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Abstract

This paper is an empirical analysis of the gains from contract farming in the case of poultry production in the state of Andhra Pradesh in India. The paper finds that contract production is more efficient than noncontract production. The efficiency surplus is largely appropriated by the processor. Despite this, contract growers still gain appreciably from contracting in terms of lower risk and higher expected returns. Improved technology and production practices as well as the way in which the processor selects growers is what makes these outcomes possible. In terms of observed and unobserved characteristics, contract growers have relatively poor prospects as independent growers. With contract production, these growers achieve incomes comparable to that of independent growers.

Keywords: Contract Farming, Contracting, Poultry, Vertical Integration

JEL Codes: L230, L240, Q130

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1. Introduction

A feature of low productivity agricultural economies is the dominance of subsistence production especially among small growers. Even though commercialization can yield substantial gains, the transition from subsistence farming to market driven production is fraught with perils (von Braun and Kennedy, 1994). First, market volatility is an enduring feature of commodity and livestock markets. This makes cultivation of cash crops and livestock risky. Second, as incomes grow, consumer taste shifts in favor of processed foods. Small farmers are too remote from consumers to track their preferences. Third, small farmers typically lack capital and technical expertise to undertake cash crop and livestock production, which are usually more input intensive than subsistence crops. These problems are serious enough that they could effectively choke off participation in markets by all except the large farmers.

In principle, contract farming could be an institutional arrangement that enables farmers to access markets. While contractual arrangements can vary by crop and by country, contracting is a form of joint production where the grower supplies tools, land, labor and management while the processor supplies technical assistance, some inputs such as seeds or pesticides and undertakes to buy the grower's output at a pre-determined price. From the point of view of the processor, this arrangement ensures raw material supplies of the desired quality (subject, of course, to production uncertainty). From the point of view of the grower, such an arrangement provides an assured market and hence reliable income (to the extent permitted by production risks). Without a contract, risks would be too much and few small growers would want to produce these crops. For this reason, Glover (1987) described contract farming as an institutional arrangement that combined the advantages of plantations (quality control, coordination of production and marketing) and of smallholder production (superior incentives, equity considerations).

These theoretical benefits, notwithstanding, contract farming has been controversial and has been criticized for being exploitative (Little and Watts, 1994). Between the giant corporation and the small farmer, bargaining power surely lies with the former. Also, in practice, growers have encountered problems with respect to manipulation of quality standards, poor technical assistance, and sometimes plain cheating and deliberate default (Glover, 1987). As a result, Glover (1987) concluded that research must "systematically examine successes and failures and from then draw generalizations about the conditions under which CF (contract farming) can operate profitably and to the benefit of small farmers" (p 447).

Taking this imperative seriously, this paper is an empirical analysis of the gains from contract farming, to both farmers and processors, in the case of poultry production in the state of Andhra Pradesh in India. The literature on contract farming is largely anecdotal possibly because of lack of data. Knoeber and Thurman (1995) and Warning and Key (2002) are two exceptions. Knoeber and Thurman analyzed the redistribution of risk because of contracting in hog production in U.S.A. Warning and Key estimated the change in producer incomes from contracting by peanut producers in Senegal. Here we draw upon a survey of contract and noncontract poultry producers to analyze both of these issues. Neither of these papers, however, consider the gains to the processors from contracting.

2. The Poultry Industry in Andhra Pradesh

The poultry industry has seen rapid growth in India. Between 1980/81 and 1998/99, poultry meat production increased about 3 times from 250,000 tons to about 770,000 tons.[1] Correspondingly, its share of total meat output rose from 20% to 27%. During the same period, egg production increased from 10,000 to 29,000 million. Andhra Pradesh is the leading poultry meat producing state within India. It accounts for over one-fifth of poultry meat as well as egg production in the country. The growth of poultry industry in Andhra Pradesh has been even more remarkable than the national growth rates. For the period 1980/81 to 1998/99, poultry meat production increased by 4.5 times while egg production rose by 3.5 times. About 30% of its broiler output and 15% of egg output are exported to other states within India.

The impressive growth in the poultry meat industry is the result of technological breakthroughs in breeding, feeding and health, and sizeable investments from the private sector. The expansion in supply has been spurred by rising incomes and has resulted in lower poultry prices in south India where much of the growth has occurred (USDA, 2004). The poultry sector is, however, highly prone to production and market risks, which periodically affect the profitability of broiler production particularly on the small farms. These risks also threaten the profitability of the industry engaged in breeding of chicks and manufacturing of feed, vaccines and medicines. In order to minimize the risks to the producers and sustain the profitability of the industry, some large poultry firms (for example, Venkateshawara Hatcheries Ltd., Suguna Hatcheries, Pioneer Hatcheries, Diamond Hatcheries, etc.) began integrating their activities with that of broiler

[1] The USDA estimates poultry production in 2002 to be of the order of 1.4 million tons, which is higher than the official estimates (USDA, 2004).

production through the institution of contract farming as early as in late 1980s. A large-scale integrated operation would typically include the raising of grandparent and parent flocks, rearing of day-old-chicks, feed milling, provision of veterinary services and contract production. Such integrators are most common in southern and western regions of the country (USDA, 2004).

3. Contracting in Poultry Production

In a poultry contract, hatcheries provide day-old chicks, feed and medicines to contract growers. The contract growers supply land, labor and other variable inputs (like electricity). At the end of the production cycle, the farmer receives a net price (by weight) that is pegged to an industry price set by a group of hatcheries (not the retail price). The industry price fluctuates within a narrow range and is a lot more stable than the retail price. Thus, the farmer receives considerable price insurance. For sharp upward deviations of the retail price from the industry price, farmers receive an incentive. This practice presumably lessens the incentives to default on the part of growers and reflects the competition from the non-contract sector.

The farmer is insured for mortality rates upto 5%. Beyond that the farmer bears the risk of loss. This controls moral hazard and provides incentives for farmers to supply their best effort. A company representative who sorts out problems especially regarding disease visits the farmer daily. According to company accounts, the processor spends time and resources in screening producers for reputation and prior experience.

