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Contract Farming, Profitability, and Adoption of Food Safety Measures in Broiler Production in Bangladesh

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ABSTRACT

This study, based on a primary survey conducted in Bangladesh in 2016, assesses the impact of contract farming in broiler production on profits and the adoption of food safety measures at the farm level. It also estimates the determinants for participation in contract farming, finding a farmer's education and broiler-housing structure to be significant determinants. This study uniquely assesses the association of contract farming with the provision of well-defined food safety attributes. It finds that contract participation enhances farmers' net returns by as much as 215–280% and raises compliance with food safety measures by around 13%. Increased productivity and provision of non-price attributes such as food safety in the product account for the difference in farmer returns.

Keywords: Contract farming, broiler, enterprise, generated instruments, Bangladesh

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ACRONYMS

2SLS	2-Stage Least Squares
DOCs	Day Old Chicks
FSI	Food Safety Adoption Index
FSMs	Food-Safety Measures
GAP	Good Agricultural Practices
IV	Instrumental Variable
OLS	Ordinary Least Squares
Tk	Taka

1. Introduction

Contract farming is one solution to overcoming market-related transaction costs. When transaction costs are high, market outcomes turn out to be inefficient owing to factors such as asymmetric information. Furthermore, when credit and insurance markets are underdeveloped, small farmers are unable to absorb fixed costs (for example, in transportation) and inherent transaction risks.

In this paper, we look at a typically smallholder-dominated production and marketing system (i.e., poultry in Bangladesh). We use this case study as a starting point for examining how some of the problems in a smallholder-based system have been addressed through contract farming between farmers and integrators. The setting is characterized by a duopoly in the output market, and our study focuses on farmers linked to one of the firms in that duopoly. We explore broad questions related to the organization of production and marketing, as well as some finer details related to cost sharing, service provision, joint ownership, profit sharing, and risk mitigation.

Understanding the implications of contract farming for small farmers is important for several reasons. First, most poultry farmers in Bangladesh are small. Second, one of the strongest objections to contract farming in developing countries stems from the perception that big integrators will exploit small farmers. Third, small farmers relying on subsistence farming shun commercial farming simply because they are unable to absorb the risk of losses associated with commercial production. In doing so, they give up opportunities to earn higher expected incomes and settle for options that yield a lower but comparatively safe return. Contract farming is expected to mitigate this predicament for small farmers.

In a smallholder-dominated system, where market volatility is common, risks associated with the commercial production of perishables are magnified. Also, as incomes rise in countries like Bangladesh, consumers increasingly demand attributes such as food safety, especially in animal-source food like poultry. Small farmers are often separated from consumers and unable to gauge consumers' preferences, or otherwise unable to deliver on them due to the fixed costs associated with ensuring safety and quality. Moreover, small farmers usually lack the capital and technical expertise required in livestock production, which is typically more input intensive than subsistence-crop farming

(Ramaswami, Joshi, and Birthal 2006). If contract farming as an organization is to succeed in developing countries, it must address the unique problems faced by small farmers and build capacity to deliver on quality and food safety.

In this paper, we argue that contract farming is, indeed, beneficial to the small farmers in the context of poultry in Bangladesh. We test several hypotheses that illustrate its benefits. If contract farmers were to make systematically higher profits, then economic rationality would imply that every farmer should be in a contract. Contract farmers must show certain characteristics that non-contract farmers do not possess, the lack of which turns out to be an entry barrier into contracting. We check for these characteristics that enable farmers (particularly small farmers) to participate in contract farming.

We find that when the integrator supplies an input, its price is lower than the prevailing market price. Correspondingly, the integrator pays a product price that is lower than the market price. Many critics of contract farming point to the lower output price as an illustration of the exploitation of small farmers by integrators. However, we show that this assessment is incorrect because it only accounts for one side of the market when the contracting firm operates on both sides—supplying inputs and buying the output. Thus, a more comprehensive examination is needed in order to ascertain the true implications of contract farming. If the firm is not allowed to pay a lower product price, then it will offset additional costs by eliminating input subsidies. Not only is this a sub-optimal scenario for the firm, but it will also result in a lower return for the liquidity-constrained small farmer.

So what exactly does the firm bring to the contract? Being risk-neutral or at least relatively less risk-averse than the farmer, the firm presents the farmer with an opportunity to exchange risk. In addition, the firm brings in new technologies as well as the monitoring and quality-control processes needed to implement them effectively. Which part of the contract is for risk mitigation and which part is a pure technological input is unclear. In both cases, the input and output prices are generally lower than prevailing market prices. This inseparability is especially apparent in the delivery of Good Agricultural Practices (GAP) by contracted farmers, which besides being the product of technological input, is also a source of reduced risk.

The objective of this study is twofold. First, we aim to identify factors that influence farmers' participation in contract farming. Second, we aim to estimate the impact of contract farming on profits

and compliance with food-safety measures (FSM). Decades ago, Glover (1987) argued that research on contract farming and small farmers must "systematically examine successes and failures and from them draw generalizations about the conditions under which contract farming can operate profitably and to the benefit of small farmers." This paper is among the few that capture the successes of contract farming in a smallholder system (in terms of farmer incomes and delivery of higher standards of food safety).

Other studies on the impact of contract farming on smallholders do depict a mixed picture, and each case merits individual exploration. The present study, like Mishra et al. (2018) and Bellemare and Lim (2018), assesses the participation in contract farming in the context of a high-value commodity in a developing country. While Mishra et al. (2018) and the present study identify risk as a prominent factor driving farmers' participation in the contract, Bellemare and Lim (2018) find that contract farming reduces risks for farmers if they participate in contract farming.

Studies do find that contract farming helps improve the income of farmers and creates employment opportunities for poor rural workers (Glover 1984; Goldsmith 1985; Glover and Kusterer 1990; Key and Rusten 1999; Warning and Key 2002; Simmons, Winters, and Patrick 2005; Ramaswami, Joshi, and Birthal 2006; Miyata, Minot, and Hu 2009; Kyomugisha, Mugisha, and Sebatta 2017). However, several studies also point to the negative impacts of contract farming on the environment and welfare of farmers (Little and Watts 1994; Singh 2002). Commonly, these papers highlight the exploitative nature of contract farming for the small farmers due to the firm's monopsony power as a buyer. Are outcomes for small farmers different in a duopoly scenario? We explore this question here.

We use primary farm household survey data collected between June and August of 2016 in two districts of Bangladesh (Kishoreganj and Narsingdi), under the Dhaka division, located in the central part of the country. In these districts, commercial broiler production under contract farming is most commonplace.

