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Risk Sharing in Broiler Contracts: A Welfare Comparison of Payment Mechanisms

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Risk Sharing in Broiler Contracts: A Welfare Comparison of Payment Mechanisms [†]

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Abstract

Previous research has found that a significant part of risk from poultry grow-out farm operations is due to market price of broilers. This risk is transferred to the integrator when the grower enters a production contract with the integrator. This follows from the absence of a market price variable in determining compensation in such contracts. In more recent contracts a market price clause is included in calculating compensation. We conduct welfare comparison of the old and new contracts and find that while including the market price clause increases the variability of grower income, it also raises grower expected return. Overall, under assumptions of fixed flock size and constant percentage mortality, which enables payment per-pound comparison, new contracts are welfare superior relative to the old contracts. However, when analysis is conducted on a total per-flock payment rather than on a per-pound payment, we find that welfare superiority of new contracts depends on the grower attitude toward risk. It turns out that with higher measures of risk aversion, growers prefer the old contracts relative to the new contracts, while those with lower measures of risk aversion prefer the new contracts.

1 Introduction

Risk is uncertainty that affects an individual's welfare and is often associated with adversity and loss (Bodie and Merton [3]). Managing risk involves choosing among alternatives to reduce the effects of risk thereby increasing welfare. One measure of risk inherent in an activity is the variance of expected returns from said activity. A risk averse individual such as a farmer, chooses an alternative which maximizes the expected utility of income. In a special case expected utility maximization can be approximated by the mean-variance model (Levy and Markowitz [9]). Under this framework the farmer is willing to accept a higher variance (i.e. more risk) in his income provided that he is compensated by higher expected returns.

There are many risk management strategies available to farmers such as enterprise diversification, futures and forward contracts, insurance and production and marketing contracts. Which strategy is chosen, in large part, depends on the particular form of risk faced by the farmer. Price variability was the largest risk faced by a farmer in the broiler industry (Knoeber and Thurman [5]). In order to reduce the price variability, a broiler grower could contract with a processing company known as an integrator. The payment scheme in such contracts used to be designed such that both the input and the output price risk were eliminated from the payment scheme. Compared to the traditional form of production, a farmer engaged in contract production will have a more stable income over time (Knoeber and Thurman [5]). More recent contracts, however, include the so called "market price clause" which results in a partial exposure of growers to output price risk. *Ceteris paribus*, one would expect the farmer to accept this higher variability of income if the expected income is high enough to compensate him for the additional risk exposure.

Apart from price risk the broiler producers' exposure to risk comes from the uncertainty in production. Similar to production of crops, raising animals is also influenced by random events such as weather and diseases. Production risk can be broken down into

a *common production (systematic) risk* and an *idiosyncratic risk*¹. Common production risk, such as the variation in temperature, a natural disaster, etc., affects all growers, whereas idiosyncratic production risk, such as the breakdown of an automatic feeder, the collapse of a chicken house roof etc., is specific to each grower.

A great majority of modern contracts are settled via the use of cardinal tournaments. A cardinal tournament is designed so that each individual grower's production cost is compared to a group average cost in order to calculate compensation. By entering into this type of a tournament, the impact of common production risk is almost completely eliminated from the growers payment, and the only risk that remains is the grower's own idiosyncratic risk.²

Risk shifting from growers to integrators has been well documented. Knoeber and Thurman [5] find that relative to production by independent growers, contract production shifts nearly 84% of risk from growers to integrator companies. Martin [11] finds the income variability of pork growers to be reduced significantly (about 90%) upon entering production contracts with an integrator. The distinct feature of all previous empirical studies is the fact that the payment schemes they analyze do not expose the grower to the volatility of market prices, either on the input or on the output side.

The objective of this paper is to solve an interesting problem concerning a change in contracts. We are interested in analyzing the welfare change to broiler growers with the inclusion of a payment mechanism which depends on the output price of broilers. There are two questions that we consider: (i) given certain assumptions about growers risk preferences we want to find out whether new contracts are welfare superior to the old

¹The term idiosyncratic risk as used in the contract literature refers to individual production risk as faced by an individual producer due to circumstances unique to that producer, but not encountered by other producers.

²In fact, tournaments suffer from another type of risk known as league (group) composition risk (Levy and Vukina [7]) which results from the exogenous mixing of growers of different abilities into tournament groups. This type of risk is ignored in this study.

contracts and (ii) how are different contracts perceived by growers of different abilities?

The results show that while including the market price clause increases the variability of grower income, it also raises grower expected return. Overall, under assumptions of fixed flock size and constant percentage mortality, which enables payment per-pound comparison, new contracts are welfare superior relative to the old contracts. However, when analysis is conducted on a total per-flock payment rather than on a per-pound payment, we find that welfare superiority of new contracts depends on the grower attitude toward risk. It turns out that with higher measures of risk aversion, growers prefer the old contracts relative to the new contracts, while those with lower measures of risk aversion prefer the new contracts.

The rest of the paper is organized as follows: Section 2 introduces the broiler industry. Section 3 presents the theoretical models of the various types of contracts. Section 4 describes the data. Section 5 presents the methodological framework for welfare comparison. Section 6 presents empirical evidence using the payment per-pound of live weight analysis, while Section 7 presents the welfare comparison of contracts based on total per-flock payments. Section 8 concludes.

