n_t - 1} \right) \right] \quad (3)$$

The equation indicates that a grower's income is determined by their effort and ability levels relative to the group average, which in the one-flock tournament consists of the n_t growers who settled their flocks in the same week. Since u_t appears in both $x_{i,t}$ and $\bar{x}_t$, it cancels out in the calculation. In this setting, all growers in the group have experienced the same common shock, so its effect is effectively removed from the payment.

Grower i's objective is to maximize his expected utility by choosing the optimal effort. Based on Equation (3), and denoting $V(e_{i,t})$ as the maximum expected utility that grower i can achieve by optimally choosing his effort, grower's objective is expressed as:

$$V(e_{i,t}) = \max_{e_{i,t}} \mathbb{E}\left[U\left[y_{i,t}^{1f} - c(e_{i,t}) \right] \right] \quad (4)$$

Taking the first-order condition yields the following closed-form solution for the optimal effort:

$$e_{i,t}^{1f} = e_t^{1f} = \frac{\beta}{K} \left(\frac{n_t - 1}{n_t} \right) \quad (5)$$

Equation (5) demonstrates that the optimal effort exerted by each grower remains identical. In reference to the standard "marginal revenue equals marginal cost" optimality condition, equation (5) shows that effort is slightly attenuated by the factor $\frac{n_t - 1}{n_t} < 1$, which accounts for a grower's own contribution to the average. Furthermore, the incentive parameter β determines the marginal benefit of effort, making the effort level proportional to its value. Since all factors influencing optimal effort are exogenous contract parameters, the grower's effort decision in an n_t-person simultaneous-move game constitutes a dominant strategy.

Substituting $e_{i,t}$ in (3) with e_t^{1f} and taking expectations yields the grower's expected income under the one-flock tournament:

$$\mathbb{E}[y_{i,t}^{1f}] = b^{1f} + \beta \left(\frac{n_t - 1}{n_t} \right) (a_i - \mathbb{E}[\bar{a}_{-i,t}]) \quad (6)$$

where $\bar{a}_{-i,t} = \frac{\sum_{j=1,j\neq i}^{N} \mathbb{D}_{j,t} a_j}{n_t - 1}$. The expected income depends on the tournament incentive parameter β and the ability gap between the individual grower and the average ability of the competing group, represented by $(a_i - \mathbb{E}[\bar{a}_{-i,t}])$. As β increases, high-ability growers tend to earn more, while low-ability growers tend to earn less. Importantly, the term $\mathbb{E}[\bar{a}_{-i,t}]$ introduces uncertainty due to variation in the composition of the tournament group faced by grower i over time. At times, the grower competes against a group with high average ability and is more likely to earn less; at other times, the group may be less skilled, increasing the likelihood of earning more. This source of risk is commonly referred to as the "league composition effect" or "group composition risk" (Levy and Vukina, 2004).

From equation (3), the variance of grower income under the one-flock tournament is derived as:

$$\sigma^2_{y,1f} = \beta^2 \left(\frac{n_t - 1}{n_t} \right) \left(\frac{\sigma^2_a}{n_t} + \sigma^2_w \right) \tag{7}$$

The income variance increases with the square of the slope coefficient β and is driven by the variances in growers' abilities and idiosyncratic shocks. Since the common shock (σ^2_u) is eliminated by the tournament structure, it does not contribute to income variability. Moreover, the effect of league composition risk (variance in abilities) diminishes as the number of growers increases, because it is scaled by $\frac{n_t - 1}{n_t^2}$. Intuitively, as the number of participants in the tournament grows, the expected average ability of the other growers converges to the overall mean ability of the population, thereby reducing the impact of group composition risk.

In the special case with CARA utility and normally distributed z, the utility function can be represented in the mean-variance (certainty equivalent) form:[8]

$$CE = \mathbb{E}[z] - \frac{r\sigma^2_z}{2} \tag{8}$$

where $r > 0$ is the coefficient of absolute risk aversion, capturing the extent of growers' risk sensitivity. The CE in equation (8) reflects not only the expected income level but also its associated risk, enabling a welfare comparison between the two tournament schemes.

Letting $z^{1f}_{i,t} = y^{1f}_{i,t} - c(e_{i,t})$, the CE of grower i under the one-flock tournament at time t is:

$$CE^{1f}_{i,t} = b^{1f} + \beta \left(\frac{n_t - 1}{n_t} \right) (a_i - \mathbb{E}[\bar{a}_{-i,t}]) - \frac{\beta^2}{2K} \left(\frac{n_t - 1}{n_t} \right)^2 - \frac{r\sigma^2_{y,1f}}{2} \tag{9}$$

Note that the only time-specific variable in $CE^{1f}_{i,t}$ is n_t. The term $\mathbb{E}[\bar{a}_{-i,t}]$ does not vary over time, as neither the grower nor the integrator knows the tournament group composition in advance.

An increase in the incentive parameter β influences $CE^{1f}_{i,t}$ through three channels. The first is the income effect, captured by the second term in Equation (9), which reflects how grower

[8] See, for example, Laffont and Martimort (2002, pp. 382–383) for a derivation of the certainty equivalent under CARA utility with normally distributed payoffs.

income increases with the ability gap, scaled by $\beta\left(\frac{n_t-1}{n_t}\right)$.

Second, a higher β induces greater effort, raising the cost of effort and thereby reducing CE. This is reflected in the third term, $-\frac{\beta^2}{2K}\left(\frac{n_t-1}{n_t}\right)^2$. While it may seem counterintuitive that greater effort leads to higher costs without improving CE, this is because effort is a dominant strategy for all growers. As a result, under the tournament payment scheme, any gains from increased effort are offset by corresponding adjustments in compensation, just as with common shocks, leaving only the additional disutility from exerting more effort.

Third, a higher β increases income variance $\sigma^2_{y,1f}$, which is proportional to β^2 as shown in equation (7), thereby further reducing CE. This increase in variance arises from the greater magnitude of compensation tied to relative performance, which fluctuates due to both group composition risk and idiosyncratic shocks. This effect is represented by the final term, which captures the negative impact of risk via the factor $-\frac{r}{2}$.

3.3 T-week Tournament

In a T-week tournament, grower i's income per flock ($y^{Tw}_{i,t}$) is determined by:

$$y^{Tw}_{i,t} = b^{Tw} + \gamma(\widetilde{x}_{i,t} - \bar{X}_t) \tag{10}$$

where b^{Tw} and γ are the corresponding base and slope parameters, $\widetilde{x}_{i,t}$ and $\bar{X}_t$ represent the individual and group average performance measures in a T-week tournament, respectively. The measures are defined as follows:

$$\widetilde{x}_{i,t} = \frac{1}{m_{i,t}} \sum_{k=0}^{T-1} \mathbb{D}_{i,t-k} x_{i,t-k} \tag{11}$$

$$\bar{X}_t = \frac{\sum_{j=1}^{N} \sum_{k=0}^{T-1} \mathbb{D}_{j,t-k} x_{j,t-k}}{\sum_{j=1}^{N} m_{j,t}} \tag{12}$$

Same as before, $\mathbb{D}_{i,t-k}$ equals 1 if grower i settled her flock in the $(t-k)$-th week and 0 otherwise, and $m_{i,t}$ denotes the number of flocks delivered by grower i during the current (t-th) week and the preceding $T-1$ weeks. That is, $m_{i,t} = \sum_{k=0}^{T-1} \mathbb{D}_{i,t-k}$. Equation (11) indicates that $\widetilde{x}_{i,t}$ represents the T-week moving average of grower i's performance over the current and prior $T-1$ weeks, while equation (12) shows that $\bar{X}_t$ is the T-week moving average of performance records for all growers in the complex over the same period. The expression $\sum_{j=1}^{N} \sum_{k=0}^{T-1} \mathbb{D}_{j,t-k} x_{j,t-k}$ aggregates historical performance records for all growers over T weeks, including the current week, and is divided by $\sum_{j=1}^{N} m_{j,t}$.

The grower's income in the T-week tournament is obtained by combining Equations (1) and

(10).[9]

$$y_{i,t}^{Tw} = b^{Tw} + \gamma \left[\left(\frac{1}{m_{i,t}} - \frac{1}{\sum_{j=1}^{N} m_{j,t}} \right) \sum_{k \in \tau_{i,t}} e_{i,k} - \frac{\sum_{j=1, j\neq i}^{N} \sum_{k \in \tau_t} \mathbb{D}_{j,k} e_{j,k}}{\sum_{j=1}^{N} m_{j,t}} + \left(a_i - \frac{\sum_{j=1}^{N} m_{j,t} a_j}{\sum_{j=1}^{N} m_{j,t}} \right) \right.$$
$$\left. + \left(\frac{1}{m_{i,t}} - \frac{n_t}{\sum_{j=1}^{N} m_{j,t}} \right) u_t + \left(\frac{1}{m_{i,t}} - \frac{1}{\sum_{j=1}^{N} m_{j,t}} \right) w_{i,t} - \frac{\sum_{j=1, j\neq i}^{N} \mathbb{D}_{j,t} w_{j,t}}{\sum_{j=1}^{N} m_{j,t}} \right] + \Phi_{i,t} \qquad (13)$$

Here, $\Phi_{i,t}$ represents the cumulative effects of common and idiosyncratic shocks over the past $T-1$ weeks:

$$\Phi_{i,t} = \gamma \left[\left(\frac{\sum_{k \in \tau_{i,t,-t}} u_k}{m_{i,t}} - \frac{\sum_{k \in \tau_{i,t,-t}} n_k u_k}{\sum_{j=1}^{N} m_{j,t}} \right) - \frac{\sum_{k \in \tau_{i,t}^c} n_k u_k}{\sum_{j=1}^{N} m_{j,t}} + \left(\frac{1}{m_{i,t}} - \frac{1}{\sum_{j=1}^{N} m_{j,t}} \right) \sum_{k \in \tau_{i,t,-t}} w_{i,k} \right.$$
$$\left. - \frac{\sum_{j=1, j\neq i}^{N} \sum_{k \in \tau_{t,-t}} \mathbb{D}_{j,k} w_{j,k}}{\sum_{j=1}^{N} m_{j,t}} \right] \qquad (14)$$

where τ_t is the set of week indices in the T-week window at t, $\tau_{t,-t}$ excludes week t, $\tau_{i,t} \subset \tau_t$ includes only weeks when grower i settled his flock, $\tau_{i,t,-t} = \tau_{i,t} \setminus \{t\}$, and $\tau_{i,t}^c = \tau_t \setminus \tau_{i,t}$. Formally,

$$\begin{aligned}
\tau_t &:= \{ k \mid t - T + 1 \leq k \leq t \}, && T\text{-week window at week } t \text{ (size: } T), \\
\tau_{t,-t} &:= \tau_t \setminus \{t\}, && \tau_t \text{ excluding current week } t \text{ (size: } T-1), \\
\tau_{i,t} &:= \{ k \in \tau_t \mid \mathbb{D}_{ik} = 1 \}, && \text{weeks in } \tau_t \text{ when grower } i \text{ settled (size: } m_{i,t}), \\
\tau_{i,t,-t} &:= \tau_{i,t} \setminus \{t\}, && \tau_{i,t} \text{ excluding current week } t \text{ (size: } m_{i,t}-1), \\
\tau_{i,t}^c &:= \tau_t \setminus \tau_{i,t}, && \text{complement of } \tau_{i,t} \text{ in } \tau_t \text{ (size: } T - m_{i,t}).
\end{aligned} \qquad (15)$$

Contrary to the one-flock tournament, the income in the T-week tournament still contains the common shock u_t, because its effect is weighted differently in the individual performance measure $\tilde{x}_{i,t}$ and the group performance measure $\bar{X}_t$. Specifically, the weight on the individual measure is $\frac{1}{m_{i,t}}$, whereas the weight on the group average measure is $\frac{n_t}{\sum_{j=1}^{N} m_{j,t}}$. As these weights differ, the common shock does not fully cancel out when computing relative performance.

Another key difference is that, in the T-week tournament, a grower's ability is compared to the aggregate average ability of all N growers, weighted by the number of performance records in the T-week window: $\frac{\sum_{j=1}^{N} m_{j,t} a_j}{\sum_{j=1}^{N} m_{j,t}}$. In the one-flock tournament, variation in group composition is the primary source of risk in the group's average ability, whereas in the T-week tournament, this risk arises from variation in the number of performance records. Because the group average in the T-week tournament is computed over all N growers, it is expected to be more stable than in the one-flock tournament, where the average is based on only n_t growers.