Results reveal that contract farming increases farm performance (in terms of profitability) relative to non-contract production. In fact, even if the surplus were appropriated by the processors, contract growers still derive significantly higher returns. Importantly, results also show contract production to be associated with higher adoption of FSMs. Compliance with GAP is also a significant

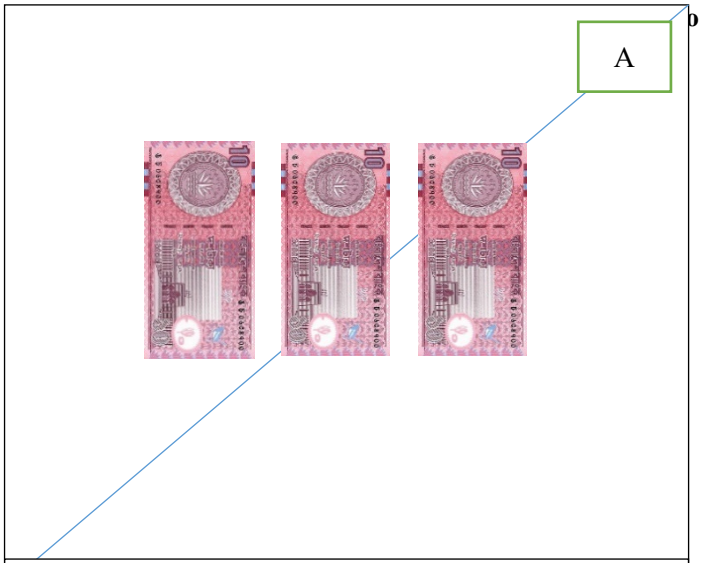
determinant of price realization in modern food systems due to consumer's willingness to pay a premium for safety. The impact of contract farming on the adoption of FSMs is often overlooked, and the existing literature presents hardly any empirical evidence related to this aspect of contract farming. This study will try to fill that void.

There is a significant issue related to selection and participation of farmers in contract farming. There are farmers with certain characteristics who might self-select into contracting. This could be in terms of educations, experience or due to risk preferences. If contract farming were primarily a risk sharing mechanism then risk averse farmers would be more likely to participate. On the integrator side, there is selection of farmers who could be most profitable for the contractor. The selection by contractor could be screening based on attributes like size, education, personal capital among others. When both sides' conditions for participation are met the farmer becomes part of contract farming arrangement.

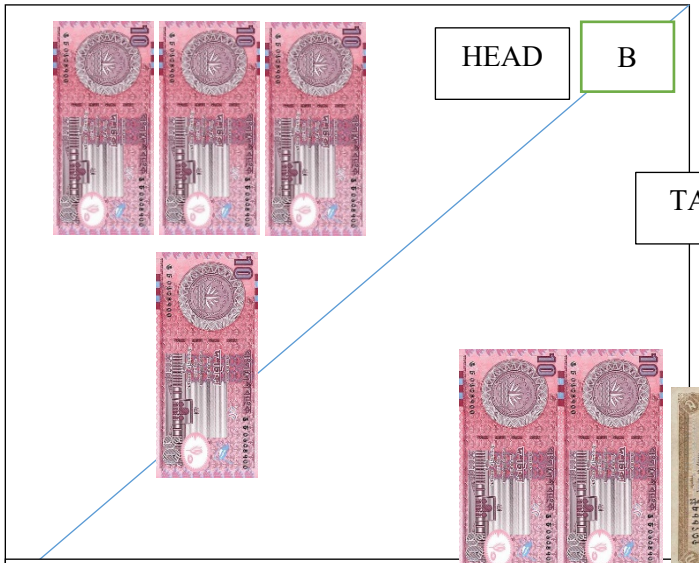
To identify the factors driving farmer participation in contract farming, we appeal to data collected from a small experimental assessment of farmer risk preference prior to entering a contract arrangement (see Figure 1.1). To elicit information on risk preferences, we rely on a simple game where different combination of payoffs were made available to farmers with varying probabilities. The prior is that the farmers who need as greater expected payoff in relation to payment with certainty are comparatively risk averse. If contract farming were to transfer risk to the integrator, ceteris paribus, degree of risk aversion measured through risk premium and the level of market risk prior to contracting would determine choice of farmers in terms of choosing to be a contract farmer or not.

In general, the perceived higher risk in the absence of a contract—stemming from variability in output prices—creates incentives for risk-averse farmers to become contract growers. In the game, we ask farmers to choose from a number of options with varying risk—reward profiles. The difference between the expected return from choosing the riskier option and the lower guaranteed return accompanying the risk-free option is a summary measure of risk premium (i.e., the extent of farmer risk aversion).

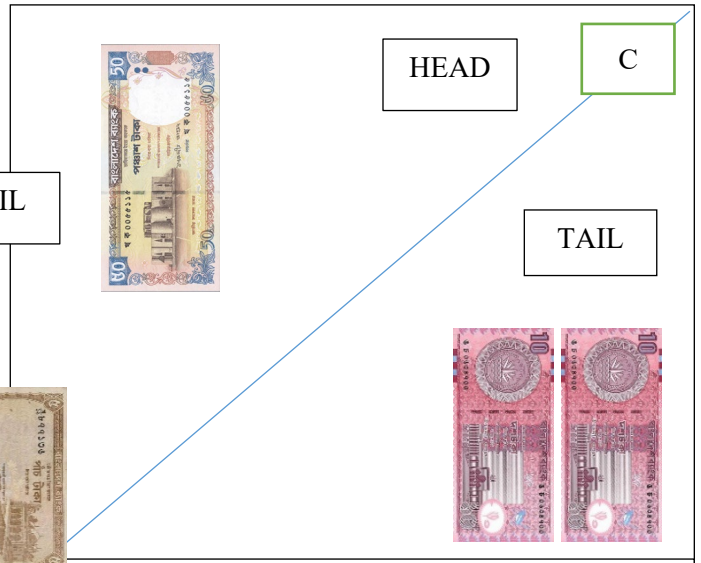
Figure 1.1: Risk measurement game: If I request you to play a game like this which option (A, B, C, D, E, F) you will choose



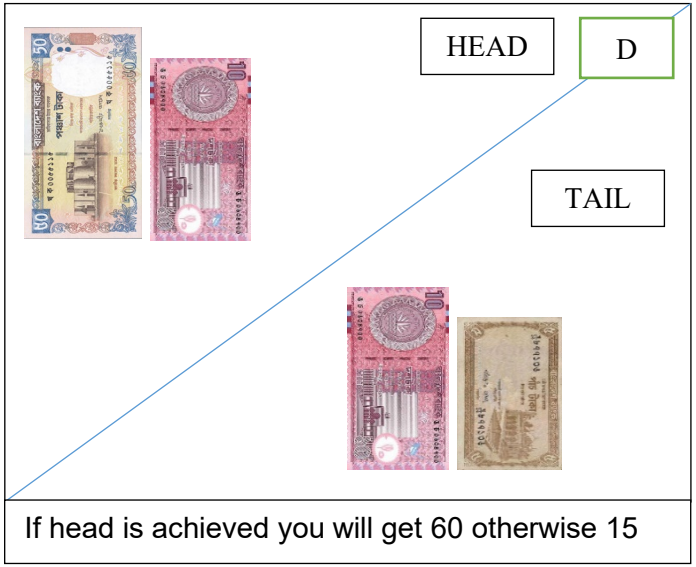
If you choose A you will get 30 Tk.