2 The Broiler Industry: A Background

A broiler is a young chicken grown exclusively for meat rather than for eggs (Rogers[14]). Broiler production is concentrated in the "broiler belt" of states, which encompasses the Delmarva region (Delaware, Maryland, Virginia), the Southeast and Texas. Broiler processing is highly integrated (see figure 1), with the processors controlling the vertical stages in the broiler industry by either owning or contracting each stage -from breeding stock to market-ready products. Figure 1 depicts a fully integrated firm. The production involves two separate processes: the production of hatching eggs (produced by breeder hens) and the grow-out of broilers. The feed mill, also owned by the integrator, supplies

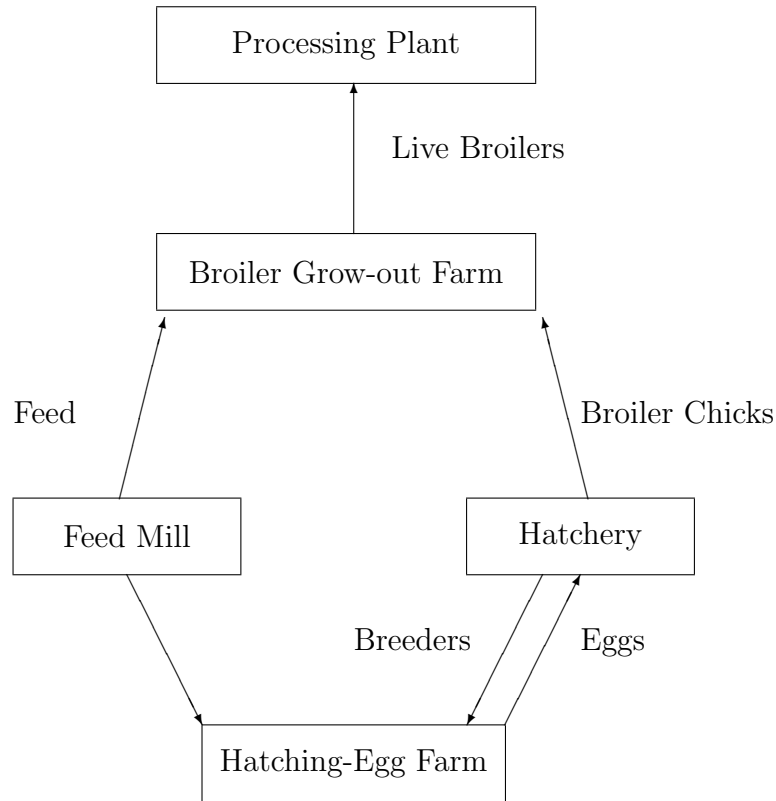


Figure 1: The Broiler Industry

feed to both the hatching-egg farm and the broiler grow-out farm. The broiler farm gets day-old chicks, which are grown to market weight before being sent to the processing plant to be slaughtered and shipped to market. The average duration of the grow-out cycle is roughly 7 to 8 weeks for an average sized bird (4 pounds). Larger birds stay in the broiler farm for an additional one or two more weeks. Broiler chickens are grown to different weights. Regular size broilers usually weigh between 3 to 5 pounds, whereas roasters weigh between 6 to 8 pounds and take anywhere from nine to eleven weeks to reach market weight. In the US, 20 integrators produced 74% of all broilers, with Tyson accounting for about 22% of industry output³. Total US output of broilers has increased from 96.5 million pounds (34 million birds) in 1934 to about 41.5 billion pounds (8.3

³USDOC[12] and *Meat Industry Internet News Service*[15]

billion birds) in 2000⁴. Most of this increased broiler production has been attributed to contract production and rapid advances made in production technology (Ensminger [4]). Over 85% of production in the U.S. broiler industry is conducted through contracting while 10% is produced on integrator-owned farms (Perry[13]).

2.1 Contracts

Under the typical contract arrangement, the integrator retains ownership of the birds, supplies the feed and medication, and provides supervisory field personnel. In return the grower is provided a payment for managerial skills, labor costs, utilities expenses and investments in housing and equipment. The contract often has incentives to encourage the production of quality broilers with minimal feed. The major integrators own feed mills and customize the feed to their needs. The timing of the next batch of chicks delivered to the grower is also determined by the integrator.

Virtually all modern broiler contracts are settled based on a two part piece rate cardinal tournament consisting of a base and a stochastic bonus, which is a linear function of the grower performance relative to the group average⁵. Historically not all contracts were settled using cardinal tournaments⁶. The payment mechanisms evolved reflecting new market conditions as well as the integrators' learning process. The most recent innovation is the introduction of the so called "market price clause" which effectively makes the base payment time dependent.