The broiler contract is an instance of a "production management" contract where the processor supplies inputs and extension, advances credit (in kind), provides price insurance and monitors grower effort through frequent inspections.[2] The detailed monitoring is because of the considerable credit advanced by the processor that provides more than 90% of the cost of production in terms of the value of inputs. Because the frequent monitoring controls for moral hazard, it is also conducive to insurance. The frequency of contact also would mean that the processor incurs considerable transactions costs.

4. Data and Descriptive Statistics

The data was collected from a primary field survey of contract and non-contract producers. The survey was undertaken in the year 2002-03 to collect the required information for the year 2001-02. The sample producers were interviewed to collect the required data, using pre-tested questionnaires, specifically prepared for each case study. Survey data was based on recall memory of the households but it was also supplemented with the records maintained by both contract and non-contract producers. Detailed information was collected about the socio-economic characteristics of the sample farmers, production-portfolio, item-wise and cycle-wise cost of broiler production, yield levels, labor use, and cost of marketing and acquiring information for various activities. A sample of 25 contract producers and an equal number of non-contract producers were randomly selected from 10 villages of Rangareddy, Mehboobnagar and Nalagonda districts in Andhra Pradesh. A majority of the contract farmers were associated with a leading poultry integrator.

[2] The terminology is taken from Minot (1986) who classified contracts according to the intensity of contact between the processor and the farmer. The production management contract involves the most contact.

The survey instrument consisted of four parts. In the first part, information about village level infrastructure was collected. This consisted of distance from various infrastructure facilities such as roads, railways, telephone, post office, regional rural bank, animal feed shop among others. Table 1 compares the availability of infrastructure across contract and noncontract farmers. The big difference between (the sample of) contract and noncontract farmers is the better access of noncontract farmers to credit facilities whether it is cooperative credit society or the regional rural bank or the primary dairy cooperative society.

The second part of the survey elicited information about the farmer including age, schooling, experience in broiler farming and previous occupation. Table 2 summarizes the differences between contract and noncontract farmers in terms of individual characteristics. Notice that the sample of noncontract farmers are twice as experienced, slightly more educated and yet a little younger than contract farmers. The sample of noncontract farmers also contains a substantially higher proportion of farmers who are specialized in poultry farming. The noncontract farmers are also those who have migrated from agriculture related occupations compared to contract farmers where the proportion of farmers with non-agriculture related occupations is large. Examples of such previous occupations include in sectors such as pharmaceuticals, electrical hardware, cement, police, clothes and wine retailing.

The third part of the survey collected information about the inputs, outputs and revenues from the last 6 production cycles of each grower. Table 3 presents information about the levels of input use per production cycle for contract and noncontract farmers. Note that the numbers are averaged twice – first over production cycles for each grower and then across all growers within the class of contract and noncontract farmers. The production process in poultry consists of transforming baby chicks into fully-grown birds. Besides chicks, the inputs into this process are feed, medicine, labor and time. Production is not instantaneous. For this reason, productivity measures have to be normalized with respect to time as well. With respect to capital assets, contract farmers have more equipment as measured by brooders, feeders and water facilities but operate in a smaller area.

From table 3, it can be seen that noncontract farmers have longer production cycles, lower flock sizes and correspondingly spend less on medicine, feed, vaccination, veterinarian fees and labor cost. Noncontract farmers depend much more on family labor than contract farmers. Medicines and feed is the single largest item of variable cost. Interestingly, even though noncontract growers manage lower flock sizes, they use almost as much quantity of feed as the contract growers.

Table 4 compares the outputs and revenues (from bird sales) of contract and noncontract producers across all production cycles. As contract producers have larger flock sizes, their output is also larger whether measured by the number of birds or the total weight of birds sold. However, the average weight of a bird is pretty much the same across contract and noncontract growers. The average revenues per kg of bird are much lower for contract farmers reflecting the netting out of input costs by the processor.[3]

The final section of the survey is relevant only to contract farmers and it obtained information about the contract between the producer and the processor. In particular, this

[3] In the table, the average revenue per kg of bird is slightly different from the ratio of average revenues and average weight of the flock. This is because the former is the average of the ratio of revenue per kg of bird across production cycles and producers while the latter is the ratio of averages of total revenue and total flock weight.

section contains information about the nature of input sharing between the producer and the processor. As noted in the earlier section, processors supply chicks, medicine, feed and veterinary services. Growers supply land, buildings, labor, and other variable inputs such as electricity and disinfectants. Using the information on input sharing, Table 5 computes the total value of variable inputs and the value of inputs supplied by the grower. For the farmers not on contract, the two figures are the same. But this is not so for contract growers. For them, the processor supplies most of the inputs measured in value terms. On average, the out of pocket expenses for inputs for contract farmers is less than 3% of total input costs.

5. Is Contract Production more Efficient?

In this section, we consider the production efficiency of contract farming relative to noncontract production. We evaluate production efficiency from the point of view of the processor. As a processor has the choice of contracting with growers or procuring the bird from noncontracted growers, contract production should reduce processor's costs if it is to be observed. The efficiency of contract production is therefore evaluated relative to the production costs of independent growers.

Costs in contract production could be lower than in noncontract production in two distinct ways. First, because of technology and management practices brought by the processor, contract production could be more efficient than noncontract production. Second, if the processor can access some inputs such as insurance and credit at lower cost than growers, then contract production could be cheaper than noncontract production even if production efficiency is unchanged. While our data set lacks evidence on credit costs, it is not clear that even if information on differential credit costs were available, whether it would be appropriate to count such savings as due to contract production. Interest arbitrage possibilities exist even in the absence of contract production and such gains are realized by the creditors of noncontract growers. Therefore, from an economy wide point of view, it is the cost reduction from better technology and production practices that should be counted as efficiency gain.

Table 6 displays the major components of production costs in both modes of production.[4] It can be seen that the cost structure is comparable across the two production systems. Feed, medicine and veterinary services accounts for about 75% of total variable cost. The expenditure on chicks is about 20-22% of cost while other variable costs such as labor and electricity constitute only 3% of total costs.