While Equation (13) is general, it is complicated for analytical purposes. In particular,

[9] The full derivation is provided in Appendix B.1.

the randomness the number of historical performance records ($m_{j,t}$) makes it difficult to derive tractable expressions for optimal effort, expected income, and welfare. To simplify the analysis, we introduce the following assumption:

Assumption 3 (Constant number of performance records) *The number of performance records in the T-week window, $m_{i,t}$, is fixed at m for all growers i and all periods t.*

This assumption eliminates the randomness in $m_{i,t}$ and allows the grower's income to be expressed in a more tractable form:

$$\begin{aligned} y_{i,t}^{Tw} =& b^{Tw} + \gamma \left[\left(\frac{N-1}{Nm} \right) \sum_{k \in \tau_{i,t}} e_{i,k} - \frac{\sum_{j=1, j\neq i}^{N} \sum_{k \in \tau_t} \mathbb{D}_{j,k} e_{j,k}}{Nm} + (a_i - \bar{a}) + \left(\frac{N-n_t}{Nm} \right) u_t \right. \\ & \left. + \left(\frac{N-1}{Nm} \right) w_{i,t} - \frac{\sum_{j=1, j\neq i}^{N} \mathbb{D}_{j,t} w_{j,t}}{Nm} \right] + \Phi_{i,t} \end{aligned} \tag{16}$$

where $\bar{a} = \frac{\sum_{j=1}^{N} a_j}{N}$ is the average ability across all growers, and $\Phi_{i,t}$ is given by:

$$\Phi_{i,t} = \frac{\gamma}{Nm} \left[\sum_{k \in \tau_{i,t,-t}} (N - n_k) u_k - \sum_{k \in \tau_{i,t}^c} n_k u_k + (N-1) \sum_{k \in \tau_{i,t,-t}} w_{i,k} - \sum_{j=1, j\neq i}^{N} \sum_{k \in \tau_{t,-t}} \mathbb{D}_{j,k} w_{j,k} \right] \tag{17}$$

Although Equation (16) is a special case of (13), it preserves the essential features of the T-week tournament for two reasons. First, the average ability $\bar{a}$ approximates the weighted average ability. This removes the uncertainty arising from variation in the weights, but the effect is negligible because $m_{i,t}$ varies little in practice and its influence is further diluted in the aggregate average. Second, the formula still contains the common shock term, which is only partially canceled. Choosing reasonable values for m (e.g., mode) should allow the expression to capture the true nature of $y_{i,t}^{Tw}$.

Note that a grower's income depends not only on current effort $e_{i,t}$, but also on past effort levels, represented by $\sum_{k \in \tau_{i,t}} e_{i,k}$ in Equation (16). Thus, current effort affects both current income and the stream of incomes over the next $T-1$ weeks. For tractability, we impose the following assumptions:

Assumption 4 (Homogeneity in expectation of production cycle length and time preference) *Growers expect a common production cycle length l for future flocks, where the integer l satisfies*

$$(m-1)l \leq T - 1 < ml \tag{18}$$

Moreover, growers share a common time preference factor $\frac{1}{1+\rho}$, where ρ is the weekly interest rate.

Combined with Assumption 3, Assumption 4 implies that, when deciding effort, growers expect to contract with the integrator $m-1$ additional times over the next $T-1$ weeks, with each cycle lasting l weeks. For example, if $l=10$ and $T=52$, growers would expect $m=6$, meaning they anticipate five additional settlements during the 51 weeks ahead. These values clearly satisfy inequality (18). The assumption also states that all growers have the same time preference, allowing the use of a common discount factor for analytical convenience.

Together with the previous assumptions, the grower i's objective function can be written as:

$$V(e_{i,t}) = \max_{e_{i,t}} \mathbb{E}\left[\sum_{k\in\tau_t^F}\left(\frac{1}{1+\rho}\right)^{k-t} U\left[y_{i,k}^{Tw} - c(e_{i,k})\right]\right] \tag{19}$$

where $\tau_t^F = \{t, t+l, t+2l, \ldots, t+(m-1)l\}$. Taking the first-order condition for $e_{i,t}$, the optimal effort is:

$$e_{i,t}^{Tw} = e^{Tw} = \frac{\gamma}{K}\left(\frac{N-1}{N}\right)\left(\sum_{s=0}^{m-1}\frac{\delta^{sl}}{m}\right) \quad \forall i,t \tag{20}$$

where $\delta \in (0,1)$ denotes the weekly discount factor, which combines the pure time preference factor, $\frac{1}{1+\rho}$, and a continuation risk factor reflecting uncertainty about future payments.[10]

Equation (20) contains no individual- or time-specific variables, indicating that all growers exert the same effort under the T-week tournament. The effort level shares several features with the one-flock tournament: it is proportional to the slope parameter γ and attenuated by the grower's contribution to the group average, represented by $\frac{N-1}{N}$.

However, there are key differences. First, as shown by the term $\sum_{s=0}^{m-1}\frac{\delta^{sl}}{m}$, optimal effort declines as the weekly discount factor δ decreases. Here, δ reflects both the grower's time preference for money and the uncertainty surrounding the contract. Higher uncertainty or a higher interest rate leads to lower effort because, unlike in the one-flock tournament where effort affects only the current flock's income, in the T-week tournament its benefits are spread across m consecutive flocks over the current and next $T-1$ weeks.

Second, the shading factor is $\left(\frac{N-1}{N}\right)\left(\sum_{s=0}^{m-1}\frac{\delta^{sl}}{m}\right)$, compared to $\frac{n_t-1}{n_t}$ in the one-flock case. Shading arises in two ways. First, as discussed above, it occurs through discounting. Second, it results from the contribution of individual effort to the group average, as in the one-flock case, but with a smaller factor $\frac{1}{N}$ since $N > n_t$. Whether the total shading effect in the T-week tournament is greater or smaller than in the one-flock tournament is ultimately an empirical question, depending on N, n_t, m, and δ.

Given that $e_{i,t}^{Tw} = e^{Tw}$ and $\mathbb{E}[u_t] = \mathbb{E}[w_{i,t}] = 0$ for all t and i, the expected value of a grower's current income is:

$$\mathbb{E}_t[y_{i,t}^{Tw}] = b^{Tw} + \gamma\left(\frac{N-1}{N}\right)(a_i - \bar{a}_{-i}) + \Phi_{i,t} \tag{21}$$

where $\bar{a}_{-i} = \frac{\sum_{j\neq i} a_j}{N-1}$. Similar to Equation (6), income depends on relative ability. However, in

[10] Derivations are provided in Appendix B.2.

this case, the grower's ability is compared with the average ability of all other growers in the complex, which removes league composition risk.[11]

The subscript t on $\mathbb{E}$ indicates that the expectation is taken at time t, with all past shocks $(\Phi_{i,t})$ already realized. As the income period of interest moves further into the future, the share of realized shocks in $\Phi_{i,\cdot}$ decreases, since shocks occurring after t remain random at the time the expectation is taken. For example, when evaluating $\mathbb{E}_t[y^{Tw}_{i,t+l}]$, $\Phi_{i,t+l}$ includes shocks that occur after t; their expectations are taken, but they are not yet realized. By the time income at $t+ml$ is evaluated from t, no shocks are realized, and $\mathbb{E}_t[\Phi_{i,t+ml}] = 0$ because both common and idiosyncratic shocks are i.i.d. with zero mean.

The impact of realized $\Phi_{i,t}$ depends on whether the common shock occurred in a week when grower i settled a flock. Shocks coinciding with the grower's settlement have a positive effect on $\Phi_{i,t}$ and thus on income, reflecting that common shocks are not fully canceled under the T-week tournament scheme. By contrast, shocks occurring in other weeks have a negative effect. This is because the individual performance measure $\widetilde{x}_{i,t}$ excludes those weeks, whereas the group performance measure $\bar{X}_t$ includes them. If common shocks were favorable in those weeks, the group average would rise while the individual measure remained unchanged, thereby reducing the grower's incentive payment.

Building on this insight, it is useful to distinguish between the *contemporaneous* and *forward* variance of grower income. The contemporaneous variance measures volatility arising solely from shocks realized in the current period t, holding past shocks constant. It captures the immediate uncertainty in the payment received at time t. In contrast, the forward variance applies when evaluating income for a future period and accounts for uncertainty from both current-period shocks and components of past shocks that affect future income but are not yet realized at time t. This measure therefore reflects not only immediate risk but also the lingering uncertainty from past shocks that will be realized in subsequent settlements.

From equation (16), the contemporaneous variance of a grower's income under the T-week tournament is given by:

$$\sigma^2_{y,Tw,0} = \left(\frac{\gamma}{Nm}\right)^2 \left[(N-n_t)^2\sigma_u^2 + (N^2-2N+n_t)\sigma_w^2\right] \tag{22}$$

and the k-weeks forward variance of a grower's income is:

$$\sigma^2_{y,Tw,k} = \sigma^2_{y,Tw,0} + \sigma^2_{\Phi,k} \tag{23}$$

where $\sigma^2_{\Phi,k}$ is the variance of shocks that have not yet been realized at time t but are included in

[11] As noted earlier, $\bar{a}_{-i}$ may vary with changes in $m_{j,t}$, but its variability is substantially smaller than that of $\bar{a}_{-i,t}$ in the one-flock tournament.

$\Phi_{i,t+k}$. For instance, if $k = sl$ for $s \in \{1,2,...,m-1\}$:

$$\sigma^2_{\Phi,sl} = \left(\frac{\gamma}{Nm}\right)^2 \left[\left(sN + 2\sum_{k=0}^{s-1} n_{t+kl} + \sum_{k=1}^{t+sl-1} n_k^2 \right) \sigma_u^2 + \left[(N-1)^2 + \sum_{k=1}^{t+sl-1} n_k - s \right] \sigma_w^2 \right] \quad (24)$$

$\sigma^2_{\Phi,k}$ increases with k, as a larger portion of the past-shock component in $\Phi_{i,t+k}$ remains unrealized. It reaches its maximum at $k = T$, when the entire past-shock component is unrealized at the time of evaluation. The distinction between $\sigma^2_{y,Tw,0}$ and $\sigma^2_{y,Tw,k}$ is crucial for the analysis, as the increasing variance feature is reflected into the discount factor δ.[12]

Both types of variance depend on the variances of both common and idiosyncratic shocks and is proportional to γ^2. Unlike the one-flock tournament, ability heterogeneity does not contribute to income variance, as performance is benchmarked against the full complex average.[13]

Nevertheless, the T-week tournament reintroduces exposure to common shocks. Notably, income variance declines as m increases, since a longer averaging window dilutes the influence of individual shocks.

We consider the CE of income k weeks ahead under the T-week tournament:

$$CE^{Tw}_{i,t,k} = b^{Tw} + \gamma \left(\frac{N-1}{N}\right)(a_i - \bar{a}_{-i}) - \frac{\gamma^2}{2K}\left(\frac{N-1}{N}\right)^2 \left(\sum_{s=0}^{m-1} \frac{\delta^{sl}}{m}\right)^2 - \frac{r\sigma^2_{y,Tw,k}}{2} + \mathbb{E}_t[\Phi_{i,t+k}] \quad (25)$$

Similar to the one-flock tournament, an increase in the incentive parameter γ under the T-week tournament affects $CE^{Tw}_{i,t,k}$ through three distinct channels. First is the income effect, captured by the second term in Equation (25), which reflects how the grower's expected income rises with a larger ability gap $(a_i - \bar{a}_{-i})$ scaled by $\gamma\left(\frac{N-1}{N}\right)$. Second, a higher γ induces greater effort, leading to increased effort costs and thereby reducing CE. This is represented by the third term, which incorporates the square of the discounted average effort weights. As in the one-flock case, while growers exert more effort when incentives strengthen, the associated income gains are offset through adjustments in compensation, leaving only the additional disutility of effort. Third, a higher γ amplifies the variance of income $\sigma^2_{y,Tw,k}$, further reducing CE. This variance arises from exposure to both common and idiosyncratic shocks, weighted by the averaging mechanism over the T-week horizon. This effect is captured in the fourth term, which reflects the risk penalty applied to the variance of income under CARA preferences.

An additional feature of the T-week tournament is that a higher discount factor δ reduces CE by inducing greater effort and, consequently, higher disutility. This result holds under the assumption that all growers share a common δ. If δ varies across growers, however, the conclusion may not hold.

[12] In Appendix B.2, we discuss how this feature is reflected into δ under the CARA utility assumption.

[13] Again, note that this result depends on the assumption that $m_{i,t}$ is constant. However, the variability in weighted average ability will be trivial, given the large number of growers within the complex.

3.4 Grower Welfare Comparison

The two tournament schemes differ in terms of the level of CE. While grower ability influences CE under both systems, the marginal effects differ: it is $\beta\left(\frac{n_t-1}{n_t}\right)$ in the one-flock tournament and $\gamma\left(\frac{N-1}{N}\right)$ in the T-week tournament. Given that closed-form expressions for CE are available under both schemes, we can directly compare which setting yields higher welfare for a grower. The difference in CE is expressed as:

$$\begin{aligned} & CE_{i,t}^{1f} - CE_{i,t,k}^{Tw} \\ &= b^{1f} - b^{Tw} + \left[\beta\left(\frac{n_t-1}{n_t}\right) - \gamma\left(\frac{N-1}{N}\right)\right] a_i - \beta\left(\frac{n_t-1}{n_t}\right)\mathbb{E}_t[\bar{a}_{-i,t}] + \gamma\left(\frac{N-1}{N}\right)\bar{a}_{-i} \\ &\quad - \left(\frac{\beta^2}{2K}\right)\left(\frac{n_t-1}{n_t}\right)^2 + \left(\frac{\gamma^2}{2K}\right)\left(\frac{N-1}{N}\right)^2\left(\sum_{s=0}^{m-1}\frac{\delta^{sl}}{m}\right)^2 - \frac{r}{2}(\sigma_{y,1f}^2 - \sigma_{y,Tw,k}^2) - \mathbb{E}_t[\Phi_{i,t+k}] \end{aligned} \tag{26}$$

A positive value of equation (26) implies that the one-flock tournament yields higher CE for grower i; a negative value indicates the opposite. The sign of the difference depends on grower ability a_i. Let a_T denote the ability level at which the CEs under both schemes are equal.