Every grower whose birds are harvested within a period of one week is entered into a tournament known as the settlement. The composition of the tournament group varies from one settlement to the next due to differences in the timing of placement of succeeding

⁴Source: National Agricultural Statistics Service, USDA[16]

⁵Payment parameters vary among companies. For a broad selection of various contracts see National Contract Poultry Growers Association web site:

<http://www.web-span.com/pga/contracts/contractsindex.html>

⁶For a complete history see Martin [10].

flocks. In calculating the average cost per pound of live weight delivered by each grower, all costs for inputs supplied by the integrator, such as cost of chicks, feed, medication etc. are included, but fluctuations in the market prices of these inputs are ignored. Instead costs are calculated by using fixed weights rather than actual prices. The grower's bonus is the difference between the group average per-pound cost of raising the broilers to market weight (\bar{c}) and the individual grower's average per-pound cost, c_i (a positive difference indicates that the producer's cost is below average). For above average performance (below average cost) the producer earns a bonus while for below average performance (above average cost), he receives a penalty. The total payment for grower i (R_i^O) under old contracts takes the following form:

$$R_i^O = [B + \beta(\bar{c} - c_i)] q_i \quad (1)$$

where B is the base payment; $\bar{c} = \frac{1}{n} \sum_{j=1}^n c_j$ is the average group settlement cost for the week; q_i is the live weight of producer i 's output; $\beta(\bar{c} - c_i)$ is the bonus for producer i where $0 \leq \beta \leq 1$ is the payment slope coefficient reflecting the power of the incentive scheme.

In a contract with a market price clause, the payment calculation is slightly different as it now includes the output price risk. All calculations are conducted in a manner similar to a contract without a market price clause, except for the addition of a market clause to the base pay. The total payment under this new type of contract is:

$$R_i^N = [B + M_t + \beta(\bar{c} - c_i)] q_i \quad (2)$$

where M_t is the market price clause defined as:

$$M_t = \delta \left[p - \left(\frac{\bar{c}}{\gamma} \right) - k \right] \quad (3)$$

where δ is a percentage factor (usually 5%) ; p is the market price (the simple average of the composite whole bird selling price for poultry delivered to New York City as quoted

the Monday of the settlement week); γ is the processed meat yield factor; k is processing cost which is fixed and the same across all contracts, and \bar{c} is the same group average producer cost previously defined. Notice that the effect of inclusion of a market price clause is to make the base payment depend on the movement of the market price of broilers. This change effectively re-introduced a part of the price risk into the grower payment scheme.

3 Grower Contracts: A Theoretical Model

The broiler growers are assumed to have the same utility function given by $U(\Pi_i)$, with $U'(\Pi_i) > 0$ and $U''(\Pi_i) < 0$, where Π_i is the profit defined as $\Pi_i = R_i - C(e_i)$. $C(e_i)$ is the cost of effort with $C(e_i)' > 0$, $C''(e_i) > 0$, $C(0) = C'(0) = 0$ and R_i is the total payment previously defined. In this model the cost of effort is a proxy for the cost of inputs supplied by the grower⁷. As is common practise in the research⁸, it is assumed that there is a fixed flock size for all growers and that the mortality rate of chicks is constant across all growers. Consequently, the quantity of broiler meat produced is the same for all growers and the objective of every grower is to produce a fixed output at the lowest possible cost. Therefore, the difference in income between growers is a result of the difference in their settlement costs which can be represented by the following stochastic relationship:

$$c_{it} = e_i + \phi_i + u_t + \epsilon_{it} \quad (4)$$

where c_{it} is the average producer cost per pound of live weight for grower i measured as a negative number, $e_i \geq 0$ is his effort, ϕ_i is the grower's inherent ability, u_t is the common production shock and ϵ_{it} is the idiosyncratic shock. Both shocks are stochastic, realized at the end of the production cycle, with mean zero and finite variances σ_u^2 and σ_ϵ^2

⁷Grower supplied inputs include housing, utilities and labor, but not inherent ability as pointed out in equation 4.

⁸see Knoeber and Thurman [5], Tsoulouhas and Vukina [17], Levy and Vukina [8]

respectively. Increasing effort exerted leads to lower settlement costs (Levy and Vukina [8]) which increases the bonus. Effort is assumed to be the only input by a grower. Given the parameters of the contract, there is an optimal effort level exerted by the agents (growers) that needs to be calculated.

3.1 Cardinal Tournament

Based on the fixed flock size and constant mortality assumptions, the cardinal tournament payment scheme from (1) reduces to:

$$P_i^O = B + \beta(\bar{c} - c_i) \quad (5)$$

If offered a cardinal tournament contract with base payment B and $\beta > 0$, the agent's optimization problem is given by:

$$\max_{e_i \in [0, \infty)} \int \int U[B + \beta(\bar{c} - c_i) - C(e_i)] f_u(u) f_\epsilon(\epsilon) du d\epsilon \quad (6)$$

where f_u and f_ϵ are the density functions of the common production (u_t) and idiosyncratic (ϵ_i) production shocks. The first order condition for this maximization is:

$$\left[\beta \left(\frac{n-1}{n} \right) - C'(e_i) \right] \int \int U'[B + \beta(\bar{c} - c_i) - C(e_i)] f_u(u) f_\epsilon(\epsilon) du d\epsilon = 0 \quad (7)$$

which leads to the unique solution

$$\beta \left(\frac{n-1}{n} \right) - C'(e_i) = 0 \quad (8)$$

(see Levy and Vukina [7]). The result in (8)⁹ indicates that when a cardinal tournament contract is offered, the effort chosen is the same for all agents regardless of their respective abilities.