As the cost of poultry production is primarily the cost of chicks and feed, the technology is characterized by constant costs. Table 7 displays the results of regressing the total variable cost on total output (measured in kgs). Recall the data set consists of observations from upto 6 production cycles for 25 contract and 25 noncontract growers. Thus, the error term will contain a producer-specific component. To take that into account, all standard errors are corrected for heteroskedasticity as well as dependence stemming from the correlation of errors from the production cycle of a particular producer.[5] The regression is done separately for contract and noncontract producers. The predicted value from these regressions is graphed against the dependent variable in Figures 1 and 2.

[4] Note we are considering only variable inputs.
[5] These are simply the Huber-White standard errors corrected for correlation within clusters (Rogers, 1993, Wooldridge, 2002). Here a cluster consists of observations from different production cycles for a particular producer.

From the results, it can be seen that it costs Rs. 30 to produce a kg of bird under contract production and Rs. 26.22 under noncontract production. This suggests that processors would be better off by abandoning contract production and should instead buy from noncontract growers. However, because contracting is a form of joint production, it should be remembered that it is the processors who determine the feed, medicine and chick costs of contract growers. Therefore, these numbers are not necessarily indicative of competitive prices but may well be a sign of transfer pricing.

To have cost figures that reflect competitive prices for feed and medicine, we recalculate contract production costs using the price paid by noncontract growers. This price is recovered from cost data of noncontract growers. Their unit feed costs depends on feed prices as well as the feed-conversion ratio. The feed price paid by noncontract growers can therefore be obtained as the ratio of their feed cost and their feed-conversion ratio.

The above procedure assumes unit costs for feed and medicine are constant. This is indeed the case as the feed and medicine costs are proportional to output. This has to be so because feed and medicine account for more than 75% of costs and as we saw earlier, total variable cost is linear in output. For noncontract growers, feed and medicine costs work out to Rs. 19 per kg of bird, which is calculated as the slope coefficient in a linear regression of feed and medicine costs on output. In the second step, we regress feed quantity on output and obtain the feed-conversion ratios as 1.88 and 2.15 for contract and noncontract growers.[6] In other words, noncontract growers use 2.15 kgs of feed to produce a kg of bird. Thus, the price of a kg of feed and medicine works out to be

(19/2.15) = Rs. 8.84 where we are assuming medicine requirements (medicine, vaccines and veterinary services) is proportional to feed.[7]

In the third step, we use this price and the feed quantity used by contract growers to recalculate their feed and medicine costs that would obtain if they were charged the same prices for feed and medicine as noncontract growers. To these costs, we add the observed costs for chicks and other inputs that are incurred by contract growers and we thus obtain a simulated figure for total costs for each production cycle of the contract grower.[8] Finally, by regressing the simulated costs on output, we obtain the marginal (and average) costs for the contract grower as Rs. 24.3. Compared to the marginal costs for the noncontract grower of Rs. 26.2 per kg, contract production involves a saving (relative to procurement from noncontract growers) of Rs 1.9 for every kg of bird.

This exercise does not take into account the fact that contract growers have shorter production cycles than noncontract growers. As contract production is more efficient than noncontract production at zero rate of interest, taking interest costs into account can only increase its relative advantage. Rs. 1.9 is a minimum bound on the surplus from contracting relative to contract production. For instance, assuming an annual interest rate of 15% per annum for both modes of production, the marginal costs

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[6] The R^2 in the regressions were 0.98 and 0.89 respectively for noncontract and contract growers. The intercept terms were positive but small. As a result, the average feed-conversion ratios are slightly larger than the marginal feed conversion ratios and this difference declines as output increases.

[7] Even if this assumption is invalid, it will not lead to large errors as medicine costs are small relative to feed costs. For noncontract growers, medicine costs are less than 0.5% of feed costs. A similar figure is not available for contract growers as the processors do not charge separately for feed and medicine. However, it is unlikely to be drastically different.

[8] In a linear regression of chick costs on chick numbers, the R^2 was 0.94 and 0.99 respectively for noncontract and contract growers, the slope coefficients were 12.03 for both groups. Thus the cost of an additional chick does not vary between the two production modes. This does not, of course, mean that the cost of day old chicks for contract growers is free from transfer pricing. A survey of the poultry industry in 2001 notes that integrated operations with breeding operations are able to produce day old chicks at a cost

of noncontract production rises to Rs. 26.77 while that of contract production rises to Rs. 24.7. The savings from contract production therefore rises to Rs. 2.07 per kg of bird per production cycle.

It might be argued that the borrowing cost of funds for growers would be higher than for processors that have access to institutional finance. For instance, if noncontract growers can borrow only at 21% when processors can borrow at 15%, the cost of noncontract production goes up to Rs. 26.95 while that of contract production does not change. It would seem then that the surplus from contract production rises to Rs. 2.28 per kg. However, note that Rs. 0.21 (the difference between Rs. 2.23 and Rs. 2.07) of this surplus is because of interest arbitrage by the processor and not because of greater production efficiency in contracting. As discussed earlier, in so far as such interest arbitrage possibilities exist even in the absence of contracting, it does not seem legitimate from an economy wide point of view to count the savings from interest arbitrage as part of the overall surplus from contracting relative to noncontracting.

The higher efficiency of contract production is driven by its lower feed-conversion ratio. To test this statistically, we pooled the samples of contract and noncontract producers and regressed feed quantity on output as well as output interacted by a contract dummy. The contract dummy is one for a contract farmer and zero otherwise. The coefficient on the interaction variable estimates the difference in feed-conversion ratios between the two groups of producers. The results are presented in Table 8. Once again the standard errors are corrected for heteroscedasticity as well as correlations between errors stemming from producer specific components. It is clear that

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lower than what independent operators source from breeders. However, our data does not allow us to adjust for transfer pricing in the cost of chicks.

the difference between the feed-conversion ratios for contract and noncontract production is statistically significant.

6. Do Contract Growers Earn More than Noncontract Growers?

In the earlier section, we analyzed the relative efficiency of the contract production system taking into account the costs to both growers and processors. Here we consider contracting from the point of view of growers alone. Do contract growers earn more than noncontract growers? To answer this question, we calculate for contract and noncontract growers their average income per kg of output from a production cycle. This is the difference between revenues and input costs. Revenues are from the sale of grown chicks, litter and bags. The value of home consumption, if any, is also imputed to revenues. Inputs consist of chicks, feed, medicine, vaccine, litter, veterinary fees, labor, electricity and disinfectants. For contact growers, however, the processor advances most of the value of inputs. Compared to the noncontract grower, the contract grower needs less working capital and therefore incurs lower interest costs. Information on the opportunity cost of funds for contract and noncontract farmers is, however, missing in the survey.