To derive a_T, we apply three simplifications. First, we set $\mathbb{E}_t[\Phi_{i,t+k}] = 0$, recognizing that its ex-ante expected value is zero. Second, we fix $n_t = n$ for all t, which empirically corresponds to choosing a representative value of n (e.g., the mode). Third, we replace $\mathbb{E}_t[\bar{a}_{-i,t}]$ with $\bar{a}_{-i}$, acknowledging the finding by Levy and Vukina (2004) that tournament group composition is randomly assigned. Specifically:

$$\begin{aligned} \mathbb{E}[\bar{a}_{-i,t}] &= \frac{1}{n_t-1}\mathbb{E}\left[\sum_{j\neq i}^{N}\mathbb{D}_{j,t}a_j\right] \\ &= \frac{1}{n_t-1}\sum_{j\neq i}\mathbb{P}(j\in S_t)a_j = \frac{1}{n_t-1}\sum_{j\neq i}\left(\frac{n_t-1}{N-1}\right)a_j = \frac{1}{N-1}\sum_{j\neq i}a_j = \bar{a}_{-i} \end{aligned}$$

where $S_t \subset \{1,\ldots,N\}\setminus\{i\}$ and $|S_t| = n_t - 1$.

Substituting these simplifications into equation (26) yields:

$$\begin{aligned} CE_i^{1f} - CE_{i,k}^{Tw} = b^{1f} - b^{Tw} + \left[\beta\left(\frac{n-1}{n}\right) - \gamma\left(\frac{N-1}{N}\right)\right]\left(\frac{N}{N-1}\right)(a_i - \bar{a}) - \left(\frac{\beta^2}{2K}\right)\left(\frac{n-1}{n}\right)^2 \\ + \left(\frac{\gamma^2}{2K}\right)\left(\frac{N-1}{N}\right)^2\left(\sum_{s=0}^{m-1}\frac{\delta^{sl}}{m}\right)^2 - \frac{r}{2}(\sigma_{y,1f}^2 - \sigma_{y,Tw,k}^2) \end{aligned} \tag{27}$$

where $\bar{a} = \frac{1}{N}\sum_{j=1}^{N}a_j$. The subscript t is omitted since the formula has no time-specific variables.

The threshold ability is therefore given by:

$$
\begin{aligned}
& a_T \\
=& \bar{a} + \frac{b^{Tw} - b^{1f} + \left(\frac{\beta^2}{2K}\right)\left(\frac{n-1}{n}\right)^2 - \left(\frac{\gamma^2}{2K}\right)\left(\frac{N-1}{N}\right)^2 \left(\sum_{s=0}^{m-1} \frac{\delta^{sl}}{m}\right)^2 + \frac{r}{2}(\sigma^2_{y,1f} - \sigma^2_{y,Tw,k})}{\beta\left(\frac{n-1}{n}\right)\left(\frac{N}{N-1}\right) - \gamma}
\end{aligned} \tag{28}
$$

In Equation (27), $(a_i - \bar{a})$ is multiplied by $\left[\beta\left(\frac{n-1}{n}\right) - \gamma\left(\frac{N-1}{N}\right)\right]$. If $\beta\left(\frac{n-1}{n}\right) > \gamma\left(\frac{N-1}{N}\right)$, the one-flock tournament becomes increasingly advantageous as grower ability rises, and growers with ability above a_T are expected to achieve a higher CE under the one-flock scheme. Conversely, if $\beta\left(\frac{n-1}{n}\right) < \gamma\left(\frac{N-1}{N}\right)$, the T-week tournament is more favorable to high-ability growers. Based on these findings, we propose the following proposition:

Proposition 1 *Given Assumptions 1–4, if $\beta\left(\frac{n-1}{n}\right) > \gamma\left(\frac{N-1}{N}\right)$, then the difference $CE^{1f}_{i,t} - CE^{Tw}_{i,t,k}$ increases monotonically with grower ability. In this case, growers with ability above a_T are expected to attain higher utility under the one-flock tournament than under the T-week tournament.*

Conversely, $\beta\left(\frac{n-1}{n}\right) < \gamma\left(\frac{N-1}{N}\right)$, then the difference decreases monotonically with ability, and growers with ability above a_T attain lower utility under the one-flock scheme.

Proposition 1 implies that the difference in CE between the two schemes is strictly monotonic in grower ability. For instance, if $\beta = \gamma$, then it follows that $\beta\left(\frac{n-1}{n}\right) < \gamma\left(\frac{N-1}{N}\right)$, indicating that the T-week tournament provides higher CE for growers with ability higher than a_T. This pattern arises from how expected income varies with grower ability. In the one-flock tournament, the incentive is attenuated by the factor $\left(\frac{n-1}{n}\right)$, because a grower's performance partially contributes to the group average, diluting the reward. In contrast, the T-week tournament involves a much larger and more temporally dispersed comparison group, rendering the grower's own influence on the group average negligible. As a result, the marginal return to ability is higher in the T-week scheme when $\beta = \gamma$.

4 Data and Descriptive Statistics

The dataset used in this study comprises unbalanced panel data from five broiler complexes, each covering different time periods: 2020–2022 for Complex A, 2020–2023 for Complex B, 2019–2020 for Complex C, 1995–1997 for Complex D, and 2018–2022 for Complex E. Data for Complexes A, B, C, and E were obtained through a cooperative agreement between AMS-USDA and NCSU, while the data for Complex D come from Levy and Vukina (2004).

Due to confidentiality concerns, since the data originate from private companies, discussion of the dataset is limited. For example, we do not disclose the exact dates and months covered in each dataset, and we refrain from providing detailed descriptive statistics for the key variables. All contract settlements in the datasets used for the empirical analysis are based on one-flock

tournaments. We exclude growers with fewer than three flocks after the first 52 weeks of the data period[14] in order to ensure a sufficient number of observations for each individual grower.

Table 1 summarizes the key variables used in the analysis, including the settlement date, grower ID, settlement cost, the number of competitors per tournament, the time between settlements, and the number of flocks settled over the past year. The settlement date, grower ID, and settlement cost are used to estimate grower ability (a_i), common shocks (u_t), and idiosyncratic shocks ($w_{i,t}$).

The weekly number of growers corresponds to n in our theoretical model and is used to compute effort levels. For the counterfactual scenario, we set $T = 52$, representing one year. Accordingly, the number of flocks settled over the past year serves as a key variable in the analysis. This variable, combined with the time between successive settlements, is used to determine the parameters m and l as defined in the theoretical framework.

Table 1 also presents summary statistics of key variables at the aggregate level: settlement cost, the weekly number of growers, the time between settlements, and the number of flocks settled over the past year. Settlement costs vary across growers and time periods, and their distribution differs across complexes. While the overall mean settlement cost is 0.2285 dollars per pound, the mean in Complex D is approximately 0.31 dollars per pound, which is notably higher than in the other complexes. This difference likely reflects the earlier period covered by Complex D (1995–1997), whereas the other datasets span more recent and comparable timeframes (2019–2022).

The weekly number of growers (n) varies within each dataset, and its distribution differs across datasets. Theoretical analysis shows that optimal effort depends on the number of growers. As discussed later, we allow effort in the one-flock tournament to vary over time, reflecting the theoretical result that optimal effort depends on n.

The mode for the number of flocks settled over the past year (m) is 5, implying a typical contract cycle of about ten weeks ($\approx 52/5$). However, both the mode of this variable and that of the time between settlements differ across datasets. As a result, growers in different datasets are likely to form different expectations about how frequently they will receive new flocks and how many past performance records will factor into their evaluations. For instance, in some datasets, the most recent five flocks may influence a grower's performance ranking, while in others, it may be as many as seven. Growers are therefore expected to adjust their effort with the understanding that their current performance will impact the next five to seven settlement evaluations over the following year, depending on the empirical patterns specific to their dataset.

We also present the average weight and mortality rate in this table. The average weight refers to the final average weight per chicken for each flock and varies across complexes. It is generally proportional to the time between settlements, since heavier birds require a longer grow-out period. However, average weight may also be influenced by factors such as technology

[14]For the counterfactual analysis, the first 52 weeks of the data period are excluded to allow growers in the 52-week tournament to accumulate sufficient performance records for calculating 52-week averages.

or breed. For instance, in dataset D, which covers an earlier period (1995–1997) than the other datasets, the average time between settlements is longer than in other complexes, even though the average weight is relatively low.

We also find that the standard deviation of average weight within each dataset does not exceed 10 percent of its mean, indicating that variation in average weight across contracts is relatively small and that chicken weights are nearly standardized.

The mortality rate is calculated as the ratio of the number of chickens delivered at the end of the contract to the number placed at the beginning. While the mean mortality rate varies somewhat across complexes, its standard deviation remains within 2–3 percent, suggesting limited fluctuation. Together with the stability in average weight, this implies that both bird size and mortality rate show little variation across growers. This consistency supports the modeling assumption of normalized output per grower.

Table 1: Description and summary statistics of variables

Variable	Description	Mean	Mode	SD
Settlement date	The date when the contract was finalized.	–	–	–
Grower ID	A unique identifier for each grower.	–	–	–
Settlement cost (\$/lb, $x_{i,t}$)	The total cost of chicks, feed, and veterinary services provided by the integrator during the growing period, divided by the final live weight of chickens produced.	0.2285	–	0.0485
Weekly number of growers (n)	The number of growers participating in each tournament.	14.9	9	7.5
Time between settlements (l)	Period between the previous and current contract settlements for the same grower.	10.2	10	3.8
Number of flocks settled over the past year (m)	The number of flocks each grower settled during the past year (52 weeks).	4.6	5	1.7
Average weight (lbs)	Average live weight of chickens produced.	6.0	–	1.5
Mortality rate (%)	Share of birds that died during the growing period.	5.0	–	2.8

Note : Descriptive statistics are reported at the aggregate level due to confidentiality concerns.
Data Source : USDA-AMS, Levy and Vukina (2004)

5 Empirical Framework

In this study, we aim to empirically assess the two tournament schemes by examining growers' effort levels, expected incomes and variances, and CEs. To achieve this, we follow three

steps: First, we set the key parameter values. Second, we estimate growers' efforts, abilities, common shocks, and idiosyncratic shocks using micro-level data on broiler production contract settlements. Third, we simulate grower payments under different scenarios to compare the two tournament schemes.

5.1 Key Parameter Values

This study empirically evaluates two tournament schemes by constructing counterfactual scenarios. Table 2 outlines the assumed values of key parameters. The base payments for each tournament (b^{1f}, b^{52w}) are fixed at \$0.058/lb across all scenarios. Although actual base payment values vary across time and datasets, we fix them for two main reasons: first, to isolate the effect of the payment calculation method on grower income and integrator profit; and second, due to confidentiality concerns, as disclosing the actual base pay could reveal the identity of a specific complex. The slope parameter for the one-flock tournament (β) is fixed at 1, while different values are used for the 52-week tournament to account for the unobserved true value of γ.

The parameter K, which determines the convexity of the cost-of-effort function, is set to 100 for both tournament schemes, following Wang and Vukina (2017).[15] For the weekly discount factor δ, which is used to compute effort under the 52-week tournament, we consider three values: $0.85^{1/52}$, $0.9^{1/52}$, and $0.95^{1/52}$. The risk aversion parameter r, used in calculating the CE for welfare analysis, is set to 0.1, following Hegde and Vukina (2003).[16]

The expected time between settlements (l) and the expected number of flocks to be settled over the current and future $T-1$ weeks (m) are set to the modal values observed in each dataset. These forward-looking expectations for the $T-1$ weeks ahead are key determinants of a grower's effort decision and should be distinguished from $l_{i,t}$ and $m_{i,t}$, which are measured in the actual data and allowed to vary. The total number of growers (N) is based on the actual number observed, excluding those with fewer than three performance records after the first 52 weeks.

5.2 Econometric Model

Our empirical approach assumes that a grower's performance follows equation (1). In essence, performance consists of the grower's effort decision, ability, common shocks shared among growers in tournament t, and idiosyncratic shocks. Empirically, the ability term corresponds to grower fixed effects, the common shock term corresponds to time fixed effects, and the idiosyncratic shock represents errors. This framework enables the use of a two-way fixed effects

[15] The choice of $K = 100$ is arbitrary, but alternative values do not materially affect the qualitative comparison between the one-flock and T-week tournaments.

[16] Hegde and Vukina (2003) also consider $r = 0.01$ and $r = 0.001$, but results using these values do not differ significantly in our context.

Table 2: Key parameter assumptions by scenario

Scenario	Parameter	Description
Common	K	Cost parameter, fixed at 100.
	Base pay (b^{1f}, b^{52w})	Base payment: \$0.058/lb.
One-flock tournament	β	Incentive slope, fixed at 1.
52-week tournament	γ	Incentive slope, varying as 0.8, 1, or 1.2.
	δ	Weekly discount factor, varying as $(0.85)^{\frac{1}{52}}$, $(0.9)^{\frac{1}{52}}$, or $(0.95)^{\frac{1}{52}}$.
	l	The expected time between settlements: 8–11 weeks, depending on the complex.
	m	The expected number of flocks to be settled over the current and future $T-1$ weeks: 5–7, depending on the complex.
	N	Total number of growers within the complex.

Note : Due to confidentiality concerns raised by the data provider, we do not disclose the specific parameter values (l, m) applied to each complex.

(TWFE) model to estimate grower abilities, common shocks, and idiosyncratic shocks, given that the datasets employed in our empirical analysis consist exclusively of one-flock tournament records with $\beta = 1$.