⁹The expression 8 follows directly from 7 if one sets the term within square brackets in 7 equal to zero, which is sufficient for the entire expression in 7 to be zero.

3.2 Cardinal Tournament with a Market Price Clause

The settlement costs in a contract with a market price clause (M_t) are calculated in the same manner as in the standard contract. If M_t is positive it essentially results in a higher base pay for the growers, whereas a negative M_t leads to a lower base pay. The M_t adds a further element of variability to the grower's pay, via the market price shock captured by the density function $f_t(t)$. The payment received by the grower under such a contract is:

$$P_i^N = B_t + \beta(\bar{c} - c_i) \quad (9)$$

where $B_t = B + M_t$. The optimization problem now facing the grower is:

$$\max_{e_i \in [0, \infty)} \int \int \int U[B_t + \beta(\bar{c} - c_i) - C(e_i)] f_u(u) f_\epsilon(\epsilon) f_t(t) du d\epsilon dt \quad (10)$$

The first order condition is:

$$\left[\beta \left(\frac{n-1}{n} \right) - C'(e_i) \right] \int \int \int U'[B_t + \beta(\bar{c} - c_i) - C(e_i)] f_u(u) f_\epsilon(\epsilon) f_t(t) du d\epsilon dt = 0 \quad (11)$$

The solution to (11) is the same as in expression (8). Thus, when a cardinal tournament with a market price clause is offered, the optimal effort is the same for all agents and is independent of market price¹⁰.

4 Data

We used two data sets: one consisting of older contracts without a market price clause (hereby referred to as the 'O' data set¹¹) and the other consisting of newer contracts

¹⁰Given the structure of the payment schemes used in the broiler industry, the statement below 11 is generally true even if the market price is zero. The nature of the tournaments guarantees the growers complete insulation against all price shocks (both inputs and outputs). It is critical to understand that the way contracts are designed, neither output nor input prices enter the settlement. The only exception is the market price clause.

¹¹This is the same data set used by Knoeber and Thurman [5], [6].

with a market price clause (the 'N' data¹²). The O data set spans from June 8, 1984 to December 17, 1985 while the N data spans from July 2, 1995 to July 12, 1997.

The O data set is broken down into two subsets based on differences in contract specifications. As of November 9, 1984, the base pay in the older contracts was increased and as such we grouped the rest of the data under a different contract. The earlier period is thus referred to as 'O1' contract while the latter period is the 'O2' contract. The slope coefficient did not change the entire period and was set at 1. All other contract specifications remain unchanged.

The N contracts differ from the O contracts in that they include a market price clause. The N data set had a separate (a so called 'rider') contract for growers who had performed poorly over some past number of tournaments. The main characteristics of the rider contract is that M_t was truncated at zero (i.e. M_t could not be negative), so as to prevent lowering of the base pay. There is no information in the data set to indicate which growers were operating under the rider contract. Therefore the rider contracts were ignored and M_t was allowed to vary freely. Each one of the five N contracts covers the production of a different size bird and as a result would have a different base payment. The slope coefficients in all five contracts are identical and equal to 1. Contracts N1 and N2 are for large broilers, N3 and N4 are for roasters with female fillers and N5 is for roasters with straight run¹³.

Payments under both the O and N contracts are calculated according to the performance of the growers relative to the group mean. In case of the O data set we used the

¹²From GIPSA, USDA

¹³Growing broilers usually requires the utilization of the entire floor of the chicken house, except when the birds are very small. The technology for growing roasters (single sex, male birds) can differ depending whether *female fillers* or *straight-run fillers* are used. The idea is that the chicken house space gets divided into two compartments, one stocked with male birds who will be harvested as roasters and the other with either single sex female birds (female fillers) or with both sexes (straight run). After about seven weeks when fillers get harvested, the barrier is removed so that roasters can use the entire floor of the chicken house for another couple of weeks to grow to their marketable weight. (Levy and Vukina [8])

original payments from the data set, whereas the N data set required the reconstruction of payments based on the payment formula from expression (2)¹⁴. In calculating the bonus payment we used the original (published) average per-pound producer cost (c_i) and tournament group average per-pound cost (\bar{c}) and calculated $(\beta(\bar{c} - c_i))$. The bonus payment was then added to the base payment¹⁵ to obtain the total payment per-pound. To calculate the total payment per-flock the original (published) number of pounds of live weight was used.

In order to calculate the market price clause (from equation (3)) the weekly market prices for broilers which we used were the twelve city¹⁶ weighted average price for truckload sales of ready-to-cook broiler-fryers delivered as published by the USDA. The meat yield factor (γ) and processing cost (k) used in calculating M_t were as published in the contracts and did not change for the duration of the contract.

Figure 2 charts the market price of broilers over the span of the N contracts. Also included in that figure is the calculated market price clause, which has a negative value over a small range of the data. Figure 2 shows the market price clause would not be binding in approximately 92% of the tournaments. So the fact that we ignored the truncation problem in rider contracts turns out to be reasonably harmless.

¹⁴Some original payments were negative and some were extraordinarily high . Some other payments were missing.