From studies of rural finance, we know that informal credit is widely prevalent and that it is more costly than credit from institutional sources. According to the all India rural credit survey, formal sector accounted for 53% of all rural credit in 1991. Moneylenders and friends or relatives account for the rest. More recent data from the World Bank indicates that access to formal sector credit is very limited for poorer households. According to the same survey, the median interest from banks (the primary institutional source) in 2003 was 12.5% per annum while the average interest rate from informal sources was 48%. For credit from institutional sources, transactions costs are also significant. These arise because of distance to financial institutions, cumbersome procedures and bribes ranging from 10% to 20% of loan amount (Srivastava and Basu, 2004). As a result, the effective cost of credit from formal sources is likely to be greater than the median interest rate. A survey in 2001 of the poultry sector reports that interest rates on commercial loans were typically around 15% per annum (USDA, 2004). As informal credit is more costly than this, an interest cost of 15% per annum can be taken to be a lower bound to the cost of credit for growers.

Table 8 compares the incomes from poultry farming for interest rates ranging from 15% to 30% per annum. As one would expect, the returns to noncontract growers declines significantly as interest rates rise while the contract farmers are almost completely insulated from credit costs. The returns are equal for both modes of production at a 10% rate of interest. For interest rates higher than 10%, the returns for contract growers are higher than that of contract growers. If we take 15% to be a representative borrowing rate for growers, contract farmers earn on average Rs. 0.15 per kg more than noncontract farmers, i.e., about 7% more than the per kg average earnings of a noncontract grower. We saw in the last section that contract production generates a minimum surplus of Rs. 1.9 per kg relative to noncontract production. If, in fact, 15% is the also cost of funds for processors, then contract production yields a surplus of Rs 2.07 per kg out of which farmers receive Rs 0.15 or about 7% of surplus. Note that the entire remainder is not the profit of processor as the processor also incurs costs in administering and managing contracts that are not taken into account here.

While the gains to contract farmer are not trivial in magnitude, they are not statistically significant when interest costs are 15% per annum (see last column of Table 8). The standard errors of the difference in returns between contract and noncontract growers are corrected for heteroskedasticity and within cluster correlation (a cluster here consists of production cycles from a particular producer). As the relative advantage of contract farmers increases with interest cost, the statistical significance of the difference also increases.

7. Correcting for Self-Selection

In the last section, we compared the average returns of contract farmers with the average returns of non-contract farmers. While this is useful to demonstrate the distribution of surplus from contracting, it is a biased measure of the gains that actually accrues to contract farmers because it does not take account of the fact that the processor purposively selects the contract farmers. Hence it is likely that the population of contract farmers differ from the population of non-contract farmers.

To take this into account, we adopt the treatment effects models from the program evaluation literature. Let y_{i1} be the returns with contracting and y_{i0} the returns without contracting for the *i*th producer. Clearly, only one outcome is observed for each producer. The average treatment effect is $E(y_{i1} - y_{i0})$ while the treatment effect on the treated is $E((y_{i1} - y_{i0}) \mid C_i = 1)$. Comparing mean outcomes of contract and noncontract farmers is equivalent to $E(y_{i1} \mid C_i = 1) - E(y_{i0} \mid C_i = 0)$ which is in general not equal to either the average treatment effect or the treatment effect on the treated.

In a regression framework, the treatment effects model is given by

(1) $$R_i = a + bC_i + \mathbf{c}'\mathbf{X}_i + \varepsilon_i$$

where R_i is the net returns of the *i*th producer, C_i is a dummy variable that takes the value 1 if farmer *i* is in contracting and takes the value 0 otherwise. $\mathbf{X}_i$ is a vector of control variables such as farmer characteristics (experience, and ε 's are zero mean random variables. *b* measures the impact of contracting on mean returns. Under the assumption of homogenous treatment effects, *b* identifies the average treatment effect as well as the treatment effect on the treated (Wooldridge, 2002).

If the variables in the **X** matrix include all the variables that influence whether a producer is a contract grower and if these variables are not correlated with the error term, then ordinary least squares estimates of (1) are consistent. These are displayed in the second column of Table 9 (assuming an interest rate of 15%). The estimate of the impact of contracting is comparable to the difference in group means (in Table 8) and is insignificant. Standard errors are corrected for heteroskedasticity and within cluster correlation. The other variables have the expected signs and are significant. The other variables in the regression are experience, experience squared, season, season squared and value of assets. Season is a variable that takes values from 1 to 12 and identifies the month in which production begins. Thus a production cycle with a season code of 1 begins production in early January and the output enters the market after mid-February. The season variable is therefore meant to take account of the seasonality in prices and production. As the seasonal trend is quadratic, we have also included the squared term of season.

If treatment impacts are heterogenous, then additional controls in the form of interactions of the contract dummy with the demeaned explanatory variables must be included (Wooldridge, 2002). These estimates are contained in the third column of Table 9. Note that under heterogenous effects, the average treatment effect and the treatment effect on the treatment no longer coincide and the coefficient on the contract dummy identifies the average treatment effect. The magnitude and significance of the average treatment effect improves but it is still not significant even at the 10% level.

We also ran these regressions assuming interest costs to growers are 20%, 25% and 30%. In Table 10, we report the summary in terms of the magnitude and significance of the contracting dummy. As one would expect, the average treatment effect is greater and statistically more significant, higher is the interest rate.

An ordinary least squares estimate of (1) is likely to be biased, however, if ε_i contains within it random unobservable factors, such as ability, which are not uniformly distributed within the population of contracting and noncontracting farmers. In such a case error term is likely to be correlated with C_i. Thus, for instance, if contract growers are more productive than noncontract growers because of unobserved ability, then a simple comparison of the means as well the OLS estimates of (1) would yield an overestimate of the true measure of gains from contracting.