Formally, a grower's ability, common shocks, and idiosyncratic shocks can be estimated using the following TWFE model:[17]

$$x_{i,t} - e^{1f*} = a_1 + \sum_{k=2}^{N} (a_k - a_1)\mathbb{D}_i^k + \sum_{l=2}^{T} u_t \mathbb{U}_t^l + w_{i,t} \tag{29}$$

where $\mathbb{D}_i^k$ is a grower dummy variable equal to 1 if $i = k$ and 0 otherwise, and $\mathbb{U}_t^l$ is a tournament dummy variable equal to 1 if $t = l$ and 0 otherwise. To prevent singularity, only $N-1$ grower dummies and $T-1$ tournament dummies are included, with the omitted ones absorbed into the intercept. Since the common shock is assumed to satisfy $u_1 = 0$, the intercept provides a clean estimate of the excluded grower's ability, a_1. The effort term is moved to the left-hand side of the regression equation and subtracted from the performance measure. As the dataset exclusively contains records from one-flock tournaments with $\beta = 1$, optimal effort e_t^{1f*} is calculated as $e_t^{1f*} = \frac{1}{100}\left(\frac{n_t - 1}{n_t}\right)$, allowing n to vary across time periods. The estimated parameters include

[17]The model assumes that a grower's ability remains constant over time. For complexes A, B, and C, this assumption may not fully hold, as some growers upgraded their facilities during the data period. However, this is not a critical issue for our analysis, as we compare the two tournaments based on payment calculations while keeping ability fixed across tournament types. Although the estimated ability may be biased for these growers, we apply the same biased estimator in both tournaments, ensuring that the bias does not affect our analysis.

a_1, $(a_k - a_1)$, u_t, and $w_{i,t}$. Grower k's ability is estimated as $\hat{a}_k = \hat{a}_0 + \widehat{(a_k - a_1)}$.

Table 3 reports the estimation results from the two-way fixed effects regression model specified in Equation (29) for each dataset (complex). The adjusted R^2 values are 0.6243 for A, 0.4152 for B, 0.7039 for C, 0.9240 for D, and 0.5163 for E, which are relatively high for cross-sectional data. The variances of ability, common shocks, and idiosyncratic shocks are denoted by $\hat{\sigma}_a^2$, $\hat{\sigma}_u^2$, and $\hat{\sigma}_w^2$, respectively.

F-test 1 evaluates the null hypothesis that growers have equal abilities. The test statistics are sufficiently large to reject the null for all datasets, indicating significant heterogeneity in growers' abilities. F-test 2 examines the null hypothesis that common shocks are absent across periods. The null is strongly rejected in all cases, confirming the presence of common shocks in growers' performance.

Table 3: Fixed effects model estimation result

Stat	Complex A	Complex B	Complex C	Complex D	Complex E
Adjusted R^2	0.6243	0.4152	0.7039	0.9240	0.5163
$\hat{\sigma}_a^2$	1.06e-05	1.27e-05	1.10e-05	2.41e-05	8.96e-06
$\hat{\sigma}_u^2$	2.57e-05	1.45e-05	4.18e-05	9.20e-04	1.85e-05
$\hat{\sigma}_w^2$	1.64e-05	2.48e-05	1.64e-05	6.54e-05	2.02e-05
F-test 1[a]	7.2927***[c]	5.2846***[c]	4.6223***[c]	3.0604***[c]	6.7416***[c]
F-test 2[b]	11.502***[c]	4.7027***[c]	30.043***[c]	338.12***[c]	15.747***[c]

Note : Estimates of the intercept and the full set of grower and week fixed effects (a_i, u_t) are omitted for brevity.
[a] H_0: $a_i = a \; \forall i = 1, ..., N$
[b] H_0: $u_t = 0 \; \forall t = 1, ..., T$
[c] *: < 0.05, **: < 0.01, ***: < 0.001

5.3 Counterfactual Analysis

Given the estimates of abilities $(\hat{a}_i)$, common shocks $(\hat{u}_t)$, and idiosyncratic shocks $(\hat{w}_{i,t})$, we construct counterfactual performance measures based on Equation (1):

$$\hat{x}_{i,t}^{1f} = e^{1f*} + \hat{a}_i + \hat{u}_t + \hat{w}_{i,t} \tag{30}$$

$$\hat{x}_{i,t}^{52w} = e^{52w*} + \hat{a}_i + \hat{u}_t + \hat{w}_{i,t} \tag{31}$$

The optimal effort levels (e^*) under each tournament scheme (e^{1f*}, e^{52w*}) are derived from Equations (5) and (20), using the parameter values specified in Table 2. We assume that the model primitives, namely ability, common shocks, and idiosyncratic shocks, remain constant across tournament schemes for the same i and t. Based on this assumption, we compute counterfactual performance measures, defined as the negative of settlement costs per pound of live weight, for both scenarios.

Substituting the estimated $\hat{x}$ values into equations (2) and (10), we simulate growers' incomes under the one-flock and 52-week tournament scenarios. To ensure comparability, we

exclude the first year of data to allow growers in the 52-week scheme sufficient time to accumulate historical performance records for computing 52-week averages.

We evaluate the two schemes in terms of effort, growers' income variance, and welfare.[18] Effort is measured as the aggregate average across all delivered flocks, obtained by substituting the parameter values into the optimal effort formulas in Equations (5) and (20).

Income variance is examined at both individual and aggregate levels. Individually, we identify the scheme with the lower variance for each grower and count the number of cases in which one scheme dominates. Aggregately, we compute the overall variance of income across all growers and their flocks. For the 52-week tournament, this corresponds to the cumulative variance in Equation (23) with $k = 52$.

For welfare, we assume CARA utility with a risk aversion parameter $r = 0.1$ and calculate CE, as defined in Equation (8). Each grower's average income and variance are computed from their counterfactual incomes and applied to the CE formula, yielding CE_i^{1f} for the one-flock tournament and $CE_{i,52}^{52w}$ for the 52-week tournament. We then determine, at the individual level, which scheme yields the higher CE and tally the number of cases where one scheme dominates, and at the aggregate level, we calculate the average CE across all growers.

6 Counterfactual Analysis Results

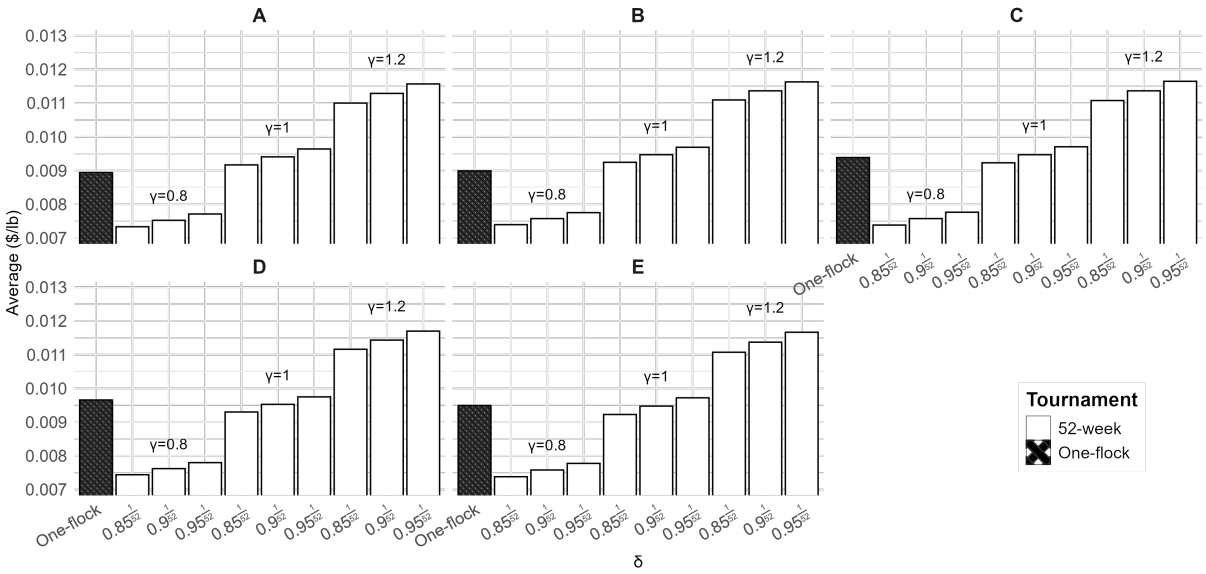
We present the counterfactual analysis results categorized by effort level, variance of grower income, and grower's certainty equivalent. The complete tables of results are provided in Appendix A, while their graphical representations are included in this section for improved readability.

Level of Effort Figure 2 presents the effort levels exerted by growers under various scenarios, derived from theoretical assumptions. Under the 52-week tournament, effort increases with γ and is comparable to or higher than that under the one-flock tournament when γ is 1 or 1.2. The figure also shows that effort rises with the discount factor δ. These graphical results are consistent with the theoretical prediction that placing greater weight on future rewards or providing stronger incentives leads to higher effort.

Variance of Grower Income Figure 3 presents the aggregate variance of growers' income across five different complexes. Remarkably, in nearly all cases, the aggregate variance is lower under the 52-week tournament than under the one-flock tournament, with the sole exception of $\gamma = 1.2$ in complex D. Consistent with the theoretical framework, the variance increases as the slope parameter γ rises, while changes in the discount factor δ have no effect.

[18] We do not compare mean income, as it is not empirically meaningful: by construction, the aggregate mean is almost identical to the base pay, with roughly half of growers earning less and the rest earning more than the base level.

Figure 2: Average grower's effort levels ($/lb)



Note: To better illustrate the differences across scenarios, the vertical axis range has been adjusted in each panel.

Figure 4 illustrates the proportion of growers with larger income variance under the 52-week tournament compared to the one-flock tournament ($P(\sigma^2_{y,52w,52} > \sigma^2_{y,1f})$). This figure aligns with the trend observed in the previous figure, showing that the individual income variance under the 52-week tournament is lower than that under one-flock for most of growers, and the share does not change with δ. Combined with the previous figure, this result strongly suggests that income variance under the 52-week tournament is generally lower than under the one-flock tournament in most cases.

Grower's Certainty Equivalent Figure 5 displays the aggregate mean of growers' CE across five different complexes. CE under the 52-week tournament decreases as either γ or δ increases, which aligns with the theoretical prediction. Note that the income effect, which reflects the increase in a grower's expected income due to a larger ability gap, is not reflected in this figure, as the ability gap is approximately zero in the aggregate statistics. Furthermore, when $\beta = \gamma = 1$, CE under the 52-week tournament is similar to or slightly higher than under the one-flock tournament, suggesting that growers may enjoy comparable or slightly greater welfare under the 52-week tournament given identical contract parameters.

Figure 6 shows the proportion of growers whose CE is higher under the one-flock tournament. This proportion increases with γ and δ, and approaches 0.5 when the contract parameters in the 52-week tournament match those in the one-flock setting, consistent with the aggregate statistics.

Figure 7 presents a scatterplot in which each dot represents a grower's ability and the difference in CE between the one-flock and 52-week tournaments ($CE_i^{1f} - CE_{i,52}^{52w}$). Since the

Figure 3: Aggregate variance of growers' income ($(\$/\text{lb})^2$)

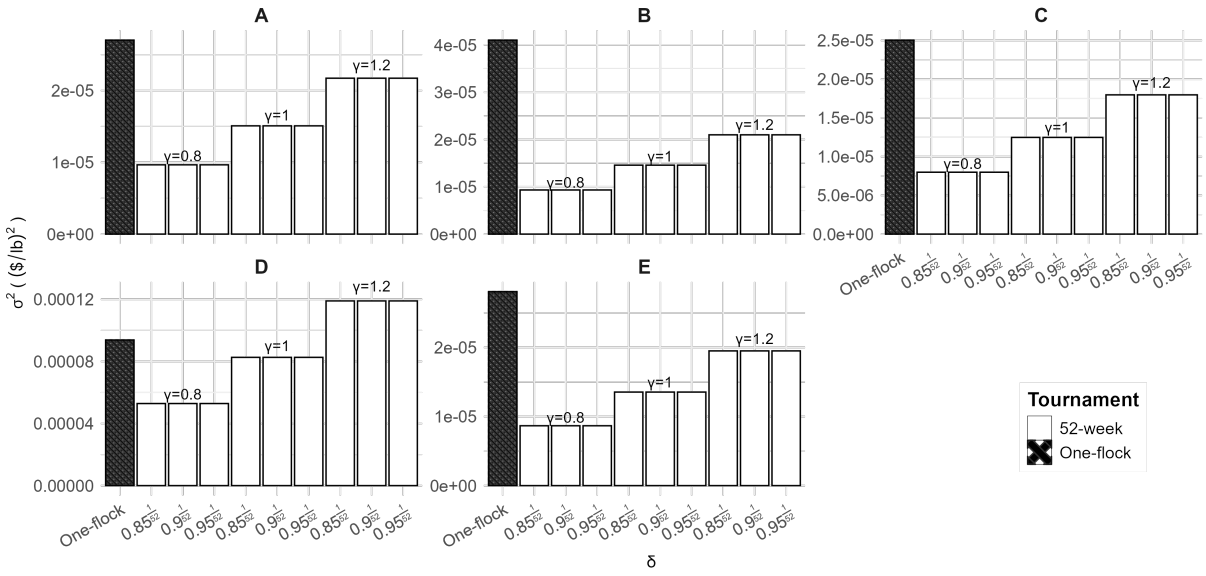


Figure 4: Proportion of growers with lower income variance under the one-flock tournament