¹⁵In the actual contracts the base pay could be one of two possible values, depending on the placement density (total area of chicken house/ number of chicks placed). If placement density was above a threshold value stated in the contract, a grower received the higher base payment. Lacking placement density information on many flocks, we chose the same lower base pay for all flocks within a given contract. If the contracts are found to be welfare enhancing with the lower base, then the same should hold true with a higher base.

¹⁶The twelve cities are: Boston, Chicago, Cincinnati, Cleveland, Detroit, Denver, Los Angeles, New York, Philadelphia, Pittsburgh, St. Louis and San Francisco.

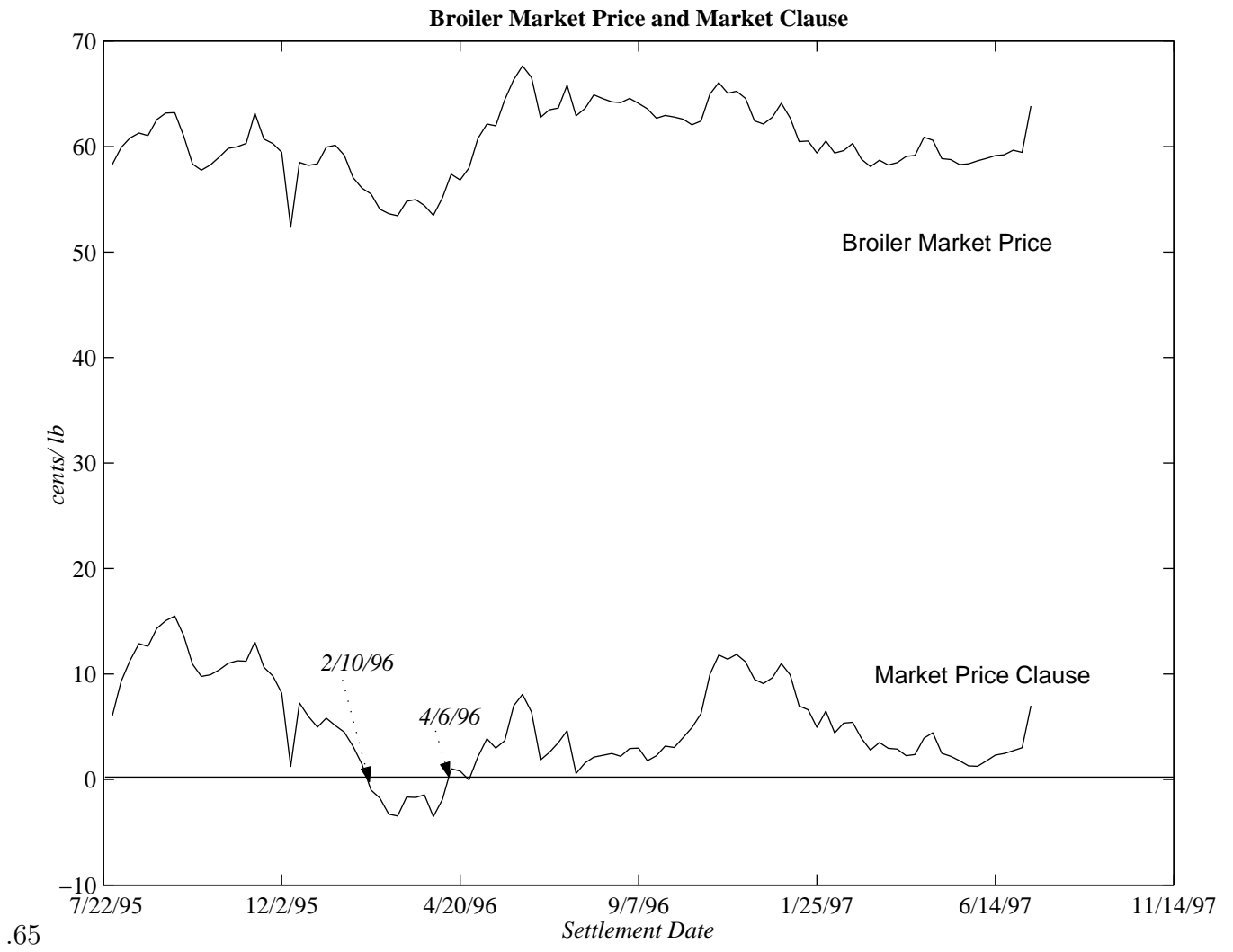


Figure 2: Broiler Prices and Market Price Clause

5 Welfare Comparison Framework

In order to carry out the welfare comparison of two contracts, we will assume that growers' preferences are represented by a constant absolute risk aversion (CARA) utility function of the form $U(\pi) = -\frac{1}{\lambda} \exp[-\lambda(P - C(e))]$ and that per unit profits π are normally distributed. Since exerted efforts are identical across all growers, so will be the disutilities of effort, and the comparison of the expected utilities of profits reduces to a comparison of the expected utilities of payment of the following form¹⁷:

$$E[U(P)] = E(P) - \frac{\lambda}{2} Var(P) \quad (12)$$

Later in the empirical part of the paper, we will relax the assumption of fixed flock size and constant percentage mortality across all growers and will carry out the welfare comparison based on the total payment per-flock and contrast results with those obtained on a payment per-pound basis in (12). We will also simulate different levels of risk aversion by varying the risk aversion parameter λ in the range of 0.1 to 0.0001.