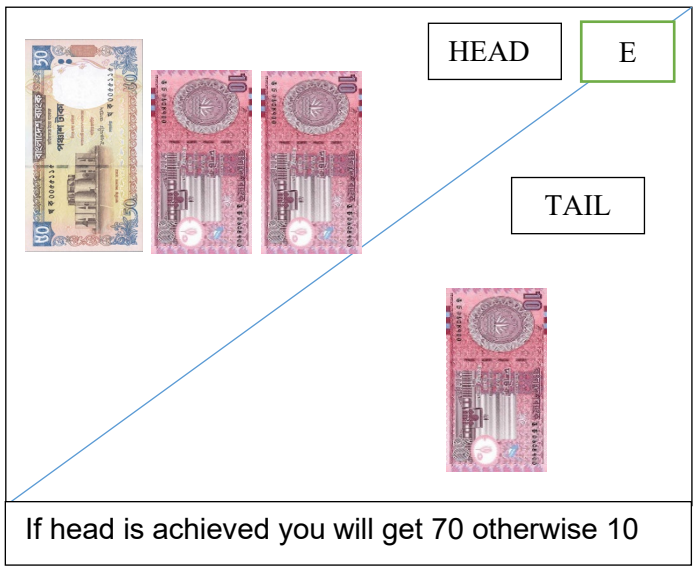
If head is achieved you will get 40 otherwise 25



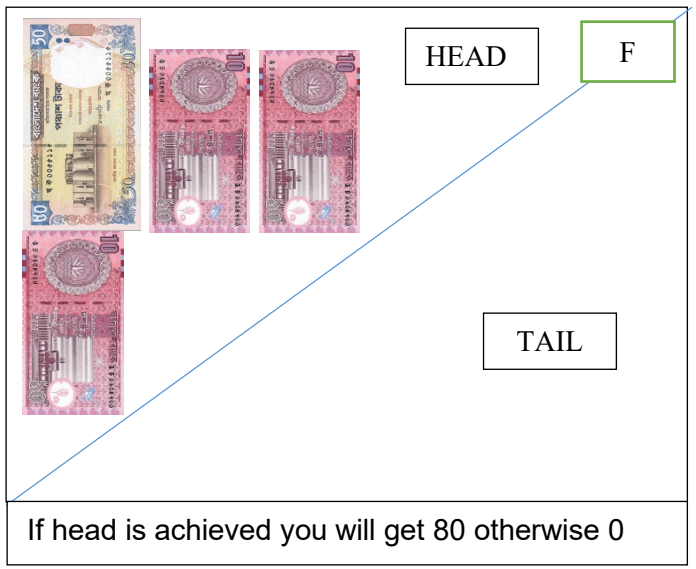
If head is achieved you will get 50 otherwise 20



If head is achieved you will get 60 otherwise 15



If head is achieved you will get 70 otherwise 10



If head is achieved you will get 80 otherwise 0

The premise is that those farmers who are comparatively risk averse would have greater incentive to enter into a contract when faced with variability in prices. Specifically, we use erstwhile variability in the output price of contract and non-contract producers interacted with farmer risk preferences as elicited from the game as an instrument for exploring the causal link between contracting and farmer returns. The instrument is rooted in an existing theory of contract farming that proposes that risk sharing between farmers and integrators is the primary driver of participation (Bellemare 2012). We see that participation in contract farming results in lower levels of price and income variability and the marginal utility of participation in contract farming is a positive function of a decrease in price or income variability in relation to the pre-contracting state. Lower variability in price is then associated with more stable incomes, which for risk-averse farmers leads to higher welfare.

Using observable data on the variability of price prior to contracting interacted with farmer-specific measures risk aversion as valid instruments, we do find support for the hypothesis that fixed-price or near-fixed-price contracts transfer price risk from the poultry grower to the integrator and are associated with participation in contract farming.

We relied on the method introduced by Lewbel (2012) to measure the robustness of our results. The Lewbel approach uses data-driven technical instruments to obviate inconsistencies in IV estimates arising from possibly invalid instruments. We do find evidence for negative selection, as contract growers have relatively weaker prospects as independent farmers. However, our results show that contract growers still gain significantly, possibly in terms of lower risk and higher expected returns. Technology transfer and the process by which the integrator selects the farmers make these outcomes possible.

The remainder of the paper is organized as follows. Section 2 describes the risk measurement game played with farmers to measure their risk preferences. The third section gives a primary overview of the poultry production system in Bangladesh. Section 4 describes the survey data and descriptive statistics. Section 5 offers a methodological approach. Estimation results are presented and discussed in Section 6, while Section 7 concludes and provides some implications of the study.

2. Risk measurement game

The questionnaire administered to the farmers during survey included a risk-measurement game, played individually with each participant to assess the risk preference level. The respondents were given a choice to select one option out of six given options. Each option was associated with a specific combination of risk and reward, based-on getting a head or a tail in tossing a coin. The extent of risk increased with each successive option, from no risk in the first option (i.e., option A) to maximum risk in the sixth option (i.e., option F). However, no actual financial transfer was involved in the game.

Figure 1.1 exhibits the pictorial presentation of the options, as given in the questionnaire. Option A offered an assured fixed payment of Taka 30, without any risk. Option B provided Taka 40 for getting a head but only Taka 25 for getting a tail, in a toss of coin. Option C involved Taka 50 for a head while Taka 20 for a tail. Option D presented Taka 60 for a head and Taka 15 for getting a tail. Option E gave Taka 70 for having a head and Taka 10 for receiving a tail. Finally, option F, representing the maximum risk, provided Taka 80 for a head but gave absolutely no money for getting a tail.

We calculated expected realization of an option as average of returns from head and tail outcomes, weighted by their probability (i.e., probability of 0.5 each for getting a head or a tail in a toss of coin). Accordingly, the expected financial realization from the six options were: Taka 30.0 (option A), Taka 32.5 (option B), Taka 35.0 (option C), Taka 37.5 (option D), Taka 40.0 (option E) and Taka 40.0 (option F).

Then, we estimated risk-preference with respect to each option. The risk-preference measure for an option was the difference between the expected financial realization of that option minus the expected realization of the first option i.e., option A that offered assured payment of Taka 30 without any risk. Hence, the risk-preference measures for the six options were: Taka 0.0 (option A), Taka 2.5 (option B), Taka 5.0 (option C), Taka 7.5 (option D), Taka 10.0 (option E) and Taka 10.0 (option F).

The farmers choosing options A had minimum risk-preference measure i.e., they had lowest risk-preference and were most averse to risks. Therefore, they were more likely to participate in the contract to mitigate their risks. On the other hand, farmers selecting option F had highest risk-preference and were less likely to participate in the contract.

3. Broiler production in Bangladesh

The livestock sector accounts for approximately 14% of agricultural gross domestic product (AgGDP) and 2% of overall GDP in Bangladesh. Poultry is a crucial component of the sector with the majority (84% in 2017-2018) of production attributed to broiler farming (BBS 2019). Out of 8.8 million agricultural households in Bangladesh, 5.3 million are engaged in broiler production (BBS 2017).[1]

Contract farming in broiler chicken is practiced in various forms in Bangladesh, ranging from formal production-marketing contracts in the case of vertically integrated enterprises to formal or informal input-marketing and output-marketing contracts (Jabbar et al. 2007). The production-marketing contracts involve the supply of inputs and services by contracting firms to the broiler producers for purchase under a predetermined condition. These are generally less common in broiler farming relative to input-marketing and output-marketing contracts, which have a more extensive spread throughout the country and cover a greater number of broiler producers.