Standard instrument variable procedures are used to correct for the bias from the endogeneity of right hand side variables. Consider a participation equation such as

(2) $$C_i = \gamma_1 + \gamma_2 Z_i + u_i$$

where Z_i is a vector of variables that matter for participation. Variables in Z_i will overlap with variables in X_i. Identification requires that there be at least one variable in Z_i that is not in X_i (Wooldridge, 2002) If this condition is met, the predicted value from (2), $\hat{C}_i$ can be used as an instrument for C_i in regression equation (1). This would yield a consistent estimate of *b* provided the instruments are uncorrelated with the error term in equation (1)

Table 11 displays the estimates from a participation equation. Growers who are at more distance from credit facilities, less specialized in poultry and with previous occupational backgrounds in nonagriculture are more likely to be contract growers. In addition, experience and schooling negatively affect the probability of being a contract grower. These results are consistent with anecdotal accounts in poultry of processors wishing to contract with growers with weak bargaining power. Such an outcome was discussed by Key and Runsten (1999). In their review of contract farming, they pointed out that the factors that disadvantage small farmers (such as lack of access to formal credit and insurance) also provide incentives for processors to contract with them.

Of the variables in the participation equation, distance from rural banks is the variable that seems to best fit the specifications of an instrument. It has predictive power in the participation equation and, conditional on the contract dummy, it is also redundant in the income equation. The variables of schooling, specialization in poultry and previous occupational background, could affect income in addition to their effect through participation. As it turns out, however, they are insignificant in the income equation possibly because their impact on the outcome works through grower's experience in poultry that is independently controlled for. Hence, these variables are also good instruments.

Table 12 contains estimates of equation (1) where the dummy for participation in contracting is instrumented by the predicted probabilities from the participation equation. Standard errors are corrected for heteroskedasticity and within cluster correlation. The other variables in the regression are experience, experience squared, season and season squared. The dependent variable in this regression is computed assuming the cost of credit to be 15% per annum. The second column in Table 12 is the IV counterpart to the OLS results in the second column in Table 9 assuming homogenous treatment effects while the third column in Table 13 is the IV counterpart to the OLS results in the third column in Table 9 and assumes heterogenous treatment effects.

The instrument variable estimates of the average treatment effect are larger and statistically more significant than the OLS estimates. The IV estimate from the homogenous effects model is significant at the 10% level and that from the heterogenous effects model is significant at the 1.4% level. Comparison with the OLS estimates suggests that correction for unobservables is important. The OLS estimates underestimate the gain from contracting because the unobserved factors that matter for selection as contract grower negatively impact incomes from poultry farming. While the OLS suggest modest impacts of between Rs. 0.15 – Rs. 0.2, the IV estimates are substantial ranging from Rs. 0.6 to Rs. 0.75 per kg. Considering average noncontract and contract returns are Rs 2.07 and Rs. 2.2 respectively, contracting raises returns by at least 25%. For higher interest rates, the impacts are even larger and highly significant. Once again, the results for these scenarios are presented only in summary form in Table 14.

8. Risk Shifting from Contracting

Calculating the mean income gains from contracting provides only a partial picture of the change in utility for contracting producers. As mentioned before, a fundamental feature of contract farming is the shifting of risk from producers to processors. In the broiler contract, much of the price risk is reduced by the use of the bro-mark (set by the processors) rather than the market price.

The most straightforward way to estimate risk shifting would be to compare the variability of net returns of contract growers with that of non-contract growers. But this comparison would once again be subject to bias because of the use of incorrect counter-factual. Knoeber and Thurman (1995) propose that the variability of net returns of contract growers be compared to the hypothetical or simulated returns that they would have received as "independent growers" i.e., if they had purchased inputs and sold their output at market prices and not contracted with the integrator.

Let σ_i denote the standard deviation for the *i*th producer. These are calculated from the data on 6 production cycles for each grower. Also let (σ_c, σ_n) and (v_c, v_n) denote mean standard deviation and mean coefficient of variation for the group of contract growers and noncontract growers respectively. They are estimated as the sample means of the σ_i's and v_i's and are reported in the first two rows (and second and third columns) of Table 15. The computations assume the lowest possible interest rate of 15% per annum. The table also reports the standard errors of these estimates. The figures show that the variability of returns of noncontract growers exceed that of contract growers by a factor of 8 or 10 depending on the measure of variability (standard deviation or coefficient of variation). However the estimate of average variability for the noncontract growers is not very precise because of the large differences in variability within the noncontract group. The coefficient of variation ranges between 0.23 and 4.3 for noncontract growers while it ranges between 0.023 and 0.26 for contract growers.

Following the Knoeber and Thurman methodology, we simulate the returns that would have been received by contract growers if they had not been on contract. There are two components of the simulation. First, for the inputs advanced by the processor (chicks, feed, medicine and vaccines), we value their cost using prices paid by noncontract farmers. Second, we use the price received by noncontract growers for their birds, bags and litter to value the output of these items by contract growers. As the prices received (for output) and prices paid (for inputs) by noncontract growers are not identically the same, we use the median figure in all the cases. In all imputations, we use figures from comparable production cycles. For instance, the price used to value a contract grower's output from production starting in January would be the median price of noncontract growers in the same month.

From the simulated series, we construct once again the mean and standard deviation of returns. Let s_i denote the standard deviation of the simulated series for the *i*th producer. Also let s_c denote the mean standard deviation for the group of contract growers. This is reported in the last column of Table 15. The variability of the simulated series is of the same order of magnitude as the variability of returns for noncontract growers. On average, the standard deviation of the simulated series is more than 8 times greater than that of the actual series.

For each individual grower we compute the ratio of the standard deviation of the simulated series to the standard deviation of the observed series. For the 25 contract growers, the average of this ratio is 13.4. The median ratio is 8.25 and the distribution ranges from a minimum value of 2.7 to a maximum value of 91. At the median level, growers under contracting bear only 12% of the risk that would have been borne by them as noncontract farmers. In other words, 88% of the risk in poultry farming is shifted from farmers to processors as a result of contracting.