5.1 Estimating the Mean and Variance of Payments

Because different growers had different number of flocks, i.e. our data set is an unbalanced panel, it was more appropriate to calculate a mean and a variance for the entire contract, rather than for an individual grower. The mean and variance of the payment per-pound for each contract was then used to calculate the expected utility based on expression (12).

When it came to calculating mean and variance of total payment per-flock, a more complicated approach was required. The problem with using the mean and variance of the entire contract is that they approximate the distribution of payments influenced by the difference in the size of operations (i.e, different number of chicken houses) across growers. This kind of variability of payments has nothing to do with the exposure to risk

¹⁷Under assumptions of CARA and normality of returns, the expected utility framework collapses to a mean-variance analysis (Levy and Markowitz [9]).

that an individual grower is facing. After the total payment per-flock for each grower was calculated, the mean and variance of the total payments of all finished flocks were then calculated for each grower. Growers with less than two flocks were deleted from the calculations. The expected utility of each grower was calculated and ranked from the highest to the lowest for each contract. Welfare comparison of contracts was performed by comparing the median expected utility of each contract. The contract with the higher median utility was considered to be welfare superior as 50% of growers would have higher expected utility under this contract than under an alternative contract.

5.2 Statistical Inference

The statistical inference in the payment per-pound analysis was based on the *difference z-test*. A difference z-test is a test of the significance of the difference between two means from independent samples, in this case the expected utilities from two contracts. A pairwise t-test would be an ideal test statistic to test significance in differences, but it requires that the observations be paired. Since the observations are unequal in number and are from different populations, pairing them is not feasible and as such a difference z-test is the appropriate measure to be used (Aggarwal [2]).

The test for the difference between two means is a variant of the z test. Let the expected utility of contract O_i be denoted by μ_i , and the expected utility of contract N_j be denoted by μ_j . The relevant statistic is the difference in the expected utilities : $d = \mu_i - \mu_j$. Based on the central limit theorem, the variance of the difference approximately equals the sum of the measured variances¹⁸ of the two sample means (p.167, [2]):

$$\sigma_d^2 = s_{\mu_i}^2 + s_{\mu_j}^2 = \frac{s_i^2}{n_i} + \frac{s_j^2}{n_j}$$

where $s_{\mu_i}^2$ and $s_{\mu_j}^2$ are the measured sample variances, and n_i and n_j are the sample sizes of the respective contracts. A rejection region is chosen after choosing a level of significance

¹⁸This is the estimated variance of the mean of expected utility across all flocks of all growers with a particular type of contract.

for the two-tailed test. A two-tailed test for a level of significance of 5% has a rejection region of $\pm 2\sigma_d$. The rule for hypothesis testing is:

$$H_O : d = 0$$

$$H_A : d \neq 0$$

Since our objective is to determine if the N contracts are welfare superior to the O contracts, we used the O contracts as the benchmark for a comparison. If the difference, d , is outside the range $\pm 2\sigma_d$, then it can be said that the expected utility from contract N_i is significantly different than the expected utility from contract O_j .

The statistical inference in case of a payment per-flock was based on the *median test*. The median test compares the median of two independent samples and is equivalent to the difference z-test for comparing the means (Aggarwal [2]). The median test provides a procedure for testing whether two independent samples differ in central tendencies i.e. whether they come from distributions with statistically different medians. The median test is computed as follows [2]: (i) Combine the two contracts being evaluated and rank the expected utilities from highest to lowest. (ii) Compute a common median for both the contracts combined. (iii) Sort the contracts and create the following 2×3 table:

	Contract i	Contract j	Total
# of obs above combined median	A	B	A+B
# of obs below combined median	C	D	C+D
	A+C	B+D	N = A+B+C+D

If both contracts are samples from population whose median is the same, one would expect about half of each group's scores to be above the combined median and about half to be below. (iv) Calculate a χ^2 as follows:

$$\chi_{obs}^2 = \frac{N(|AD - BC| - \frac{N}{2})^2}{(A + B)(C + D)(A + C)(B + D)}$$

(v) The rule for hypothesis testing is:

$$H_O : C = D$$

$$H_A : C \neq D$$

If $\chi_{obs}^2 \geq 3.84$ ($\chi_{0.05,1}^2$) then reject H_O , which implies that the medians of expected utility are significantly different from each other.

6 Payment Per Pound Results

The welfare comparison of broiler contracts will be carried out in two ways. In the first approach we assume that all growers are of equal abilities and conduct the welfare analysis based on the entire population of growers belonging to a particular contract to see which contract is on average preferred by all growers. The second approach sorts growers into homogeneous ability groups and carries out the welfare comparison of contracts for each of the three ability groups separately.