[1] The commercial production of broiler began during the early 1990s in Bangladesh. Since then, the rising demand for broiler has resulted in the emergence of many commercial broiler farms in Bangladesh. Private firms like Aftab Bahumukhi Farm Limited, Biman Poultry Complex, Kazi Farm Limited, Paragon Poultry, and Nourish Feed Limited have invested in augmenting the supply of key inputs like DOCs (day old chicks) and feed for commercial production of broiler in Bangladesh.

4. Data and Descriptive Statistics

4.1 Data

Multi-stage sampling design was used in the survey. In the first stage, eight sub-districts were selected in two districts based on the incidence of contract farming. In the second stage, we identified 34 union councils from these sub-districts based on the prevalence of contract production. Finally, two villages were randomly selected from each union. In total, 359 households were sampled in the selected villages. The sample comprises 175 contract farmers and 184 non-contract farmers. Detailed information was collected about the socio-economic characteristics of the contract and independent farmers, along with information regarding production portfolios, income and asset levels, costs of broiler production, yield levels, labor use, production practices, social networks used for acquiring information for various activities, and contracting experiences.

4.2 Characteristics of Contract and Independent Producers of Broiler

The survey instrument also collected information about village-level infrastructure where the farmer was located. Comparing contract and non-contract farmers, we include indicators for socio-economic and demographic characteristics. The survey elicited information about farmer characteristics including age, schooling, and experience in broiler farming. Table 4.1 summarizes the differences between contract and non-contract farmers in terms of individual characteristics.

The average age of surveyed farmers was 41 years, and the average educational background included 9 years of schooling. Landholdings among surveyed farmers were particularly small, though non-contract farmers held slightly more land on average. Only 21% of broiler producers had a *Pucca* (concrete) broiler housing structure, with fewer contract growers having such an arrangement. The average asset index for contract producers (2.1%) was lower than that for independent farmers (3.7%). The average batch size was 1,743 birds for contract growers and 1,840 birds for non-contract producers. The majority of broiler farmers, and especially contract farmers, we surveyed were thus small-scale producers. Contract growers produced an average of 5.8 batches annually, while non-contract farmers averaged 6 batches per year.

Production costs were lower among contract farmers, possibly because these farmers had access to cheaper inputs (e.g., credit and insurance) and more sophisticated technology and management practices supplied by the integrator. Around 28% of surveyed households had access to institutional credit. Access to credit is a significant differentiator between contract and non-contract poultry growers in the sample, as substantially more contract farmers (37.1%) had access to institutional credit relative to their independent counterparts (20.1%). Contract farmers could thus be better insulated from interest rate changes that increase credit costs, relative to non-contract farmers. However, our data lacks evidence on differential credit costs between contract and independent producers.

In terms of access to information, 39% of farmers were visited by government extension agencies and 30% were visited by private extension agencies. A smaller percentage of contract growers had links with private or public extension entities, as these services are included in contract provisions

The average weight of birds sold by contract growers (1.71 kg/bird) was higher compared to independent producers (1.66 kg/bird). Moreover, the cost of production of broilers was lower for contract producers (Taka 124.2/kg) than for independent farmers (Taka 127.1/kg). Table A.1 provides a percent composition of costs associated with broiler production. Feed accounts for the greatest percentage of total cost (55.4%) followed by day-old chicks (31.3%). Table A.2 presents these costs in terms of cost per kilogram of bird sold. Contract producers incurred an average feed cost of Taka 68.1/kg, compared to Taka 70.5/kg for non-contract farmers. The level of compliance with FSM in broiler production was significantly higher among contract farmers (53.7%) than it was among their independent counterparts (47.9%).

Contract producers were adopting 54% of food safety measures prescribed for broiler farming, whereas 48% of these measures were being adopted by independent farmers. Further, across various batch-size classes, contract farmers were better adopters of FSM than their non-contract counterparts (Table A.3). Overall, around 36% of broiler farmers were low adopters of FSM, following less than 40% of the prescribed food safety practices. Around 33% of contract farmers and 27% of non-contract farmers were high adopters of FSM and followed more than 70% of the prescribed food safety practices (Table A.4). Table A.5 shows adoption levels for various practices associated with food safety across each farmer category. Adoption of two of these practices—'assessment and protection of environment

& natural resources' and 'appropriate use/handling of facilities for broiler rearing'—was significantly higher among contract farmers than non-contract farmers

Table 4.1: Characteristics of contract and independent broiler farmers in Bangladesh

Characteristics	All	Contract	Independent	Difference	*t*-Test value
Age (years)	41.1	41.5	40.7	0.8	0.6827
Education (years)	9.0	8.8	9.1	-0.2	0.5382
Experience in broiler-farming (years)	6.8	7.2	6.4	0.8	1.2688
Income earners in family (number)	1.5	1.6	1.5	0.1	0.7638
Islam as religion (% of farmers)	91.9	91.4	92.4	-1.0	0.3337
Land size (ha)	0.42	0.39	0.46	-0.07	1.4448
Pucca broiler housing (% of farmers)	21.2	13.7	28.3	-14.5***	3.4175
Asset index (%)	2.9	2.1	3.7	-1.6**	2.2856
Average size of batch (Number)	1,792.5	1,742.9	1,839.7	-96.8	0.7312
Number of batches per year	5.9	5.8	6.0	-0.2	1.3567
Experience in broiler-farming (years)	6.8	7.2	6.4	0.8	1.2688
Access to institutional credit (% of farmers)	28.4	37.1	20.1	17.0***	3.6324
Institutional credit amount (Taka)	27,716	22,886	32,310	-9,424	0.7461
Member of social community organization (%)	8.6	11.4	6.0	5.5*	1.8413
Government extension (% of farmers)	39.3	33.7	44.6	-10.9**	2.1115
Private extension (% of farmers)	29.5	26.9	32.1	-5.2	1.0800
Owning agricultural transport (% of farmers)	7.5	8.0	7.1	0.9	0.3348
Weight of bird sold (kg/bird)	1.69	1.71	1.66	0.05***	3.3450
Price of bird (Taka/kg)	133.1	132.4	133.9	-1.5	0.9849
Cost of production (Taka/kg)	125.7	124.2	127.1	- 2.9*	1.7121
Profit (Taka/kg)	8.2	8.9	7.5	1.4	0.5847
Adoption percentage of FSM	50.7	53.7	47.9	5.7**	2.0232

Source: Field survey (2016).
Note: ***, ** and * represent significance at 1%, 5% and 10% levels, respectively.

5. Contract Farming and Farmer Outcomes

To further our understanding of the impact of contract farming on farm performance, we use profit and adoption of food safety measures as outcome variables. We create a food safety adoption index (FSI) for measuring the adoption of FSMs, following Kumar, Wright and Singh (2011) and Kumar et al. (2017). Various studies determine the probability of a farmer's decision to contract as the first step in a two-step process for analyzing the impact of contract farming on farmer welfare (Katchova and Miranda 2004; Simmons, Winters, and Patrick 2005; Wang, Zhang, and Wu 2011; Bellemare 2012; Gupta and Roy 2012). Many other studies focus only on the decision to participate in contract farming (Birthal, Joshi, and Gulati 2005; Guo, Jolly, and Zhu 2005; Masakure and Henson 2005; Zhu and Wang 2007; Fischer and Qaim 2012). In this study, we check for characteristics that enable farmers to participate in contract farming.