The statistical significance of the reduction in variability can be assessed for each grower by testing the hypothesis that the simulated variance for the *i*th contract grower equals the variance of the observed series. As the simulated and observed series are correlated, Knoeber and Thurman derive a Wald statistic that takes this correlation into account. The statistic is

$$T_i = (s_i^2 - \sigma_i^2)/[(2/n)(s_i^4 + \sigma_i^4 - 2\rho_i^2)]^{1/2}$$

where for the *i*th producer, s_i^2 and σ_i^2 are the sample variances of the simulated and actual series, ρ_i^2 is the covariance between the two series and *n* is the number of production cycles. Under the null hypothesis that the variances of the two series are identical, the Wald statistic is asymptotically standard normal.

The median value of the Wald ratio is 1.69, which means that for 50% of contract growers the null of no difference in variability is rejected in favor of the one-sided alternative that the variability is greater in the simulated series at the 5% significance level. The smallest Wald ratios is 1.41. Hence the null would be rejected in favor of the alternative for all growers at the 10% significant level. The reason that the differences are not statistically valid at the 5% level for some growers is because of the very small number of production cycles as a result of which the differences in variability are estimated imprecisely.

The risk reduction from contracting can also be assessed by testing the null hypothesis that the median value of σ_i and s_i are equal. This can be done by making use of nonparametric tests for difference in medians using paired data. The paired data in this instance involves the observed and simulated standard deviations for each grower. The sign test considers the number of times the difference between the simulated and observed standard deviations is positive. The null is rejected if the number of differences of one sign is too large or too small (Gibbons and Chakraborti, 1992). In our case, the difference between the simulated and observed standard deviations is positive for each grower. Hence the null is rejected in favor of the alternative hypothesis that the median difference is positive.

If the distributions can be regarded as symmetric, one can also use the Wilcoxon signed-rank test. Here the absolute differences between the paired values is ranked and the test statistic is the sum of the positive signed ranks that is then compared to the tabulated critical values (Gibbons and Chakraborti, 1992). Here too the null is resoundingly rejected in favor of the alternative of positive differences at the 0% significance level.

9. Concluding Remarks

The literature on contract farming has emphasized the role of insurance and credit in explaining the existence and success of contract farming arrangements. This is undoubtedly the case in the instance of poultry farming as well. In terms of value, the processor advances the bulk of the inputs. Thus, we find that the gains to contract growers (relative to noncontract growers) is higher, greater is the cost of funds. We also find that contracting shifts a large portion of market risk from the grower to the processor.

In addition to these aspects, the poultry case considered here highlights the efficiency factor that has not received much attention in the contract farming literature. We find that contract production is more efficient than production by independent growers. As a result, by contracting, processors generate an efficiency surplus that is almost entirely appropriated by them. However, and despite this, contract growers do gain substantially even in terms of expected income even though their returns are not much different from what is received by independent growers (unless interest rates are greater than 20%).

The key to this puzzle is that poultry processors choose as contract growers those whose skills, experience and access to credit make them relatively poor prospects as independent growers. With contract production, these growers achieve incomes comparable to that of independent growers. As a result, the processor is able to capture most of the surplus from contract production (relative to procurement from independent growers) while offering at the same time significant gains to contract growers in terms of a reduction in risk as well as higher expected returns.

Crucial to this outcome are the improved technology and management practices that are employed in contract production. This results in lower feed-conversion ratio and is achieved by producers whose endowments are not as suited to poultry production as the independent growers. This is possibly due to standardization of production practices in contract production as contract growers exhibit a striking homogeneity in feed-conversion ratios and expected returns relative to independent growers. As this is achieved by close supervision on the part of the processor, contract farming in poultry can be seen as a response to double-sided moral hazard, which was put forward, by Eswaran and Kotwal (1985) to explain sharecropping.

The fact that contract production in poultry has benefited growers substantially suggests that these growers are not bereft of bargaining power. But what is the source of this bargaining strength? Why does not the processor offer growers a contract that is only slightly better than their reservation utility in their alternative enterprise (say as subsistence growers)? Poultry contracting involves the use of improved and standardised technology and production practices. This involves supply of inputs, close contact and training of the contract grower. Protecting this investment (in inputs and training) requires that default by growers and turnover in their ranks should be minimum. This in turn is achieved by processors offering above reservation utility contracts akin to efficiency wages. In its absence, the threat of denial of future contracts is not a major deterrent to default and defection by contract growers.[9]

The poultry case study suggests that contract farming is a useful institutional arrangement for the supply of credit, insurance and technology to farmers – all of which are otherwise very demanding problems. For many commodities, however, contract farming in India is not legal because of the agricultural produce marketing acts which make it mandatory for commodities under the act to be wholesaled in regulated markets. Removing these prohibitions would be important to widen the scope of contract farming. Some observers believe that contract farming should be regulated to ensure that processors live up to the promises made in the contract regarding the quality of inputs,

[9] Such threats are the primary means by which processors enforce contracts (Key and Runsten, 1999). A leading processor in India commented "Our rule is very clear – we will never work with you once you violate our contract" (interview with Executive Director, Pepsico Holdings Pvt. Ltd, Agriculture Today, September 2004).

provision of credit and the buy-back arrangements. Note, however, that this is not an issue in the poultry example where the processor supplies 97% of the value of inputs. As a result, the interests of the processor and the grower are closely aligned.