6.1 Homogeneous Growers

A contract is said to be preferred if its expected utility is higher than the expected utility of another contract. Table 1 demonstrates that the expected utilities of the N contracts are greater than the O contracts. The variance of payments is higher under new contracts, increasing the risk faced by growers. However, the growers are appropriately compensated for this additional risk with a higher mean payment. Thus contracts with M_t have a higher expected utility relative to the O contracts. Given that the market price of broilers fluctuates, very rarely is the market price clause less than zero (see figure 2). So majority of the time M_t is simply a positive addition to the base pay resulting in

Table 1: Expected Utility of Payment per pound: Homogeneous Growers

<i>Contract</i>	Expected Utility		
	$\lambda = 0.1$	$\lambda = 0.01$	$\lambda = 0.001$
N1	3.8179	3.8299	3.8311
N2	2.6174	2.6340	2.6357
N3	3.8002	3.8161	3.8177
N4	3.4927	3.5146	3.5167
N5	3.7634	3.7756	3.7768
O1	2.9654	2.9681	2.9684
O2	3.3785	3.3831	3.3836

Numbers in Table represent units of utility and not actual payments under any contract.

the higher mean of payments. Figures in bold indicate the most preferred contract under each different value for λ . Based on a difference z-test all differences in expected utilities between N contracts and O contracts are significant at 5% level. Hence, the N contracts have significantly higher expected utilities and as such are preferred to O contracts.

Among N contracts, N1 is preferred to all other contracts since it has the highest expected utility for all values of λ . N1 has the highest mean payment per-pound among all contracts and the lowest variance among N contracts. Recall that N1 is the contract for large broilers with the lowest harvested birds average weight among all N contracts. It turns out that growing small size birds on average is the most preferred by all growers because it strikes the most favorable balance between expected payments and the volatility of payments.

6.2 Heterogeneous Ability Growers

Let us now turn to the question of how the different contracts are perceived by growers of different abilities? The assumed production technology in (4) indicates that ability

is expected to reduce the settlement cost. If ability is defined as knowledge and skills, a high ability producer will be more skillful in tasks such as the proper maintenance of automatic feeders, waterers and other equipment and thus would have a lower settlement cost. Ability is also reflected in such things as knowing the optimal temperature in the chicken house for maximum efficient broiler growth [1]. One can also think about high ability as resulting in minimizing the impact of idiosyncratic shocks. A high ability grower would prefer a contract where he can make the best use of his ability. Since the importance of a grower's ability is more pronounced in the early stages of a chick's life, a contract which allows for more flock turnover will be preferred by high ability growers. More flock turnover is possible if the production process is shorter, i.e in contracts calling for the grow-out of lighter birds. Having said this, we hypothesize that a high ability grower would prefer a contract with a shorter duration and lighter birds i.e. contracts N1 or N2.

The sorting of growers into ability groups was conducted based on their settlement cost, over the span of the data. The settlement costs for each tournament were ranked from the lowest to the highest. The top, middle and bottom thirds of the ranking were assigned ranks of one, two and three respectively. Ranks from each tournament were then aggregated to form an overall rank for each grower. This aggregate ranking was then used to rank the growers within each contract into 'high' ability, 'medium' ability and 'low' ability categories. For each ability group, the mean and variance of payments were calculated under each contract, using the same methodology as previously described. The expected utility was then calculated for each group within each contract. The results are displayed in table 2.

All ability types prefer the N over the O contracts. As anticipated, the highest ability growers receive the highest utility. However the low and medium ability growers prefer N1 while the high ability prefer N3. Contract N3 is for a medium sized bird while N1 is a smaller bird. Therefore, the empirical evidence does not support our hypothesis that the higher ability growers would prefer contracts with lighter birds. The explanation for

Table 2: Expected Utility of Payment per pound: Heterogeneous Growers

<i>Contract</i>	$\lambda = 0.1$	$\lambda = 0.01$	$\lambda = 0.001$
HIGH			
N1	4.2838	4.2937	4.2947
N2	3.2820	3.2854	3.2857
N3	4.3618	4.3659	4.3663
N4	4.1213	4.1229	4.1231
N5	4.2375	4.2413	4.2417
O1	3.2539	3.2544	3.2544
O2	3.7119	3.7135	3.7137
MEDIUM			
N1	3.9325	3.9331	3.9332
N2	2.6532	2.6543	2.6544
N3	3.8451	3.8465	3.8466
N4	3.7105	3.7111	3.7112
N5	3.7061	3.7077	3.7079
O1	2.9618	2.9622	2.9622
O2	3.3456	3.3462	3.3463
LOW			
N1	3.3476	3.3515	3.3519
N2	1.9969	2.0098	2.0111
N3	3.2244	3.2370	3.2383
N4	3.1700	3.1775	3.1783
N5	2.9675	2.9881	2.9902
O1	2.7158	2.7162	2.7162
O2	3.0280	3.0286	3.0286

Numbers in Table represent units of utility and not actual payments under any contract.

this mostly lies in the fact that this analysis assumes equal output for all growers. It may be more reasonable to believe that high ability is best reflected in preventing broiler mortality such that better growers will always produce more pounds of meat compared to low ability growers with identical initial placement. This is the analysis that we turn to next.