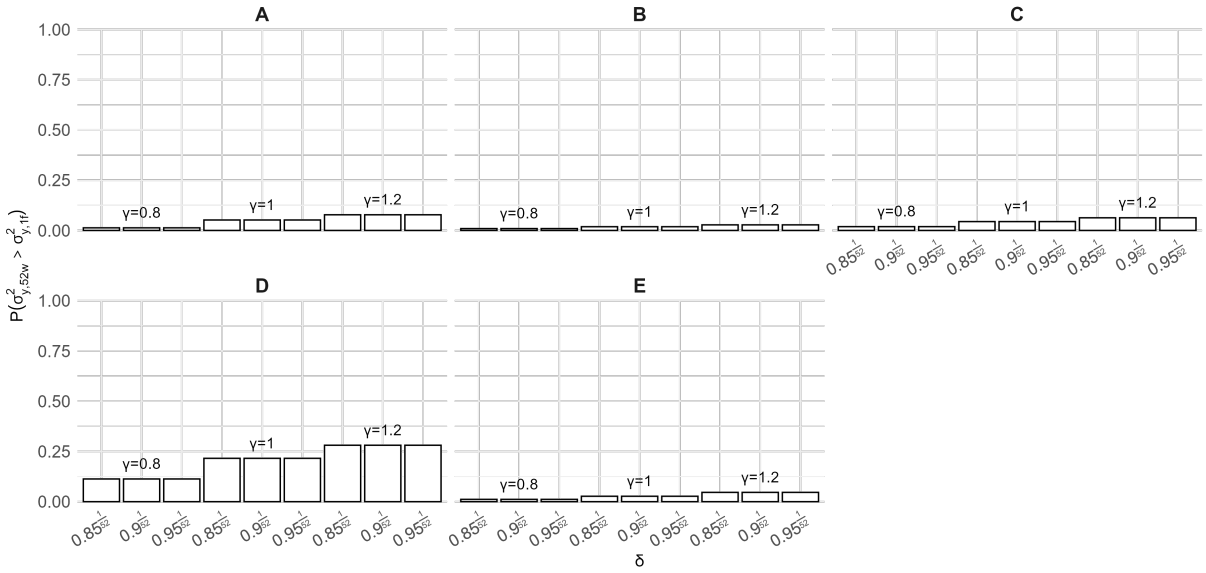
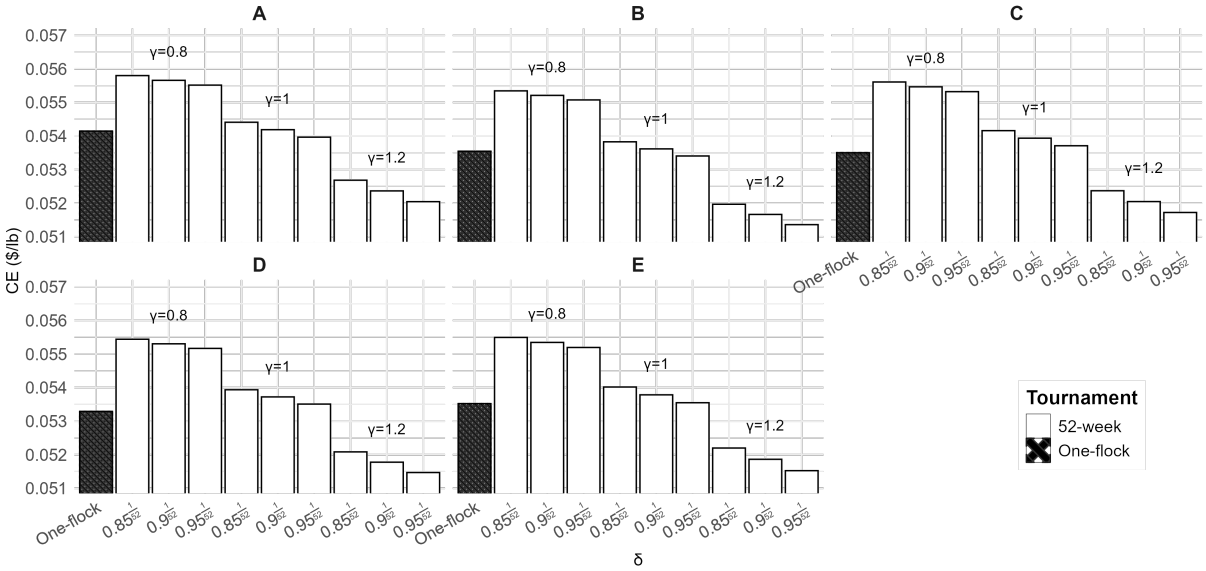
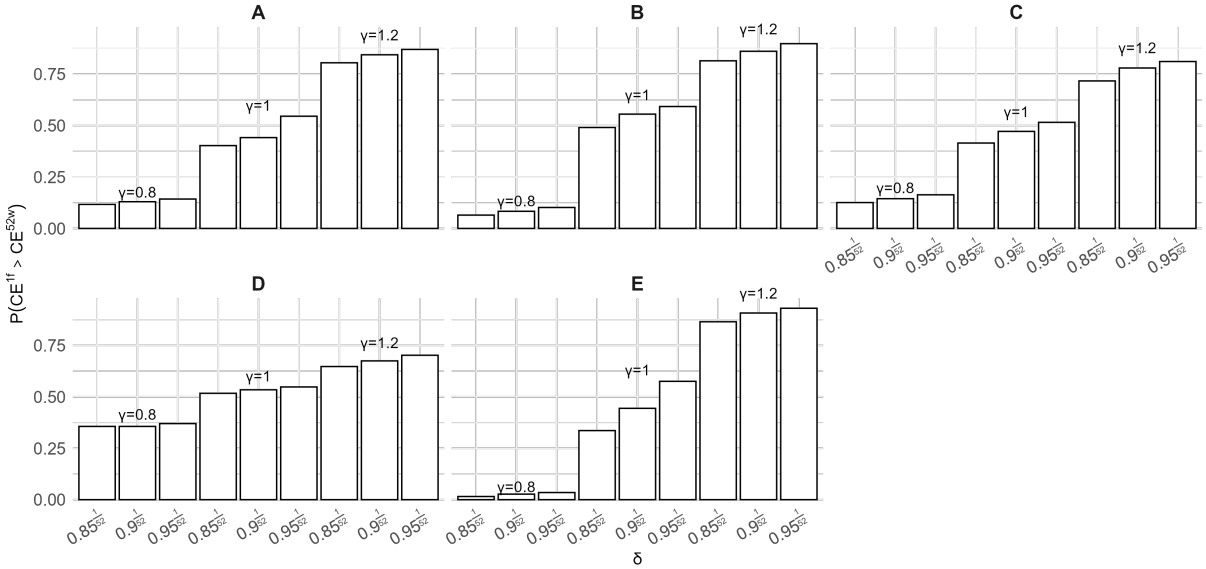


Figure 5: Aggregate mean of growers' certainty equivalent ($/lb)



Note: To better illustrate the differences across scenarios, the vertical axis range has been adjusted in each panel.

Figure 6: Proportion of growers with higher certainty equivalent under the one-flock tournament



discount factor δ has minimal influence on the relationship between ability and CE, we set $\delta = 0.9^{1/52}$ for ease of exposition. The dots are color-coded by the value of γ: blue for 0.8, orange for 1.0, and green for 1.2.

Proposition 1 implies that when $\beta\left(\frac{n-1}{n}\right) < \gamma\left(\frac{N-1}{N}\right)$, as in the cases $\beta = \gamma = 1$ and $\beta = 1, \gamma = 1.2$, there is a negative relationship between ability and the CE difference, producing a downward-sloping trend. In particular, when $\beta = \gamma = 1$, this trend is expected to be substantially weaker in complexes with larger N, since n and N tend to be proportional and both $\frac{n-1}{n}$ and $\frac{N-1}{N}$ converge to 1 as n and N increase.

To see if this proposition is valid in practice, we overlay trend lines for each scenario: a solid blue line for $\gamma = 0.8$, an orange dashed line for $\gamma = 1$, and a green dotted line for $\gamma = 1.2$. Table 4 reports the estimated slope, $\widehat{\beta\left(\frac{n-1}{n}\right) - \gamma\left(\frac{N-1}{N}\right)}$. The results show a positive slope for $\gamma = 0.8$ across all complexes, and a negative slope for $\gamma = 1.2$, which is consistent with theoretical expectations. However, in the case of $\gamma = 1$, the slope is negative in Complexes A, D, and E, but not in B and C. In particular, the slope in Complex B is significantly positive.

These inconsistencies may result from violations of simplifying assumptions in the theoretical model. First, Equation (27) supposes that group assignments are random and equally likely for all growers. If this argument is violated, grower ability a_i may be correlated with group mean ability $\bar{a}_{-i,t}$, which can bias the slope estimate. Second, the equation adopts a simplification by fixing a number of growers per tournament as n. In practice, however, n_t varies over time, so that $\beta\left(\frac{n_t-1}{n_t}\right) \neq \beta\left(\frac{n-1}{n}\right)$, and this variation introduces bias, especially if ability is correlated with n_t.

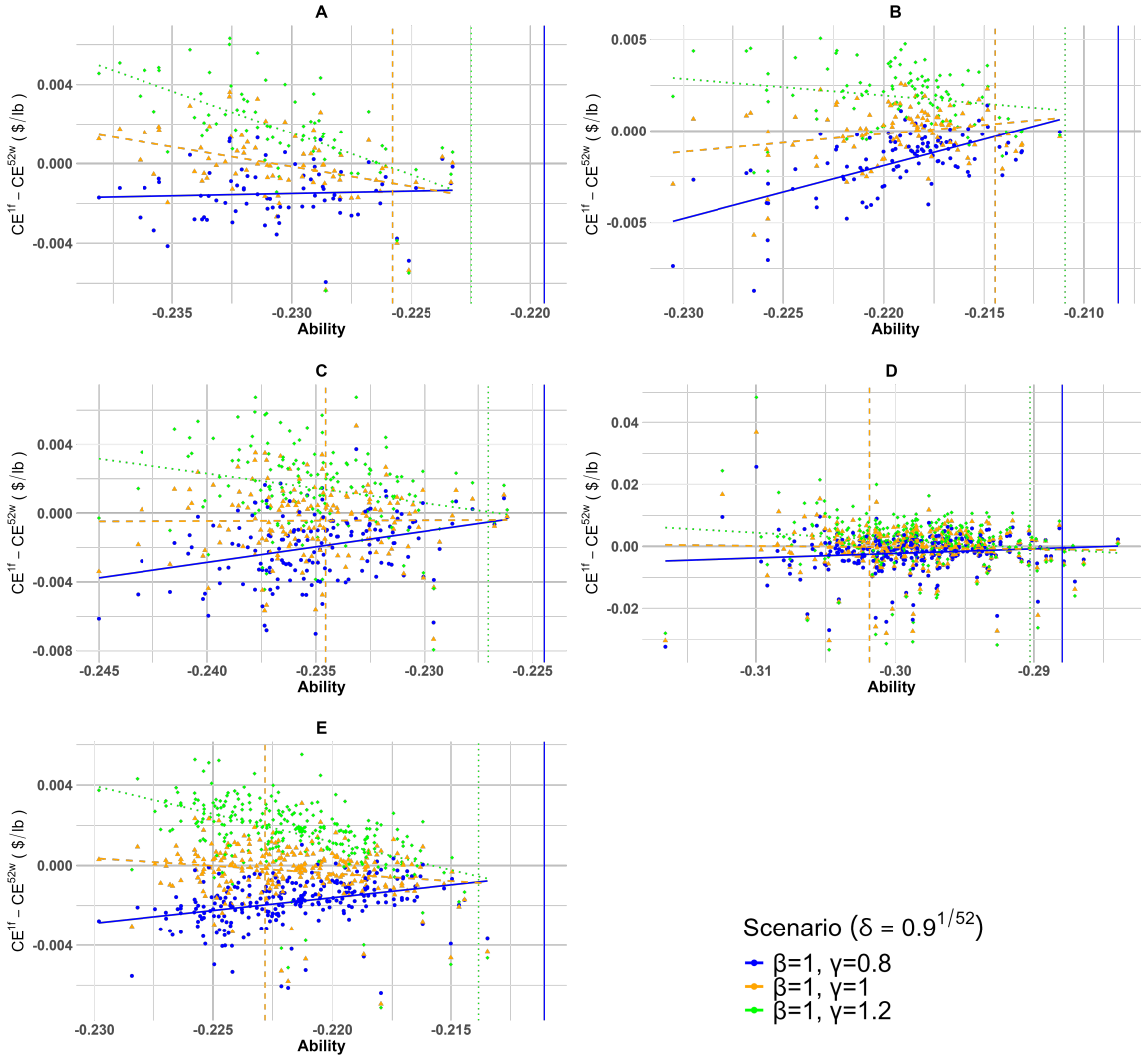
To explore these possibilities, we compute Pearson correlations between grower ability a_i and the individual-level averages of $\bar{a}_{-i,t}$, denoted $\bar{\bar{a}}_{-i}$, and n_t, denoted $\bar{n}_i$, across all tournaments in which grower i participated. Table 5 shows that in Complex E, a_i and $\bar{\bar{a}}_{-i}$ are strongly positively correlated, while in Complex B, a_i and $\bar{n}_i$ are strongly negatively correlated.

These correlations help explain the observed deviations from the theoretical predictions. Although the exact numbers of growers in each complex cannot be disclosed for confidentiality reasons, Complexes C, D, and E have substantially larger N than Complexes A and B. In Complex E, where a_i is strongly positively correlated with $\bar{\bar{a}}_{-i}$, the slope estimate may have been amplified. This is consistent with the fact that in Complexes C and D, where N is also large, the slope estimates for the scenario $\beta = \gamma = 1$ are not statistically significant. In Complex B, where a_i is significantly negatively correlated with $\bar{n}_i$, the slope may have even been reversed. Since such correlations are not commonly observed in typical settings, we interpret the empirical findings as largely consistent with the theoretical predictions.[19]

[19]Some growers suggest that integrators may strategically adjust contract renewal timing to maximize expected profit, potentially creating a correlation between grower ability and either group-average ability or group size. While such behavior may raise concerns about fair contracting practices, it lies beyond the scope of this study. Moreover, Vukina and Zheng (2011) argue that heterogeneous group composition is more beneficial to both integrators and growers than homogeneous grouping in a one-flock tournament. The latter corresponds to a positive correlation between a_i and $\bar{a}_{-i,t}$. Given this, we do not interpret the observed positive correlation as evidence of deliberate group assignment by the integrator.