Figure 1: Cost Function for Noncontract Producers

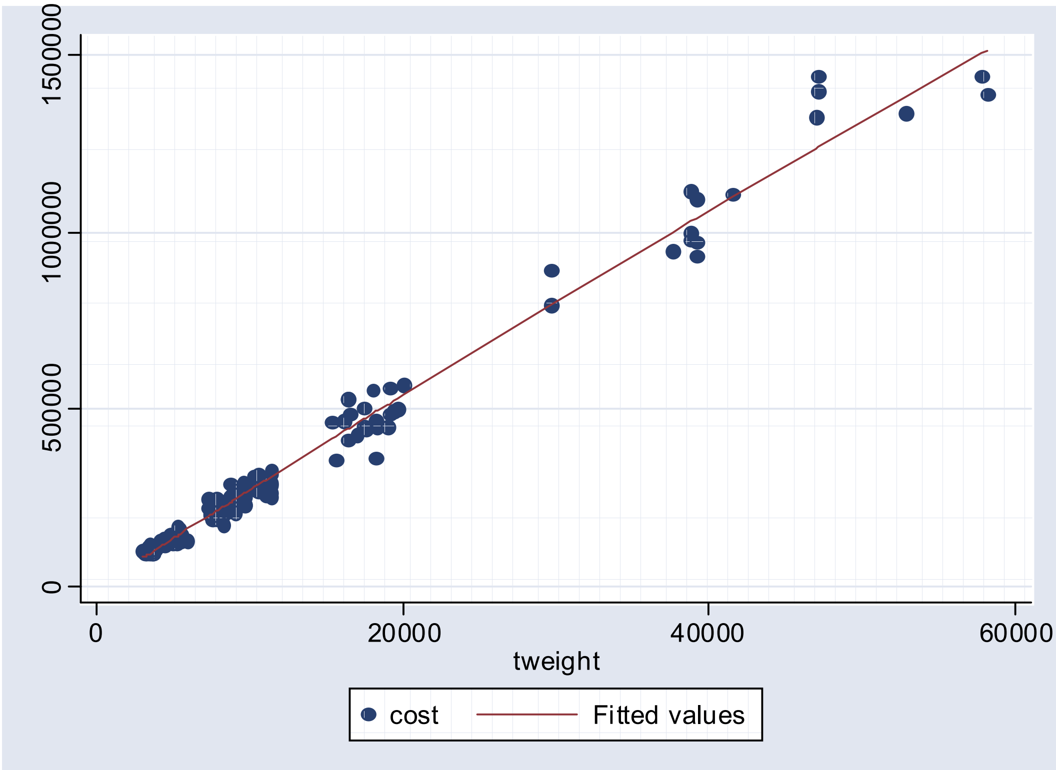

Figure 2: Cost Function for Contract Producers

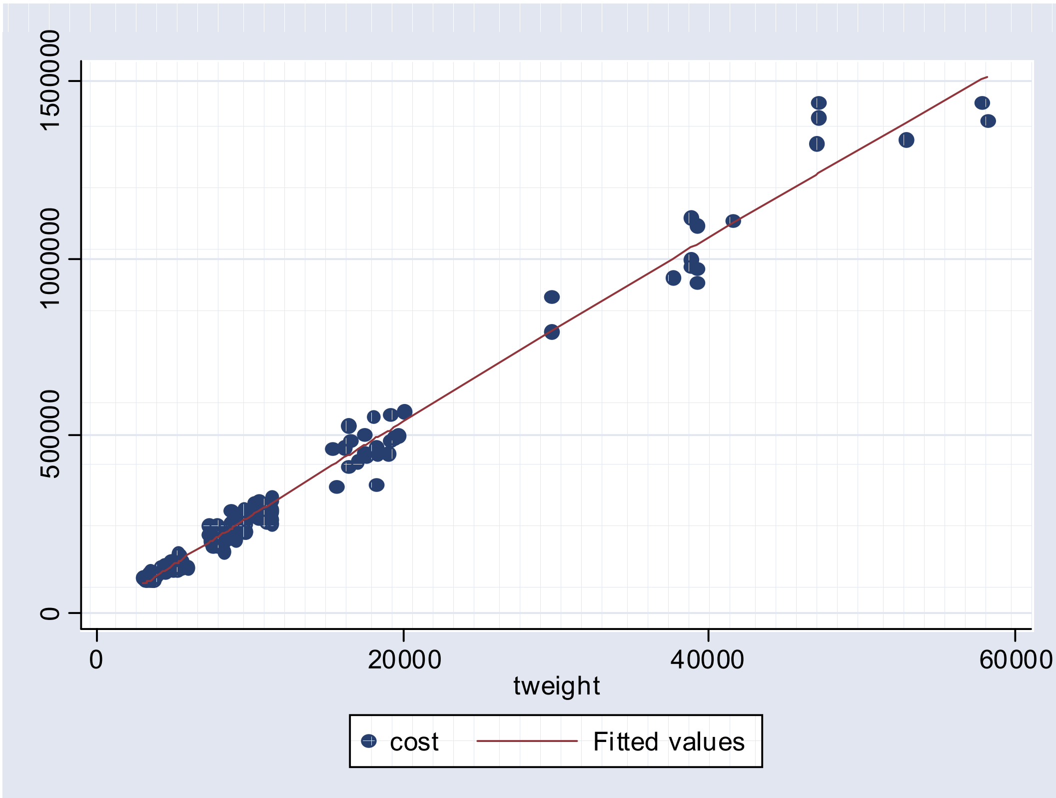

Table 1. Access to Infrastructure

Item	Noncontract	Contract
Distance to urban area	28.36	17.16
Distance to coop credit society	0.43	2.48
Distance to regional rural bank	1.2	6.84
Distance to primary dairy cooperative society	0.48	8.5
Distance to vet. Hospital	.8	0.71

Table 2. Characteristics of Poultry Producers

Item	Noncontract	Contract
Experience in poultry	9.8	4.9
Age	36	39
Years of schooling	11.6	10.9
Proportion of farmers whose main occupation is poultry	72	36
Proportion of farmers whose subsidiary occupation is poultry	28	64
Proportion of farmers whose earlier occupation was in agriculture/poultry/ dairy/ agricultural labour/ agriculture-related business	75	58
Proportion of farmers whose earlier occupation was in non-agriculture	25	42

Table 3. Input Use by Poultry Producers
Averages Per Production Cycle

Item	Noncontract	Contract
Time: Cycle length (days)	48.4	42.6
Litter, quantity (quintals)	13.2	17.8
Litter , value (Rs.)	991	1,375
No of chicks	6,891	8,149
Chicks, value (Rs.)	70,217	96,558
Feed qty (quintals)	276	277
Medicine + Feed, Value (Rs.)	244,615	307,246
Vaccinations per cycle	2.53	3
Vaccination, cost	6,174	8,148
Veterenian fees (Rs.)	268	566
Labour cost (Rs.)	5,076	6,152
Family labour (male) (Days)	26	23
Family Labour (female) (Days)	4	3.2
Hired labour (male) (Days)	76	104
Hired labour (female) (Days)	37	33
Electricity, value (Rs.)	2,930	2,925
Bulbs, (Rs.)	335	274
Disinfectants (Rs.)	861	993
Total shed area (square feet) per grower	9501	6335
No. of Brooders per grower	12	24
No. of Feeders per grower	158	175
No. of borewells per grower	0.36	0.6
No. of overhead tanks per grower	0.72	0.68