We find that the prices of inputs supplied by the integrator are lower than prevailing market prices. Correspondingly, the integrator pays a product price that is lower than the market rate. There is, on average, little difference in output prices when comparing farmers under contract and independent farmers. Instead, non-price attributes (e.g., food safety), which are a product of technical and physical inputs provided to the farmer, ultimately determine the farmer's net returns."

As previously stated, comparatively risk-averse farmers facing considerable price variability have a greater propensity for participation in contract farming, as the arrangement allows them to exchange risk with a likely risk-neutral integrator, thus reducing uncertainty. Identifying the causal impact of contract farming on farm performance is a recurring challenge in the literature, as several observed and unobserved characteristics that influence farmer participation in contract farming are also likely to influence farmers' outcomes. A farmer's involvement in a contract is not decided randomly. Farmers are either selected by the contractor for a contract or make the choice to participate (i.e., self-selection). Thus, the possibility of omitted variables implies that simple linear estimates of the effects of contract farming can be biased.

We use the 2-Stage Least Squares (2SLS) instrumental variable (IV) regression model to address the issue of endogeneity. The equation for the 2SLS regression is

$$\pi_i = \alpha + \delta d_i + \gamma X_i + \varepsilon_i \quad (1)$$

where, π_i is the outcome (unit profit/adoption of FSM) for broiler producers, d_i is a dummy variable that equals 1 if a farmer is under contract and 0 if not under contract, X_i is a vector of farm and household characteristics, and ε_i is the error term.

In the first stage of 2SLS regression the dependent variable is binary (farmer's participation in contract farming = 1, otherwise = 0), and the independent variables are a mix of qualitative and quantitative factors, representing various farmer characteristics, such as age, education, broiler farming experience, access to institutional credit, type of broiler-housing structure, and access to public and private extension facilities. As mentioned above, different observed and unobserved factors can also influence farmers' entry into contract farming, and the variable representing a farmer's participation in contract farming (d_i) can be endogenous and thus correlate with the error term ε_i.

It is indeed hard to find an ideal instrument in this setting. Taking the role of contract farming as a provider of partial or full insurance, as discussed above, we use the instrument, price risks faced before contracting interacted with the measure of a farmer's risk preference, which is a significant determinant of contracting for the equation pertaining to profit. Farmers facing higher variability are hypothesized to be more likely to opt for contract farming.

We use the coefficient of variation in prices received by farmers as a measure of variability prior to contracting.

Comparatively risk-averse farmers facing higher price variability tend to enter contracting in a bid to diffuse risk. The contractual arrangement is expected to control fluctuation in prices of broilers. The IV coefficient of variation in prices interacted with the measure of risk aversion is positively correlated with variable d_i (representing participation in contract farming).

We also use another IV to represent the intensity of information on contracting received from a farmer organization. This IV is derived by interacting a dummy variable representing information received on contracting from an institutional source (e.g., farmer organization or cooperative) and time spent with the relevant farmer organization in hours per annum. This IV is positively related to participation in contract farming; farmers who receive information on contracting and spend comparatively more time with farmer organizations are more likely to participate.

This instrument is used in both our profit equation and our measure of food safety adoption, in conjunction with technical instruments from Lewbel (2012).

While the IVs are strongly related with d_i, we expect them to not be systematically related to the dependent variable, (i.e., profit or FSM adoption) in equation (1). In other words, in the case of the IV 'interaction of risk preference with variability in prices', variability in prices relates to prior production and marketing periods rather than current periods. In the case of the network IV, information on contracting facility received is not related to production or income.

It is often challenging to establish an assumption on the validity of an instrument in terms of exclusion restriction. If an assumption does not hold, IV estimates will be inconsistent. To overcome this challenge, we use the technical instruments provided by the method recently introduced by Lewbel (2012). Emran and Shilpi (2012) similarly employ a technique given by Lewbel (2012) in assessing the causal relationship between the extent of the market and the pattern of crop specialization in a village economy.

The heteroscedasticity-based identification relies on heteroscedasticity working as a probabilistic shifter, the essential idea to tracing a causal relationship via exclusion restrictions. Practically, this method involves constructing instruments as simple functions of the model's data. This approach can be followed when no external instruments are available, or it can be used to supplement external instruments to improve the efficiency of the IV estimator. The estimators customarily make use of appropriate lagged values of endogenous regressors to identify the model (Lewbel 2012).

Let $Y1$ and $Y2$ be observed endogenous variables, X is a vector of observed exogenous regressors, and $\varepsilon = (\varepsilon 1, \varepsilon 2)$ are unobserved errors. Following are structural models of the form:

$$Y_1 = X'\beta_1 + Y_2\Upsilon_1 + \varepsilon_1 \quad (2)$$

$$Y_2 = X'\beta_2 + Y_1\Upsilon_2 + \varepsilon_2 \quad (3)$$

This system is triangular when $\Upsilon_2 = 0$ (or when $\Upsilon_1 = 0$). Otherwise, it is fully simultaneous. The errors $\varepsilon_1, \varepsilon_2$ may be correlated with each other.

If the endogeneity assumption i.e. error being not correlated with endogenous variable holds, meaning $E(\varepsilon X) = 0$, the reduced form is identified, but in the absence of identifying restrictions, the structural parameters are not identified. These restrictions often involve setting certain elements of β_1 or β_2 to

zero, which makes instruments available. Identification in Lewbel's approach is achieved by restricting correlations of $\varepsilon\varepsilon'$ with X. This relies upon higher moments.

The parameters of the structural model will remain unidentified under the standard homoscedasticity assumption (i.e., $E(\varepsilon\varepsilon'|X)$ is a matrix of constants). However, when heteroscedasticity related to at least some elements of X is present, identification can be achieved. In a fully simultaneous system, assuming that $cov(X, \varepsilon_j^2) \neq 0,\ j = 1,2$ and $cov(Z, \varepsilon_1\varepsilon_2) = 0$ for observed Z will identify the structural parameters. Note that Z may be a subset of X, so no information outside the model specified above is required (see Lewbel 2012 for details).

6. Results and Discussions

Table 6.1 reports the estimates of the first-stage of the 2SLS regression model. We have the interaction between measure of a farmer's risk preference (i.e., expected price realization minus the option guaranteeing a reward of Taka 30) and the coefficient of variation in prices (two years before contract for contract farmers and last two years for independent farmers) as our IV (see Figure 1.1 for the options where option A is risk free and B onwards have increasing risk).

Further, we also get results by just using the dummy for risk preference level (i.e., "1" for producers accepting risk by choosing options B, C, D, or F; and "0" for those avoiding risk by choosing option A). The results are omitted here for brevity but are available upon request.