7 Total Payment Results

Acknowledging the fact that the assumptions in earlier sections were restrictive and that the variability of total payments may come from the difference in the total number of pounds of live weight produced, we conduct welfare comparison using the total payment received by the grower. Equation (12) needs to be rewritten as:

$$E[U(R)] = E(R) - \frac{\lambda}{2} Var(R) \quad (13)$$

where R represents total revenue from equations (1) and (2). As explained earlier, welfare analysis was conducted on an individual grower basis. If more than 50% of growers in a contract prefer that contract, then the entire contract is considered welfare superior to another contract.

Table 3 shows that the median expected utility is negative for all contracts when $\lambda = 0.1$ and for N contracts when $\lambda = 0.01$. Using the median test, the differences among median utilities are found to be significant at a 5% level for all values of λ . Unlike with analysis using payment per-pound, the results from using total payment do not support the hypothesis that new contracts with a market price clause are welfare enhancing relative to the old contracts. These results are sensitive to the choice of a risk aversion parameter, signifying the added impact of output volatility which leads to high variance of payment.

As the risk aversion parameter gets smaller the median expected utility increases. This is a consequence of the fact that variance of total payment was very large. The

Table 3: Median of Expected Utility of Total Pay Per Flock: Homogeneous Growers

<i>Contract</i>	Expected Utility			
	$\lambda=0.1$	$\lambda=0.01$	$\lambda=0.001$	$\lambda=0.0001$
N1	-136553	-5442	5845	8086
N2	-90781	-3090	3870	5664
N3	-230783	-14096	8401	11662
N4	-94929	-844	8058	9706
N5	-225327	-9254	8599	12301
O1	-3357	2844	4678	4900
O2	-4819	844	6784	9003

Numbers in Table represent units of utility and not actual payments under any contract.

large variance in total pay was a result of high variance in the quantity of broiler meat produced. One explanation for the high variance in quantity of broiler meat produced is the difference in mortality. While poultry losses due to diseases may not be completely preventable, the more knowledgeable producer can, however, reduce such losses by early detection, fast response and many other disease prevention techniques. Mortality losses generally average 2% during the first three weeks of a chick's life and about 1% a month for the remainder of the chick's stay at the broiler farm (Ensminger [4]). This observation emphasizes the importance of proper care in the early stages of growth. As hypothesized earlier, we would then expect the high ability growers to prefer contracts for lighter birds.

As indicated by table 4, testing the relationship between ability and preferable bird size produces mixed results. All growers, regardless of ability, prefer N5 for low values of risk aversion ($\lambda = 0.001$) and one of the old contracts when $\lambda = 0.1$. When $\lambda = 0.01$, all growers prefer N4. Despite relaxing assumptions regarding mortality, the empirical evidence does not support our hypothesis that the higher ability growers would prefer contracts with lighter birds.

Table 4: Median of Expected Utility of Total Pay: Heterogeneous Growers

<i>Contract</i>	$\lambda=0.1$	$\lambda=0.01$	$\lambda=0.001$	$\lambda=0.0001$
HIGH				
N1	-30623	3886	7546	7878
N2	-76039	3646	12912	13526
N3	-260694	-11451	16537	21720
N4	-150713	5224	18710	23605
N5	-300226	-5683	18694	23944
O1	-2271	4380	5541	5638
O2	-3357	3685	4981	5583
MEDIUM				
N1	-149378	-747	14138	15729
N2	-131934	-686	11227	13189
N3	-356214	-10943	20234	23785
N4	-100884	5311	15327	19613
N5	-233529	-2424	20832	24223
O1	-16522	2428	5368	5489
O2	-3419	2674	4150	4654
LOW				
N1	-486629	-25387	16593	22188
N2	-108453	-1290	10785	12852
N3	-315594	-15330	19383	23321
N4	-105174	5225	17546	18556
N5	-275622	-3797	17870	24161
O1	-2757	2319	3594	3654
O2	-4108	2660	4357	4826

Numbers in Table represent units of utility and not actual payments under any contract.

8 Conclusion

One of the most important benefits of contract production is risk shifting from the agents to the principal. Previous research has found that a significant part of this risk shifting in poultry contracts is due to the absence of price risk in the payment mechanism on either the input or the output side. The objective of this paper was to analyze the newer contracts which include a part of the output price risk through the inclusion of a market price clause. Conducting welfare comparison on a payment per-pound basis we found that new contracts are welfare superior to the old contracts. When comparison was conducted on payment per-flock, we found that the results were mixed and were sensitive to the choice of a risk aversion parameter.

Our most surprising finding was that the hypothesized relationship between ability of growers and the preferred size of the bird grown was negative. This was true under both payment per-pound and payment per-flock analyses, although the latter results were more tentative. It is not incomprehensible that the results did not support our hypothesis under the payment per-pound analysis. However, it is surprising that in the payment per-flock analysis, where ability matters in preventing mortality, our results did not support the hypothesis that the high ability growers would prefer contracts for lighter birds. One explanation for this result is that an analytical solution for optimal effort under payment per-flock analysis was not derived. Similar to payment per-pound, all growers were assumed to exert the same effort and therefore have the same cost of effort. Suggestions for future research would be to derive the correct optimal effort under payment per-flock. Also it would be interesting to empirically estimate the risk aversion parameter from the data rather than using ad hoc values as was done in this paper.

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