Each scatterplot also includes a vertical line indicating the theoretical threshold a_T, computed from Equation (28) using scenario-specific parameters, the mode of n_t, and estimates. Table 4 lists the calculated values of a_T and the estimated CE difference at this threshold, $\widehat{CE^{1f}_{i,t} - CE^{52w}_{i,t,52}}|_{a_T}$, based on the trend line. Some of the estimates are statistically significant, which contradicts the theoretical prediction of a zero difference. This inconsistency may arise from a lack of observations near the threshold ability. For example, in the scenario $\beta = 1, \gamma = 0.8$, all complexes except D have insufficient observations around the threshold. If more data were available near this level, the estimated CE difference would likely approach zero, consistent with the theoretical prediction.

Figure 7: Difference in CE vs Ability scatterplot



7 Conclusion

The one-flock tournament contract, which compensates growers based on their performance relative to the group average, has long been prevalent in the broiler industry. Prior research

Table 4: Estimation results on parameters

Scenario	Parameter	Complex				
		A	B	C	D	E
$\beta=1$, $\gamma=0.8$	$\widehat{\beta\left(\frac{n-1}{n}\right)-\gamma\left(\frac{N-1}{N}\right)}$	0.0234 (0.0482)	0.2890*** (0.0358)	0.1810*** (0.0436)	0.1480* (0.0701)	0.1280*** (0.0221)
	a_T	-0.2194	-0.2082	-0.2245	-0.2880	-0.2111
	$\widehat{CE_i^{1f}-CE_{i,52}^{52w}}\|_{a_T}$	-1.26e-03* (5.52e-04)	1.40e-03*** (4.02e-04)	-6.03e-05 (4.81e-04)	-4.79e-04 (8.07e-04)	-4.71e-04 (2.43e-04)
$\beta=1$, $\gamma=1$	$\widehat{\beta\left(\frac{n-1}{n}\right)-\gamma\left(\frac{N-1}{N}\right)}$	-0.1990*** (0.0557)	0.0992** (0.0384)	0.0044 (0.0486)	-0.0515 (0.0848)	-0.0755** (0.0258)
	a_T	-0.2258	-0.2145	-0.2346	-0.3019	-0.2228
	$\widehat{CE_i^{1f}-CE_{i,52}^{52w}}\|_{a_T}$	-9.28e-04** (3.06e-04)	3.02e-04 (1.99e-04)	-4.36e-04** (1.63e-04)	-1.33e-04 (6.45e-04)	2.60e-05 (1.25e-04)
$\beta=1$, $\gamma=1.2$	$\widehat{\beta\left(\frac{n-1}{n}\right)-\gamma\left(\frac{N-1}{N}\right)}$	-0.4220*** (0.0640)	-0.0901* (0.0417)	-0.1720** (0.0544)	-0.2500* (0.0999)	-0.2790*** (0.0299)
	a_T	-0.2225	-0.2109	-0.2270	-0.2903	-0.2138
	$\widehat{CE_i^{1f}-CE_{i,52}^{52w}}\|_{a_T}$	-1.63e-03** (5.56e-04)	1.14e-03** (3.73e-04)	8.57e-05 (4.70e-04)	-5.11e-04 (9.44e-04)	-5.26e-04** (2.51e-04)

*: < 0.05, **: < 0.01, ***: < 0.001

Table 5: Pearson correlation test results

Stat	Complex A	Complex B	Complex C	Complex D	Complex E
$Corr(a_i, \bar{\bar{a}}_{-i})$	-0.0447	0.0329	0.0628	-0.0276	0.1553*
$Corr(a_i, \bar{n}_i))$	0.0702	-0.3037**[a]	-0.0933	-0.0416	0.0747

*: < 0.05, **: < 0.01, ***: < 0.001

generally suggests that such tournament-based contracts mitigate grower income risk compared to simpler piece-rate alternatives, ultimately benefiting growers. However, concerns remain, particularly regarding income volatility, which has drawn increasing attention from regulators. As the debate continues, alternative payment schemes are emerging within the industry, yet these remain relatively understudied.

In this paper, we compare growers' effort decisions and resulting welfare under one-flock and T-week tournaments. We develop analytical models of growers' effort choices and performance under each contract type. Using a theoretical framework and empirical data from broiler contract settlements, we estimate grower efforts, abilities, common shocks, and idiosyncratic shocks. We then conduct a counterfactual analysis to compare outcomes under the two tournament structures.

Our theoretical analysis shows that the comparison between the two tournaments involves a trade-off between two sources of risk: league composition risk and common production risk. The traditional one-flock tournament completely removes common production shocks from grower payments but exposes growers to league composition risk. In contrast, the T-week tournament is subject to common production risk, both because the group average performance

includes periods in which a grower did not participate and because common shocks during participation may receive different weights in the group average than in the individual measure, preventing them from fully canceling out. However, the T-week tournament largely insulates growers from composition risk by averaging over nearly all growers in the complex.

An increase in the incentive parameter raises overall grower effort but reduces their welfare, as measured by CE. It also increases income variance by magnifying the compensation or penalty associated with relative performance. In contrast, a higher discount factor in the T-week tournament induces greater effort and lowers grower welfare, but has no effect on the variance of income.

Our empirical analysis confirms the theoretical prediction that growers' effort, income variance, and welfare respond in line with expectations to changes in the incentive parameter and the discount factor. The counterfactual analysis shows that most growers would experience higher welfare and lower volatility under the 52-week tournament compared to the one-flock tournament. It also reveals that grower effort would remain stable or increase, provided that the incentive parameter under the 52-week tournament is equivalent to or greater than that of the one-flock contract. However, our expectation that the 52-week tournament would be more favorable for high-ability growers when $\beta \leq \gamma$ is not fully supported by the empirical results. This discrepancy arises from the correlation between individual ability and the number of growers per tournament, which is not commonly observed in practice.

Our findings suggest that the T-week tournament offers an alternative to the one-flock tournament, with the potential to reduce income volatility and possibly enhance grower welfare. This has important policy implications, especially in light of ongoing regulatory efforts to promote fairness and transparency in grower contracting. While the findings are informative, further investigation is needed to understand how the new tournament performs in practice.

In particular, the behavior of the integrator warrants further study, given that this paper focuses on the grower's utility maximization. The integrator, who offers a take-it-or-leave-it contract to growers within the complex, sets the contract parameters (base pay and incentive parameter), which are typically uniform across growers. The integrator's profit maximization problem under moral hazard should be formally modeled and solved to determine optimal contract parameters. This would clarify the theoretical relationship between the incentive parameter in the one-flock tournament, which is empirically fixed at one, and the optimal incentive parameter in the T-week tournament.

Appendix A. Three-flock Tournament Contract

Here the performance is measured as a three-flock moving average:

$$y_{i,t}^{3f} = \gamma(\widetilde{x}_{i,t} - \bar{X}_t) - \frac{Kx_{i,t}^2}{2} \tag{32}$$

Here, $y_{i,t}^{3f}$ represents the payoff for grower i at flock t, and $\widetilde{x}_{i,t}$ and $\bar{X}_t$ are performance measures derived from historical data. $\widetilde{x}_{i,t}$ is referred to as the 'individual performance measure' and is calculated as the average of the performance of the current flock (t) and the two most recent performances:

$$\widetilde{x}_{i,t} = \frac{1}{3}\sum_{k=0}^{2} x_{i,t-k} \tag{33}$$

$\bar{X}_t$, termed the 'group performance measure', averages historical performance records of all growers over the current and previous two flocks:

$$\bar{X}_t = \frac{\sum_{j=1}^{N}\sum_{k=0}^{2} x_{j,t-k}}{3N} = \frac{\sum_{j=1}^{N} \tilde{x}_{j,t}}{N} \tag{34}$$

The expression $\sum_{j=1}^{N}\sum_{k=0}^{2} x_{j,t-k}$ aggregates historical performances by all growers over three flock periods, including the current flock, divided by $3N$. Rearranging, as seen on the right side of the equation, provides an alternative interpretation of this group performance measure: it is the average of individual performance measures.

In this case, grower i's effort made in period t will affect his individual performance and group performance in periods $t+1$ and $t+2$ as well. Therefore, assuming that the grower expects the contract to continue indefinitely, his objective function is:

$$\begin{aligned} V_{i,t} &= \max_{\{e_{i,t+k}\}_{k=0}^{\infty}} \sum_{k=0}^{\infty} \delta^k y_{i,t+k}^{3f} \\ &= \max_{\{e_{i,t+k}\}_{k=0}^{\infty}} \sum_{k=0}^{\infty} \delta^k \left[\gamma(\widetilde{x}_{i,t+k} - \bar{X}_{t+k}) - \frac{Ke_{i,t+k}^2}{2} \right] \end{aligned} \tag{35}$$

where δ represents per flock discount factor.

Assuming that the effort decisions of the other players are given, the first-order condition

for $e_{i,t}$ is as follows:

$$\begin{aligned}
\frac{\partial V_{i,t}}{\partial e_{i,t}} &= \frac{\partial y_{i,t}^{3f}}{\partial e_{i,t}} + \delta \frac{\partial y_{i,t+1}^{3f}}{\partial e_{i,t}} + \delta \frac{\partial y_{i,t+2}^{3f}}{\partial e_{i,t}} \\
&= \left(\frac{\partial y_{i,t}^{3f}}{\partial \widetilde{x}_{i,t}} \frac{\partial \widetilde{x}_{i,t}}{\partial e_{i,t}} + \frac{\partial y_{i,t}^{3f}}{\partial \bar{X}_t} \frac{\partial \bar{X}_t}{\partial e_{i,t}} + \frac{\partial y_{i,t}^{3f}}{\partial e_{i,t}} \right) + \delta \left(\frac{\partial y_{i,t+1}^{3f}}{\partial \widetilde{x}_{i,t+1}} \frac{\partial \widetilde{x}_{i,t+1}}{\partial e_{i,t}} + \frac{\partial y_{i,t+1}^{3f}}{\partial \bar{X}_{t+1}} \frac{\partial \bar{X}_{t+1}}{\partial e_{i,t}} \right) \\
&+ \delta^2 \left(\frac{\partial y_{i,t+2}^{3f}}{\partial \widetilde{x}_{i,t+2}} \frac{\partial \widetilde{x}_{i,t+2}}{\partial e_{i,t}} + \frac{\partial y_{i,t+2}^{3f}}{\partial \bar{X}_{t+2}} \frac{\partial \bar{X}_{t+2}}{\partial e_{i,t}} \right) \\
&= \left(\frac{\gamma}{3} - \frac{\gamma}{3N} - K e_{i,t} \right) + \delta \left(\frac{\gamma}{3} - \frac{\gamma}{3N} \right) + \delta^2 \left(\frac{\gamma}{3} - \frac{\gamma}{3N} \right) \\
&= -K e_{i,t} + \frac{\gamma}{3} \left(\frac{N-1}{N} \right) (1 + \delta + \delta^2) = 0 \\
&\Leftrightarrow e_{i,t}^{SP} = \frac{\gamma}{K} \left(\frac{N-1}{N} \right) \left(\frac{1+\delta+\delta^2}{3} \right)
\end{aligned} \tag{36}$$

The first-order condition with respect to $e_{i,t+1}$ is as follows:

$$\begin{aligned}
\frac{\partial V_{i,t}}{\partial e_{i,t+1}} &= \delta \frac{\partial y_{i,t+1}^{3f}}{\partial e_{i,t+1}} + \delta^2 \frac{\partial y_{i,t+2}^{3f}}{\partial e_{i,t+1}} + \delta^2 \frac{\partial y_{i,t+3}^{3f}}{\partial e_{i,t+1}} \\
&= -K \delta e_{i,t+1} + \frac{\gamma}{3} \left(\frac{N-1}{N} \right) (\delta + \delta^2 + \delta^3) = 0 \\
&\Leftrightarrow e_{i,t+1}^{SP} = \frac{\gamma}{K} \left(\frac{N-1}{N} \right) \left(\frac{1+\delta+\delta^2}{3} \right)
\end{aligned} \tag{37}$$

We can observe that $e_{i,t}^{SP}$ in equation (36) and $e_{i,t+1}^{SP}$ in equation (37) are the same, and this holds for other periods as well. Additionally, we note that there are no individual-specific variables in those equations. Therefore, we can conclude that e^{SP} is:

$$e^{SP} = \frac{\gamma}{K} \left(\frac{N-1}{N} \right) \left(\frac{1+\delta+\delta^2}{3} \right) \tag{38}$$