The variables "Type of broiler-housing structure (Pucca=1, 0 otherwise)" and "Extension visits by government extension officer (Yes=1, 0 otherwise)" indicate negative selection in the regression. Contract farmers tend to have lower access to public extension services and producers with a Pucca broiler-housing structure-a measure of wealth are less likely to enter a contract, while those with a Kuttcha (temporary) broiler-housing structure are more likely to participate in contract farming. Also, producers with poor access to government extension facilities are more likely to participate in contract farming, indicating negative selection in terms of access to information.

As previously stated, our approach jointly estimates both the selection and outcome equations. As there is a possibility of heteroscedasticity in the data, we implement technical instruments given in Lewbel (2012). The Breusch–Pagan test (mentioned in the following tables) indicates the presence of heteroscedasticity. We find parameter estimates for (i) IVs with both generated instruments and external instruments, and (ii) IVs with generated instruments only.

The estimates of selection equations that represent the determinants of participation in contract farming are given in Table 6.1 (as the first stage of the two-step 2SLS model). The outcome equations that represent the impact of contract farming on net returns and compliance with FSM are given in Table 6.2 and Table 6.3, respectively.

6.1 Determinants of Farmers' Participation in Contract Farming

The results of the participation equation given in Table 6.1 suggest that the drivers of broiler producers' decisions to become contract farmers include education, type of broiler-housing structure (a proxy for wealth status), and extension visit by a government official. There is no consensus in the literature on the sign and significance of most of the socio-economic and demographic variables on participation in contract farming. Many studies support the positive relationship between education and contract farming (Jabbar et al. 2007; Zhu and Wang 2007; Arumugam et al. 2011; Hu 2012; Kumar et al. 2016).

However, other studies also find a negative or insignificant relationship between educational attainment and participation in contract farming (Guo, Jolly, and Zhu 2005; Ramaswami, Joshi, and Birthal 2006; Miyata, Minot, and Hu 2009; Wang, Zhang, and Wu 2011; Bellemare 2012; Ito, Bao, and Sun 2012; Wainaina, Okello, and Nzuma 2012; Wang, Yu, and Li 2013). Our results indicate that an increase in education is associated with a higher likelihood of participation in contract farming. Education aids producers in understanding and adopting modern methods of broiler farming, and in understanding the technicalities of the contract. A comparatively more-educated farmer is better equipped to follow the production and FSM requirements outlined in the contract.

Broiler farmers with *pucca* broiler-housing structures are less likely to participate in contract farming. The presence of a *pucca* broiler-housing structure is linked to farm size in broiler production. In general, large producers have *pucca* broiler-housing structures while small producers have *kutcha* structures. The large producers, relatively less averse to price risk, look for riskier but high revenue-generating marketing options, other than the contract. The descriptive statistics (Table 4.1) also show that contract farmers have a smaller average batch size (1,743 birds) than independent producers (1,840 birds). Along with the differences in the poultry housing structure, lower asset levels and lower access to information sources indicate negative selection in contract farming.

The coefficient of variation in the price of broiler (taken from the two years preceding contract participation for contract farmers and the last two years for independent farmers) when interacted with measure of risk aversion is positively related to participation in contract farming. Mishra et al. (2018) also identify risk as a prominent factor driving farmers' engagement in contract farming of onion in India. Bellemare and Lim (2018) observe that contract farming reduces the risks of the participants upon joining.

Table 6.1: Determinants of farmers' participation in contract farming of broilers in Bangladesh: *First-stage of IV regression*

Dependent variable: Participation in Contract Farming (Yes = 1, 0 otherwise)				
	Specification 1		Specification 2	
Variable	**IV with generated and external instruments**	**IV with generated instruments only**	**IV with generated and external instruments**	**IV with generated instruments only**
(1)	**(2)**	**(3)**	**(4)**	**(5)**
Socio-Demographic variables				
ln(Age of the household head) (Years)	-1.23	-1.426	-1.428	-1.426
	(2.371)	(2.351)	(2.267)	(2.351)
Square of ln(Age of the household head)	0.151	0.181	0.185	0.181
	(0.317)	(0.314)	(0.303)	(0.314)
Religion (Islam=1, 0 otherwise)	0.044	0.048	0.043	0.048
	(0.103)	(0.101)	(0.1)	(0.101)
ln(Years of education of the household head)	0.433***	0.417***	0.417***	0.417***
	(0.107)	(0.112)	(0.117)	(0.112)
Square of ln(Years of education of the household head)	-0.128***	-0.121***	-0.118***	-0.121***
	(0.03)	(0.032)	(0.033)	(0.032)
ln(No of economically active household members)	-0.036	-0.023	-0.018	-0.023
	(0.06)	(0.061)	(0.06)	(0.061)
ln(Owned farmland)	-0.018	-0.017	-0.017	-0.017
	(0.012)	(0.013)	(0.012)	(0.013)
Economic variables				
Member of community organization (Yes=1 , 0 otherwise)	0.08	0.064	-0.009	0.064
	(0.085)	(0.085)	(0.105)	(0.085)
ln(Amount of credit) (Taka)	0.001	0.003	0.005	0.003
	(0.005)	(0.005)	(0.005)	(0.005)
Asset index (%)	-0.002	-0.001	-0.001	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)
ln(Experience in broiler farming) (years)	-0.007	-0.017	-0.023	-0.017
	(0.025)	(0.024)	(0.024)	(0.024)
Type of broiler-housing structure (*Pucca*=1, 0 otherwise)	-0.206***	-0.195***	-0.158**	-0.195***
	(0.072)	(0.074)	(0.071)	(0.074)
Extension visits by government extension officer (Yes=1, 0 otherwise)	-0.089	-0.108*	-0.115*	-0.108*
	(0.057)	(0.058)	(0.063)	(0.058)
Extension visits by private extension officer (Yes=1, 0 otherwise)	0.006	0.038	-0.024	0.038
	(0.053)	(0.055)	(0.061)	(0.055)
ln(Batch-size of broiler) (number)	-0.062	-0.051	-0.048	-0.051
	(0.048)	(0.049)	(0.047)	(0.049)
Owning Agricultural Transport (Yes=1 , 0 otherwise)	-0.009	-0.019	0.017	-0.019
	(0.088)	(0.092)	(0.094)	(0.092)
Instrumental variables				
Risk preference x variation in price in last two years	0.001***			
	(0.0002)			
Intensity of information on contracting facility received from farmer organization			0.016***	
			(0.004)	
Constant	3.351	3.622	3.531	3.622
	(4.465)	(4.44)	(4.286)	(4.44)
No. of observations	359	359	359	359
Sub-district Fixed Effect	Yes	Yes	Yes	Yes

Source: Authors' analysis based on field survey (2016)
Notes: Standard errors in parentheses; ***, ** and * represent significance at 1%, 5% and 10% levels, respectively. Standard errors are clustered at the Village level. The generated instruments are based on Lewbel (2012) methodology. A total of twenty-one moments are generated, pertaining to each one of the exogenous variables (independent variables).

6.2 Profit Effects

Table 6.2 investigates the effect of contract farming on net returns from broiler production, as in the second stage of the 2SLS model. Table 6.2 exhibits two specifications of instrumental variables. The first specification uses "Interaction of risk preference and variation in price in last two years" as the instrumental variable. The second specification employs "Information on contracting facility received from farmer organization weighted by the time spent with the organization" as instrumental variables. Our findings, from both the specifications, show that contract farming in broiler production has a significant positive impact on unit profit in the range of Taka 16.09/kg to Taka 20.89/kg, using (i) generated and external instruments as well as (ii) generated instruments only. The regressions include sub-district fixed effects and standard errors are clustered at the village level.