Table 4. Output and Revenues: Averages Per Production Cycle

	Noncontract	Contract
Output: # of birds	6583	7808
Mortality: # of birds	302	388
Average total weight of birds sold (Kgs)	12105	13638
Average Weight per bird, Kgs	1.87	1.87
Revenues from bird sales (Rs.)	355,732	37,217
Average Revenues/Kg of bird sold	29.1	2.62

Table 5: Input Sharing: Averages per Production Cycle

Value of all inputs (Rs.)	331,468	424,200
Value of inputs supplied by farmer (Rs.)	331,468	12,249

Table 6: Cost structure of Poultry Production
Averages per Production Cycle

	NonContract	Contract
Chicks, value (Rs.)	70,217 (20%)	96,558 (22.5%)
Feed & Medicines (including vaccinations and veterinarian fees)	251,058 (77%)	315,959 (74.5%)
Labor, electricity & other inputs	9,203 (3%)	10,344 (3%)
Total	331,468	424,200

Table 7: Cost function of Poultry Producers

Dependent Variable: Variable cost per production cycle

Variable	Non-Contract	Contract
Constant	6635 (2.17)	-11192 (-1.45)
Output (kgs)	26.28 (110)	30 (36)
R^2	0.983	0.98
# Observations	145	140

t-statistics in parantheses

Table 8: Feed-Conversion Ratios

Dependent Variable: Feed Quantity

Constant	7.98 (1.8)
Output (kgs)	2.16 (81)
Output x Contract Dummy	-.029 (-3.9)
R^2	0.983
# Observations	145

t-statistics in parantheses

**Table 9. Returns to Poultry Producers:
Average Income Per Production Cycle (Rs/Kg)**

Annual interest rate	Contract	Noncontract	Difference (t-value)
15%	2.20	2.05	0.15 (0.76)
20%	2.20	1.9	0.3 (1.49)
25%	2.19	1.66	0.44 (2.2)
30%	2.18	1.47	0.58 (2.84)

Table 10. Income Equation: Ordinary Least Squares

Dependent Variable: Income (Rupees) per kg per production cycle

Explanatory Variables	Coefficients (t-values): Homogenous Treatment Effects	Coefficients (t-values): Heterogenous Treatment Effects
Contract Dummy: C	0.16 (0.97)	0.21 (1.39)
Season: X_1	-0.66 (4.98)	-1.23 (5.18)
Season squared: X_2	0.055 (5.27)	0.09 (5.72)
Experience: X_3	0.19 (3.77)	0.29 (3.15)
Experience squared: X_4	-0.01 (3.93)	-0.017 (3.52)
$C*(X_1 - \overline{X}_1)$	---	1.16 (4.87)
$C*(X_2 - \overline{X}_2)$	---	-0.09 (5.33)
$C*(X_3 - \overline{X}_3)$	---	-0.25 (2.33)
$C*(X_4 - \overline{X}_4)$	---	.015 (2.39)
Constant	2.98 (8.83)	3.84 (2.39)
R^2	0.15	0.23
No of Observations		

Table 11: OLS estimates of Treatment Effects Under Varying Interest Rates

Interest Rate	Average Treatment Effect (t-value): Homogenous Effects	Average Treatment Effect (t-value): Heterogenous Effects
15%	0.16 (0.97)	0.21 (1.39)
20%	0.3 (1.85)	0.35 (2.36)
25%	0.44 (2.69)	0.49 (3.28)
30%	0.58 (3.47)	0.63 (4.16)

Table 12: Probit Equation: Factors Influencing Participation in Contracting

Explanatory Variables	Coefficients (t-values)	Marginal Effects
Distance from Regional Rural Bank	0.17 (6.62)	.07
Years of Schooling	-0.06 (-2.2)	-0.02
Experience	-0.54 (5.94)	-0.21
Experience squared	0.02 (4.52)	0.009
Whether previous in Non-Agriculture	0.74 (3.17)	0.29
Whether Poultry is main occupation	-0.84 (-4.01)	-0.32
Constant	2.45 (5.6)	--
No. of Observations	50	50

Table 13: Income Equation: Instrument Variables

Dependent Variable: Income (Rupees) per kg per production cycle

Explanatory Variables	Coefficients (t-values): Homogenous Treatment Effects	Coefficients (t-values): Heterogenous Treatment Effects
Contract Dummy: C	0.61 (1.69)	0.74 (2.54)
Season: X_1	-0.66 (4.99)	-1.05 (4.07)
Season squared: X_2	0.055 (5.32)	0.08 (4.4)
Experience: X_3	0.22 (3.37)	0.33 (2.54)
Experience squared: X_4	-0.01 (3.68)	-0.017 (3.04)
$C*(X_1-\overline{X}_1)$	---	0.78 (2.37)
$C*(X_2-\overline{X}_2)$	---	-0.06 (2.33)
$C*(X_3-\overline{X}_3)$	---	-0.24 (1.14)
$C*(X_4-\overline{X}_4)$	---	.014 (0.93)
Constant	2.47 (4.97)	2.96 (1.07)
No. of Observations	285	285

Table 14: IV estimates of Treatment Effects Under Varying Interest Rates

Interest Rate	Average Treatment Effect (t-value): Homogenous Effects	Average Treatment Effect (t-value): Heterogenous Effects
15%	0.61 (1.69)	0.74 (2.54)
20%	0.76 (2.11)	0.9 (3.05)
25%	0.92 (2.50)	1.05 (3.53)
30%	1.06 (2.87)	1.19 (3.97)

Table 15: Variability of Returns

	Noncontract	Contract (Observed)	Contract (Simulated)
Mean of Standard Deviations of Individual Growers (standard error)	$\sigma_n = 2.29$ (0.84)	$\sigma_c = 0.26$ (0.16)	$s_c = 2.17$ (1.29)

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