Appendix B. Derivations

Appendix B.1. Derivation for $y_{i,t}^{Tw}$

By substituting Equation (1) into $\tilde{x}_{i,t}$ and $\bar{X}_t$, the relative performance term $\tilde{x}_{i,t} - \bar{X}_t$ in Equation (10) can be expressed as follows:

$$
\begin{aligned}
&\tilde{x}_{i,t} - \bar{X}_t \\
=&\frac{\sum_{k=0}^{T-1} \mathbb{D}_{i,t-k} x_{i,t-k}}{m_{i,t}} - \frac{\sum_{j=1}^{N}\sum_{k=0}^{T-1} \mathbb{D}_{j,t-k} x_{j,t-k}}{\sum_{j=1}^{N} m_{j,t}} \\
=&\frac{\sum_{k=0}^{T-1} \mathbb{D}_{i,t-k}(e_{i,t-k} + a_i + u_{t-k} + w_{i,t-k})}{m_{i,t}} - \frac{\sum_{j=1}^{N}\sum_{k=0}^{T-1} \mathbb{D}_{j,t-k}(e_{j,t-k} + a_j + u_{t-k} + w_{j,t-k})}{\sum_{j=1}^{N} m_{j,t}} \\
=&\frac{\sum_{k=0}^{T-1} \mathbb{D}_{j,t-k} e_{i,t-k}}{m_{i,t}} - \frac{\sum_{j=1}^{N}\sum_{k=0}^{T-1} \mathbb{D}_{j,t-k} e_{i,t-k}}{\sum_{j=1}^{N} m_{j,t}} + \left(a_i - \frac{\sum_{j=1}^{N} m_{j,t} a_j}{\sum_{j=1}^{N} m_{j,t}}\right) + \frac{\sum_{k=0}^{T-1} \mathbb{D}_{i,t-k} u_{t-k}}{m_{i,t}} \\
&- \frac{\sum_{j=1}^{N}\sum_{k=0}^{T-1} \mathbb{D}_{j,t-k} u_{t-k}}{\sum_{j=1}^{N} m_{j,t}} + \frac{\sum_{k=1}^{T-1} \mathbb{D}_{i,t-k} w_{i,t-k}}{m_{i,t}} - \frac{\sum_{j=1}^{N}\sum_{k=0}^{T-1} \mathbb{D}_{j,t-k} w_{j,t-k}}{\sum_{j=1}^{N} m_{j,t}}
\end{aligned} \tag{B.1}
$$

The terms $\frac{\sum_{j=1}^{N}\sum_{k=0}^{T-1} \mathbb{D}_{j,t-k} u_{t-k}}{\sum_{j=1}^{N} m_{j,t}}$ and $\frac{\sum_{j=1}^{N}\sum_{k=0}^{T-1} \mathbb{D}_{j,t-k} w_{j,t-k}}{\sum_{j=1}^{N} m_{j,t}}$ can be separated into two cases, depending on whether week $t-k$ is the week when grower i settled his flock. The τ sets defined in (15) are used to distinguish these cases. Continuing from (B.1),

$$
\begin{aligned}
=&\frac{\sum_{k\in\tau_{i,t}} e_{i,k}}{m_{i,t}} - \frac{\sum_{j=1}^{N}\sum_{k\in\tau_t} \mathbb{D}_{j,k} e_{j,k}}{\sum_{j=1}^{N} m_{j,t}} + \left(a_i - \frac{\sum_{j=1}^{N} m_{j,t} a_j}{\sum_{j=1}^{N} m_{j,t}}\right) + \frac{\sum_{k\in\tau_{i,t}} u_k}{m_{i,t}} - \frac{\sum_{j=1}^{N}\sum_{k\in\tau_{i,t}} \mathbb{D}_{j,k} u_k}{\sum_{j=1}^{N} m_{j,t}} \\
&- \frac{\sum_{j=1}^{N}\sum_{k\in\tau_{i,t}^c} \mathbb{D}_{j,k} u_k}{\sum_{j=1}^{N} m_{j,t}} + \frac{\sum_{k\in\tau_{i,t}} w_{i,k}}{m_{i,t}} - \frac{\sum_{j=1}^{N}\sum_{k\in\tau_t} \mathbb{D}_{j,k} w_{j,k}}{\sum_{j=1}^{N} m_{j,t}} \\
=&\left(\frac{1}{m_{i,t}} - \frac{1}{\sum_{j=1}^{N} m_{j,t}}\right)\sum_{k\in\tau_{i,t}} e_{i,k} - \frac{\sum_{j=1,j\neq i}^{N}\sum_{k\in\tau_t} \mathbb{D}_{j,k} e_{j,k}}{\sum_{j=1}^{N} m_{j,t}} + \left(a_i - \frac{\sum_{j=1}^{N} m_{j,t} a_j}{\sum_{j=1}^{N} m_{j,t}}\right) + \left(\frac{\sum_{k\in\tau_{i,t}} u_k}{m_{i,t}}\right. \\
&\left. - \frac{\sum_{k\in\tau_{i,t}} n_k u_k}{\sum_{j=1}^{N} m_{j,t}}\right) - \frac{\sum_{k\in\tau_{i,t}^c} n_k u_k}{\sum_{j=1}^{N} m_{j,t}} + \left(\frac{1}{m_{i,t}} - \frac{1}{\sum_{j=1}^{N} m_{j,t}}\right)\sum_{k\in\tau_{i,t}} w_{i,k} - \frac{\sum_{j=1,j\neq i}^{N}\sum_{k\in\tau_t} \mathbb{D}_{j,k} w_{j,k}}{\sum_{j=1}^{N} m_{j,t}} \\
=&\left(\frac{1}{m_{i,t}} - \frac{1}{\sum_{j=1}^{N} m_{j,t}}\right)\sum_{k\in\tau_{i,t}} e_{i,k} - \frac{\sum_{j=1,j\neq i}^{N}\sum_{k\in\tau_t} \mathbb{D}_{j,k} e_{j,k}}{\sum_{j=1}^{N} m_{j,t}} + \left(a_i - \frac{\sum_{j=1}^{N} m_{j,t} a_j}{\sum_{j=1}^{N} m_{j,t}}\right) + \left(\frac{1}{m_{i,t}}\right. \\
&\left. - \frac{n_t}{\sum_{j=1}^{N} m_{j,t}}\right) u_t + \left(\frac{1}{m_{i,t}} - \frac{1}{\sum_{j=1}^{N} m_{j,t}}\right) w_{i,t} - \frac{\sum_{j=1,j\neq i}^{N} \mathbb{D}_{j,t} w_{j,t}}{\sum_{j=1}^{N} m_{j,t}} + \phi_{i,t}
\end{aligned} \tag{B.2}
$$

where

$$\phi_{i,t} = \left(\frac{\sum_{k \in \tau_{i,t,-t}} u_k}{m_{i,t}} - \frac{\sum_{k \in \tau_{i,t,-t}} n_k u_k}{\sum_{j=1}^{N} m_{j,t}} \right) - \frac{\sum_{k \in \tau_{i,t}^{c}} n_k u_k}{\sum_{j=1}^{N} m_{j,t}} + \left(\frac{1}{m_{i,t}} - \frac{1}{\sum_{j=1}^{N} m_{j,t}} \right) \sum_{k \in \tau_{i,t,-t}} w_{i,k} - \frac{\sum_{j=1, j \neq i}^{N} \sum_{k \in \tau_{t,-t}} \mathbb{D}_{j,k} w_{j,k}}{\sum_{j=1}^{N} m_{j,t}} \tag{B.3}$$

By substituting Equation (B.2) into Equation (10), we obtain Equation (13).

Appendix B.2. Derivation for e^{Tw}

We show that the optimal effort under the T-week tournament is constant across growers and time periods under Assumptions 1–4. Let $z_{i,t}^{Tw} = y_{i,t}^{Tw} - c(e_{i,t})$. Taking the first-order condition of Equation (19) with respect to $e_{i,t}$ yields:

$$\begin{aligned}
\frac{dV(\cdot)}{de_{i,t}} &= \mathbb{E}_t \left[\frac{\partial U(z_{i,t}^{Tw})}{\partial e_{i,t}} + \left(\frac{1}{1+\rho} \right)^{l} \frac{\partial U(z_{i,t+l}^{Tw})}{\partial e_{i,t}} + \ldots + \left(\frac{1}{1+\rho} \right)^{(m-1)l} \frac{\partial U(z_{i,t+(m-1)l}^{Tw})}{\partial e_{i,t}} \right] \\
&= \mathbb{E}_t \left[\gamma \left(\frac{N-1}{Nm} \right) \sum_{s=0}^{m-1} \left(\frac{1}{1+\rho} \right)^{sl} U'(z_{i,t+sl}^{Tw}) - U'(z_{i,t}^{Tw}) K e_{i,t} \right] = 0 \\
&\Leftrightarrow \mathbb{E}_t \left[U'(z_{i,t}^{Tw}) \right] K e_{i,t} = \gamma \left(\frac{N-1}{Nm} \right) \sum_{s=0}^{m-1} \left(\frac{1}{1+\rho} \right)^{sl} \mathbb{E}_t [U'(z_{i,t+sl}^{Tw})] \\
&\Leftrightarrow e_{i,t} = \frac{\gamma}{K} \left(\frac{N-1}{Nm} \right) \sum_{s=0}^{m-1} \left(\frac{1}{1+\rho} \right)^{sl} \frac{\mathbb{E}_t [U'(z_{i,t+sl}^{Tw})]}{\mathbb{E}_t [U'(z_{i,t}^{Tw})]} \\
&\Leftrightarrow e^{Tw} = \frac{\gamma}{K} \left(\frac{N-1}{N} \right) \left(\sum_{s=0}^{m-1} \frac{\delta^{sl}}{m} \right)
\end{aligned} \tag{B.4}$$

where $\delta^{sl} = \left(\frac{1}{1+\rho} \right)^{sl} \frac{\mathbb{E}_t [U'(z_{i,t+sl}^{Tw})]}{\mathbb{E}_t [U'(z_{i,t}^{Tw})]}$.

The value of δ is constant in s if the ratio $\frac{\mathbb{E}_t [U'(z_{i,t+sl}^{Tw})]}{\mathbb{E}_t [U'(z_{i,t}^{Tw})]}$ is exponential in s. For example, under CARA utility:

$$U(z) = -\exp(-rz), \quad U'(z) = r\exp(-rz)$$

so that for $z \sim \mathcal{N}(\mu, \sigma^2)$,

$$\mathbb{E}\left[U'(z) \right] = r\mathbb{E}\left[\exp(-rz) \right] = r\exp\left(-r\mu + \frac{r^2\sigma^2}{2} \right) \tag{B.5}$$

Applying Equation (B.5) to the ratio gives:

$$\begin{aligned}\frac{\mathbb{E}_t[U'(z^{Tw}_{i,t+sl})]}{\mathbb{E}_t[U'(z^{Tw}_{i,t})]} &= \frac{r\exp\left(-r\mathbb{E}_t[z^{Tw}_{i,t+sl}] + \frac{r^2\sigma^2_{y,Tw,sl}}{2}\right)}{r\exp\left(-r\mathbb{E}_t[z^{Tw}_{i,t}] + \frac{r^2\sigma^2_{y,Tw,0}}{2}\right)} \\ &= \exp\left(-r\left[\mathbb{E}_t[z^{Tw}_{i,t+sl}] - \mathbb{E}_t[z^{Tw}_{i,t}]\right] + \frac{r^2}{2}(\sigma^2_{y,Tw,sl} - \sigma^2_{y,Tw,0})\right)\end{aligned}$$

Here, $\mathbb{E}_t[z^{Tw}_{i,t+sl}]$ and $\mathbb{E}_t[z^{Tw}_{i,t}]$ differ only in their shock histories: $\Phi_{i,t+sl}$ vs. $\Phi_{i,t}$. While $\Phi_{i,t+sl}$ shares some shocks with $\Phi_{i,t}$, it also contains shocks occurring after t. Since these shocks are i.i.d. with zero mean, the difference in expectations is negligible. Thus:

$$\begin{aligned}&\approx \exp\left(\frac{r^2}{2}(\sigma^2_{y,Tw,sl} - \sigma^2_{y,Tw,0})\right) \\ &= \exp\left(\frac{r^2}{2}\sigma^2_{\Phi,sl}\right)\end{aligned}$$

where:

$$\sigma^2_{\Phi,sl} = \left(\frac{\gamma}{Nm}\right)^2\left[\left(sN + 2\sum_{k=0}^{s-1} n_{t+kl} + \sum_{k=1}^{t+sl-1} n_k^2\right)\sigma_u^2 + \left((N-1)^2 + \sum_{k=1}^{t+sl-1} n_k - s\right)\sigma_w^2\right]$$

Assuming $n_k = n$ for all $k \geq t$, we have:

$$\sigma^2_{\Phi,sl} = s\left(\frac{\gamma}{Nm}\right)^2\left[(N - 2n + ln^2)\sigma_u^2 + (N^2 - 2N + ln)\sigma_w^2\right]$$

so that:

$$\frac{\mathbb{E}_t[U'(z^{Tw}_{i,t+sl})]}{\mathbb{E}_t[U'(z^{Tw}_{i,t})]} \approx \exp(sA) \tag{B.6}$$

where:

$$A = \frac{r^2}{2}\left(\frac{\gamma}{Nm}\right)^2\left[(N - 2n + ln^2)\sigma_u^2 + (N^2 - 2N + ln)\sigma_w^2\right]$$