The OLS estimates a Taka 4.66/kg higher unit profit for contract farmers. Other variables that seem to impact profit include land size, type of broiler-housing structure, and broiler batch size. Land size and batch size, both indicators of the scale of production, seem to have a positive effect on net returns, indicating scale economies in broiler production. The Pucca broiler-housing structure provides a more protected and hygienic environment that facilitates the production of healthy broilers for the market. By way of comparison with current estimates, Wainaina, Okello, and Nzuma (2012) report a roughly 27% higher net revenue per bird for contract producers of poultry over independent farmers. Birthal, Joshi, and Gulati (2005) find that contract growers in India enjoy a 13% higher net profit, and Ramaswami, Joshi, and Birthal (2006) find that contracting raises returns by at least 25% in poultry production. Kalamkar (2012) estimates that contract farmers see net returns that are around 223% greater than those of independent broiler producers. Begum (2005) observes a 170% higher net return per bird for contract farmers over independent farmers in Bangladesh. Depending on methods used, there seems to be wide variation in the estimates of the impact of contracting on profits, likely due to identification issues.

Table 6.2: Impact of contract production on profits for broiler producers in Bangladesh: *Second-stage of IV regression*

Dependent variable: Unit profit in production of broiler (Taka/kg)					
		Specification 1		Specification 2	
Variable	**OLS**	**IV with generated and external instruments**	**IV with generated instruments only**	**IV with generated and external instruments**	**IV with generated instruments only**
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Contract Farming (Yes = 1, 0 otherwise)	4.655*	16.09**	20.891**	18.05**	20.891**
	(2.449)	(7.732)	(8.867)	(7.824)	(8.867)
Socio-Demographic variables					
ln(Age of the household head) (Years)	-62.61	-63.54	-63.937	-63.70	-63.937
	(113.7)	(116.1)	(118.616)	(117.0)	(118.616)
Square of ln(Age of the household head)	7.806	7.985	8.059	8.015	8.059
	(15.35)	(15.64)	(15.962)	(15.75)	(15.962)
Religion (Islam=1, 0 otherwise)	-2.772	-2.813	-2.83	-2.820	-2.83
	(4.739)	(4.870)	(5.018)	(4.924)	(5.018)
ln(Years of education of the household head)	11.04	5.938	3.8	5.067	3.8
	(7.617)	(7.079)	(7.395)	(7.349)	(7.395)
Square of ln(Years of education of the household head)	-2.619	-1.162	-0.55	-0.913	-0.55
	(2.176)	(2.045)	(2.152)	(2.136)	(2.152)
ln(No of economically active household members)	-1.958	-1.399	-1.163	-1.303	-1.163
	(2.718)	(2.689)	(2.725)	(2.687)	(2.725)
ln(Owned farmland)	1.388**	1.474**	1.509**	1.488**	1.509**
	(0.679)	(0.703)	(0.717)	(0.707)	(0.717)
Economic variables					
Member of community organization (Yes=1 , 0 otherwise)	-0.525	-1.769	-2.289	-1.981	-2.289
	(3.926)	(3.658)	(3.624)	(3.652)	(3.624)
ln(Amount of credit) (Taka)	-0.287	-0.290	-0.29	-0.290	-0.29
	(0.231)	(0.238)	(0.245)	(0.240)	(0.245)
Asset index (%)	0.0278	0.0562	0.068	0.0611	0.068
	(0.118)	(0.106)	(0.103)	(0.105)	(0.103)
ln(Experience in broiler farming) (years)	-1.849	-1.477	-1.32	-1.413	-1.32
	(1.443)	(1.572)	(1.665)	(1.630)	(1.665)
Type of broiler-housing structure (*Pucca*=1, 0 otherwise)	8.236*	10.72**	11.758***	11.14**	11.758***
	(4.473)	(4.301)	(4.319)	(4.225)	(4.319)
Extension visits by government extension officer (Yes=1, 0 otherwise)	-4.594	-3.104	-2.479	-2.850	-2.479
	(3.000)	(3.077)	(3.179)	(3.121)	(3.179)
Extension visits by private extension officer (Yes=1, 0 otherwise)	0.221	-0.101	-0.236	-0.156	-0.236
	(3.164)	(3.332)	(3.462)	(3.391)	(3.462)
ln(Batch-size of broiler) (number)	4.247**	4.885**	5.152**	4.994**	5.152**
	(1.957)	(2.037)	(2.099)	(2.039)	(2.099)
Owning Agricultural Transport (Yes=1 , 0 otherwise)	5.688	4.825	4.462	4.677	4.462
	(4.563)	(4.303)	(4.312)	(4.326)	(4.312)
Constant	88.01	78.89	75.066	77.33	75.066
	(205.4)	(208.0)	(212.504)	(209.7)	(212.504)
No. of observations	359	359	359	359	359
R-squared (Centered)	0.187	0.138	0.088	0.120	0.088
Root MSE	20.899	21.52	22.14	21.75	22.14
Sub-district Fixed Effect	Yes	Yes	Yes	Yes	Yes
Test of heteroscedasticity (Pagan-Hall general test statistic):					
Chi-sq		33.721		33.713	
P-value		0.052		0.053	
Over-identification test					
Hansen's J statistics		16.814	11.693	17.119	11.693
Chi-sq P-value		0.7223	0.9262	0.7039	0.9262
Weak identification test					
Kleibergen-Paap rk Wald F statistic		7.409	5.424	8.268	5.424

Source: Authors' analysis based on field survey (2016)
Notes: Standard errors in parentheses; ***, ** and * represent significance at 1%, 5% and 10% levels, respectively. Standard errors are clustered at the Village level. The generated instruments are based on Lewbel (2012) methodology. A total of twenty-one moments are generated, pertaining to each one of the exogenous variables (independent variables).

6.3 FSM Adoption Effects

Table 6.3 investigates the impact of contract farming on the adoption of FSM at the farm level, in the second stage of the 2SLS model (fourth, sixth, and eighth columns). The instrumental variable used is "information on contracting facility received from farmer organization weighted by the time spent with the organization (intensity of information)." The coefficients of the contract farming dummy are positive and significant. Our findings are consistent with earlier studies. Participation in contract farming enhances compliance with food safety measures, as measured by FSI, at the farm level by 12.53% (when both generated and external IVs are used), 12.69% (when only generated IVs are used), and 17.67% (when standard IV is employed). Other variables that increase the adoption of FSM are asset index, the type of broiler-housing structure, and visit by private extension officials. Asset index is a measure of wealth for the farmer. A wealthy farmer has better access to resources and higher capacity to invest in food safety measures; therefore, farmers with higher asset index values are likely to have better adoption of FSM at the farm level. The *Pucca* broiler-housing structure provides a safer environment for rearing birds in line with the prescribed FSM, and extension visits by private officials help raise farmers' awareness about good broiler-farming practices, further improving FSM at the farm level. The variable that indicates a negative association with the adoption of FSM is experience in broiler farming, as young and new entrants to broiler farming seem more likely to deliver on the adoption of FSM at the farm level. Hausman test for endogeneity in the profit and FSM equations are given in Table A.6.