Thus:

$$\delta \approx \left(\frac{1}{1+\rho}\right)\exp\left(\frac{A}{l}\right)$$

Appendix C. Summary of Counterfactual Analysis Results

Table 6: Aggregate comparison of one-flock and 52-week tournaments

Complex	Scenario			$\bar{e}^{a}$	σ_y^{2b}	$\bar{CE}^{c}$
A	One-flock			8.94e-03	2.70e-05	5.41e-02
	52-week	$\gamma = 0.8$	$\delta = 0.85^{(\frac{1}{52})}$	7.33e-03	9.65e-06	5.58e-02
			$\delta = 0.90^{(\frac{1}{52})}$	7.53e-03	9.65e-06	5.57e-02
			$\delta = 0.95^{(\frac{1}{52})}$	7.71e-03	9.65e-06	5.55e-02
		$\gamma = 1.0$	$\delta = 0.85^{(\frac{1}{52})}$	9.17e-03	1.51e-05	5.44e-02
			$\delta = 0.90^{(\frac{1}{52})}$	9.41e-03	1.51e-05	5.42e-02
			$\delta = 0.95^{(\frac{1}{52})}$	9.64e-03	1.51e-05	5.40e-02
		$\gamma = 1.2$	$\delta = 0.85^{(\frac{1}{52})}$	1.10e-02	2.17e-05	5.27e-02
			$\delta = 0.90^{(\frac{1}{52})}$	1.13e-02	2.17e-05	5.24e-02
			$\delta = 0.95^{(\frac{1}{52})}$	1.16e-02	2.17e-05	5.20e-02
B	One-flock			8.99e-03	4.10e-05	5.35e-02
	52-week	$\gamma = 0.8$	$\delta = 0.85^{(\frac{1}{52})}$	7.40e-03	9.33e-06	5.53e-02
			$\delta = 0.90^{(\frac{1}{52})}$	7.58e-03	9.33e-06	5.52e-02
			$\delta = 0.95^{(\frac{1}{52})}$	7.75e-03	9.33e-06	5.51e-02
		$\gamma = 1.0$	$\delta = 0.85^{(\frac{1}{52})}$	9.25e-03	1.46e-05	5.38e-02
			$\delta = 0.90^{(\frac{1}{52})}$	9.47e-03	1.46e-05	5.36e-02
			$\delta = 0.95^{(\frac{1}{52})}$	9.69e-03	1.46e-05	5.34e-02
		$\gamma = 1.2$	$\delta = 0.85^{(\frac{1}{52})}$	1.11e-02	2.10e-05	5.20e-02
			$\delta = 0.90^{(\frac{1}{52})}$	1.14e-02	2.10e-05	5.17e-02
			$\delta = 0.95^{(\frac{1}{52})}$	1.16e-02	2.10e-05	5.14e-02
C	One-flock			9.39e-03	2.50e-05	5.35e-02
	52-week	$\gamma = 0.8$	$\delta = 0.85^{(\frac{1}{52})}$	7.38e-03	7.99e-06	5.56e-02
			$\delta = 0.90^{(\frac{1}{52})}$	7.58e-03	7.99e-06	5.55e-02
			$\delta = 0.95^{(\frac{1}{52})}$	7.76e-03	7.99e-06	5.53e-02
		$\gamma = 1.0$	$\delta = 0.85^{(\frac{1}{52})}$	9.23e-03	1.25e-05	5.42e-02
			$\delta = 0.90^{(\frac{1}{52})}$	9.47e-03	1.25e-05	5.39e-02
			$\delta = 0.95^{(\frac{1}{52})}$	9.71e-03	1.25e-05	5.37e-02
		$\gamma = 1.2$	$\delta = 0.85^{(\frac{1}{52})}$	1.11e-02	1.80e-05	5.24e-02
			$\delta = 0.90^{(\frac{1}{52})}$	1.14e-02	1.80e-05	5.20e-02
			$\delta = 0.95^{(\frac{1}{52})}$	1.16e-02	1.80e-05	5.17e-02
	One-flock			9.66e-03	9.38e-05	5.33e-02
		$\gamma = 0.8$	$\delta = 0.85^{(\frac{1}{52})}$	7.44e-03	5.29e-05	5.54e-02
			$\delta = 0.90^{(\frac{1}{52})}$	7.62e-03	5.29e-05	5.53e-02

Continued on next page

Table 6 (continued)

Complex		Scenario		$\bar{e}$[a]	σ_y^{2}[b]	$\bar{CE}$[c]
D	52-week		$\delta = 0.95^{(\frac{1}{52})}$	7.80e-03	5.29e-05	5.52e-02
		$\gamma = 1.0$	$\delta = 0.85^{(\frac{1}{52})}$	9.30e-03	8.26e-05	5.39e-02
			$\delta = 0.90^{(\frac{1}{52})}$	9.53e-03	8.26e-05	5.37e-02
			$\delta = 0.95^{(\frac{1}{52})}$	9.75e-03	8.26e-05	5.35e-02
		$\gamma = 1.2$	$\delta = 0.85^{(\frac{1}{52})}$	1.12e-02	1.19e-04	5.21e-02
			$\delta = 0.90^{(\frac{1}{52})}$	1.14e-02	1.19e-04	5.18e-02
			$\delta = 0.95^{(\frac{1}{52})}$	1.17e-02	1.19e-04	5.15e-02
E		One-flock		9.49e-03	2.81e-05	5.35e-02
	52-week	$\gamma = 0.8$	$\delta = 0.85^{(\frac{1}{52})}$	7.38e-03	8.67e-06	5.55e-02
			$\delta = 0.90^{(\frac{1}{52})}$	7.58e-03	8.67e-06	5.53e-02
			$\delta = 0.95^{(\frac{1}{52})}$	7.78e-03	8.67e-06	5.52e-02
		$\gamma = 1.0$	$\delta = 0.85^{(\frac{1}{52})}$	9.23e-03	1.35e-05	5.40e-02
			$\delta = 0.90^{(\frac{1}{52})}$	9.48e-03	1.35e-05	5.38e-02
			$\delta = 0.95^{(\frac{1}{52})}$	9.72e-03	1.35e-05	5.35e-02
		$\gamma = 1.2$	$\delta = 0.85^{(\frac{1}{52})}$	1.11e-02	1.95e-05	5.22e-02
			$\delta = 0.90^{(\frac{1}{52})}$	1.14e-02	1.95e-05	5.19e-02
			$\delta = 0.95^{(\frac{1}{52})}$	1.17e-02	1.95e-05	5.15e-02

$\bar{e}$: Mean effort

σ_y^2: Variance of grower income

$\bar{CE}$: Mean certainty equivalent

Table 7: Individual comparison of one-Flock and 52-Week tournaments

Complex	Scenario		$P(\sigma^2_{y,Tw,52} > \sigma^2_{y,1f})$	$P(CE_i^{1f} > CE_{i,52}^{52w})$
A	$\beta = 1,$ $\gamma = 0.8$	$\delta = 0.85^{(\frac{1}{52})}$	0.0130	0.1169
		$\delta = 0.90^{(\frac{1}{52})}$	0.0130	0.1299
		$\delta = 0.95^{(\frac{1}{52})}$	0.0130	0.1429
	$\beta = 1,$ $\gamma = 1.0$	$\delta = 0.85^{(\frac{1}{52})}$	0.0519	0.4026
		$\delta = 0.90^{(\frac{1}{52})}$	0.0519	0.4416
		$\delta = 0.95^{(\frac{1}{52})}$	0.0519	0.5455
	$\beta = 1,$ $\gamma = 1.2$	$\delta = 0.85^{(\frac{1}{52})}$	0.0779	0.8052
		$\delta = 0.90^{(\frac{1}{52})}$	0.0779	0.8442
		$\delta = 0.95^{(\frac{1}{52})}$	0.0779	0.8701
B	$\beta = 1,$ $\gamma = 0.8$	$\delta = 0.85^{(\frac{1}{52})}$	0.0093	0.0648
		$\delta = 0.90^{(\frac{1}{52})}$	0.0093	0.0833
		$\delta = 0.95^{(\frac{1}{52})}$	0.0093	0.1019
	$\beta = 1,$ $\gamma = 1.0$	$\delta = 0.85^{(\frac{1}{52})}$	0.0185	0.4907
		$\delta = 0.90^{(\frac{1}{52})}$	0.0185	0.5556
		$\delta = 0.95^{(\frac{1}{52})}$	0.0185	0.5926
	$\beta = 1,$ $\gamma = 1.2$	$\delta = 0.85^{(\frac{1}{52})}$	0.0278	0.8148
		$\delta = 0.90^{(\frac{1}{52})}$	0.0278	0.8611
		$\delta = 0.95^{(\frac{1}{52})}$	0.0278	0.8981
C	$\beta = 1,$ $\gamma = 0.8$	$\delta = 0.85^{(\frac{1}{52})}$	0.0189	0.1258
		$\delta = 0.90^{(\frac{1}{52})}$	0.0189	0.1447
		$\delta = 0.95^{(\frac{1}{52})}$	0.0189	0.1635
	$\beta = 1,$ $\gamma = 1.0$	$\delta = 0.85^{(\frac{1}{52})}$	0.0440	0.4151
		$\delta = 0.90^{(\frac{1}{52})}$	0.0440	0.4717
		$\delta = 0.95^{(\frac{1}{52})}$	0.0440	0.5157
	$\beta = 1,$ $\gamma = 1.2$	$\delta = 0.85^{(\frac{1}{52})}$	0.0629	0.7170
		$\delta = 0.90^{(\frac{1}{52})}$	0.0629	0.7799
		$\delta = 0.95^{(\frac{1}{52})}$	0.0629	0.8113
D	$\beta = 1,$ $\gamma = 0.8$	$\delta = 0.85^{(\frac{1}{52})}$	0.1130	0.3562
		$\delta = 0.90^{(\frac{1}{52})}$	0.1130	0.3562
		$\delta = 0.95^{(\frac{1}{52})}$	0.1130	0.3699
	$\beta = 1,$ $\gamma = 1.0$	$\delta = 0.85^{(\frac{1}{52})}$	0.2158	0.5171
		$\delta = 0.90^{(\frac{1}{52})}$	0.2158	0.5342
		$\delta = 0.95^{(\frac{1}{52})}$	0.2158	0.5479
	$\beta = 1,$ $\gamma = 1.2$	$\delta = 0.85^{(\frac{1}{52})}$	0.2808	0.6473
		$\delta = 0.90^{(\frac{1}{52})}$	0.2808	0.6747

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Table 7 (continued)

Complex	Scenario		$P(\sigma^2_{y,Tw,52} > \sigma^2_{y,1f})$	$P(CE_i^{1f} > CE_{i,52}^{52w})$
		$\delta = 0.95^{(\frac{1}{52})}$	0.2808	0.7021
E	$\beta = 1$, $\gamma = 0.8$	$\delta = 0.85^{(\frac{1}{52})}$	0.0116	0.0154
		$\delta = 0.90^{(\frac{1}{52})}$	0.0116	0.0270
		$\delta = 0.95^{(\frac{1}{52})}$	0.0116	0.0347
	$\beta = 1$, $\gamma = 1.0$	$\delta = 0.85^{(\frac{1}{52})}$	0.0270	0.3359
		$\delta = 0.90^{(\frac{1}{52})}$	0.0270	0.4440
		$\delta = 0.95^{(\frac{1}{52})}$	0.0270	0.5753
	$\beta = 1$, $\gamma = 1.2$	$\delta = 0.85^{(\frac{1}{52})}$	0.0463	0.8649
		$\delta = 0.90^{(\frac{1}{52})}$	0.0463	0.9073
		$\delta = 0.95^{(\frac{1}{52})}$	0.0463	0.9305

$P(\sigma^2_{y,Tw,52} > \sigma^2_{y,1f})$: Share of growers whose income is less volatile under the one-flock tournament compared to the 52-week tournament.
$P(CE_i^{1f} > CE_{i,52}^{52w})$: Share of growers whose certainty equivalent is higher under the one-flock tournament compared to the 52-week tournament.

References

Agranov, M. and Tergiman, C. (2013). Incentives and compensation schemes: An experimental study. *International Journal of Industrial Organization*, 31(3):238–247. Tournaments, Contests and Relative Performance Evaluation.

Bull, C., Schotter, A., and Weigelt, K. (1987). Tournaments and piece rates: An experimental study. *Journal of Political Economy*, 95(1):1–33.

Hegde, S. A. and Vukina, T. (2003). Risk sharing in broiler contracts: a welfare comparison of payment mechanisms.

Knoeber, C. R. (1989). A real game of chicken: contracts, tournaments, and the production of broilers. *The Journal of Law, Economics, and Organization*, 5(2):271–292.

Knoeber, C. R. and Thurman, W. N. (1994). Testing the theory of tournaments: An empirical analysis of broiler production. *Journal of labor economics*, 12(2):155–179.

Laffont, J.-J. and Martimort, D. (2002). *The theory of incentives: the principal-agent model*. Princeton university press.

Lazear, E. P. and Rosen, S. (1981). Rank-order tournaments as optimum labor contracts. *Journal of political Economy*, 89(5):841–864.

Levy, A. and Vukina, T. (2004). The league composition effect in tournaments with heterogeneous players: An empirical analysis of broiler contracts. *Journal of labor economics*, 22(2):353–377.

Marinakis, K. and Tsoulouhas, T. (2012). A comparison of cardinal tournaments and piece rate contracts with liquidity constrained agents. *Journal of Economics*, 105:161–190.

McLaughlin, K. J. et al. (1988). Aspects of tournament models: A survey. *Research in labor economics*, 9(1):225–256.

Stiglitz, J. E. (1987). The causes and consequences of the dependence of quality on price. *Journal of Economic Literature*, 25(1):1–48.

Tsoulouhas, T. (2010). Hybrid cardinal tournaments. *Economics Bulletin, Forthcoming*.

USDA (2022). Poultry growing tournament systems: Fairness and related concerns. Last accessed 26 March 2024.

Vukina, T. and Zheng, X. (2011). Homogenous and heterogenous contestants in piece rate tournaments: Theory and empirical analysis. *Journal of Business & Economic Statistics*, 29(4):506–517.

Wang, Z. and Vukina, T. (2017). Welfare effects of payment truncation in piece rate tournaments. *Journal of Economics*, 120(3):219–249.

Wu, S. and Roe, B. (2006). Tournaments, fairness, and risk. *American Journal of Agricultural Economics*, 88(3):561–573.

Zheng, X. and Vukina, T. (2007). Efficiency gains from organizational innovation: Comparing ordinal and cardinal tournament games in broiler contracts. *International Journal of Industrial Organization*, 25(4):843–859.