The Pagan-Hall general test statistic indicates presence of heteroscedasticity. The Hansen's J statistics depict insignificance, meaning our instruments are valid.

Table 6.3: Impact of contract production on adoption of food safety practices (FSI) for broiler producers in Bangladesh: *First- and Second-stages of IV regression*

Dependent variable: Food Safety Adoption Index (FSI)							
Variable	**OLS**	**Standard IV results**		**IV with generated and external instruments**		**IV with generated instruments only**	
		Ist stage	**2nd stage**	**Ist stage**	**2nd stage**	**Ist stage**	**2nd stage**
(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**
Contract Farming (Yes = 1, 0 otherwise)	6.937**		17.67*		12.53**		12.69*
	(3.415)		(9.851)		(6.001)		(6.737)
Socio-Demographic variables							
ln(Age of the household head) (Years)	-112.8	0.154	-113.6	-1.428	-113.2	-1.426	-113.231
	(123.4)	(2.431)	(125.5)	(2.267)	(123.9)	(2.351)	(123.864)
Square of ln(Age of the household head)	16.48	-0.0213	16.65	0.185	16.57	0.181	16.572
	(16.56)	(0.328)	(16.91)	(0.303)	(16.65)	(0.314)	(16.645)
Religion (Islam=1, 0 otherwise)	4.272	0.00701	4.233	0.043	4.252	0.048	4.251
	(5.701)	(0.0965)	(6.473)	(0.1)	(6.083)	(0.101)	(6.093)
ln(Years of education of the household head)	10.53	0.433***	5.745	0.417***	8.037	0.417***	7.966
	(7.997)	(0.153)	(9.586)	(0.117)	(8.244)	(0.112)	(8.292)
Square of ln(Years of education of the household head)	-3.274	-0.121***	-1.906	-0.118***	-2.561	-0.121***	-2.541
	(2.308)	(0.0453)	(2.758)	(0.033)	(2.384)	(0.032)	(2.397)
ln(No of economically active household members)	1.828	-0.0426	2.353	-0.018	2.101	-0.023	2.109
	(2.918)	(0.0612)	(2.997)	(0.06)	(3.001)	(0.061)	(3.036)
ln(Owned farmland)	-0.0758	-0.00728	0.00477	-0.017	-0.0338	-0.017	-0.032
	(0.766)	(0.0135)	(0.818)	(0.012)	(0.791)	(0.013)	(0.789)
Economic variables							
Member of community organization (Yes=1 , 0 otherwise)	6.502	0.0188	5.335	-0.009	5.894	0.064	5.876
	(6.192)	(0.0818)	(7.021)	(0.105)	(6.467)	(0.085)	(6.415)
ln(Amount of credit) (Taka)	0.208	0.00326	0.206	0.005	0.207	0.003	0.206
	(0.317)	(0.00594)	(0.325)	(0.005)	(0.320)	(0.005)	(0.319)
Asset index (%)	0.263***	-0.00175	0.289***	-0.001	0.276***	-0.001	0.276***
	(0.0732)	(0.00198)	(0.0774)	(0.002)	(0.0743)	(0.002)	(0.075)
ln(Experience in broiler farming) (years)	-4.013***	-0.0415	-3.663**	-0.023	-3.831**	-0.017	-3.825**
	(1.473)	(0.0296)	(1.601)	(0.024)	(1.497)	(0.024)	(1.49)
Type of broiler-housing structure (*Pucca*=1, 0 otherwise)	7.799**	-0.173**	10.13**	-0.158**	9.012**	-0.195***	9.046**

Dependent variable: Food Safety Adoption Index (FSI)							
Variable	OLS	Standard IV results		IV with generated and external instruments		IV with generated instruments only	
		Ist stage	2nd stage	Ist stage	2nd stage	Ist stage	2nd stage
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	(3.387)	(0.0687)	(4.867)	(0.071)	(3.940)	(0.074)	(3.834)
Extension visits by government extension officer (Yes=1, 0 otherwise)	5.106	-0.132*	6.505	-0.115*	5.835	-0.108*	5.855
	(4.012)	(0.0707)	(4.057)	(0.063)	(3.939)	(0.058)	(4.008)
Extension visits by private extension officer (Yes=1, 0 otherwise)	9.370**	-0.0377	9.067**	-0.024	9.212**	0.038	9.207**
	(3.675)	(0.0798)	(3.682)	(0.061)	(3.676)	(0.055)	(3.679)
ln(Batch-size of broiler) (number)	-1.898	-0.0536	-1.300	-0.048	-1.586	-0.051	-1.577
	(2.682)	(0.0490)	(2.710)	(0.047)	(2.621)	(0.049)	(2.601)
Owning Agricultural Transport (Yes=1 , 0 otherwise)	-6.223	0.104	-7.034	0.017	-6.646	-0.019	-6.657
	(5.469)	(0.0847)	(5.470)	(0.094)	(5.444)	(0.092)	(5.409)
Instrumental variables							
Intensity of information on contracting facility received from farmer organization		0.0178***		0.016***			
		(0.00334)		(0.004)			
Constant	235.3	0.570	226.7	3.531	230.8	3.622	230.717
	(240.1)	(4.507)	(240.4)	(4.286)	(240.2)	(4.44)	(240.54)
No. of observations	359	359	359	359	359	359	359
R-squared (Centered)	0.225	0.266	0.195		0.217		0.2164
Root MSE	24.406		24.88		24.54		24.54
Sub-district Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Test of heteroscedasticity (Pagan-Hall general test statistic):							
Chi-sq			62.316				
P-value			0.000				
Over-identification test							
Hansen's J statistics			0		15.819		15.808
Chi-sq P-value					0.7797		0.7285
Weak identification test							
Kleibergen-Paap rk Wald F statistic			31.196		8.268		5.424

Notes: Standard errors in parentheses; ***, ** and * represent significance at 1%, 5% and 10% levels, respectively. Standard errors are clustered at the Village level. The generated instruments are based on Lewbel (2012) methodology. A total of twenty-one moments are generated, pertaining to each one of the exogenous variables (independent variables).

7. Conclusions and Policy Implications

This study, based on a primary survey of broiler-farming households in Bangladesh conducted in 2016, presents the impacts of participation in contract farming in broiler production on profits and FSM adoption at the farm level. The study also estimates the determinants of participation in contract farming. There is evidence of negative selection based on wealth, access to information, flock sizes, and education, as farmers who enter contractual arrangements probably have, on average, worse prospects as independent farmers than those who choose not to participate in contract farming. The study shows that education level and broiler-housing structure are the determinants for participation in contract farming. Conditional on participation, small contract farmers earn significantly higher profits. Further, contract farming has a positive impact on the adoption of FSM at the farm level. This finding can have important implications for improving the food safety attributes of the product in the supply chain of high-value perishable commodities like broilers. The adoption of food safety measures is a significant determinant of higher price realization.

Contract farming is often criticized in developing countries based on the perception that 'big' integrators exploit small farmers. In fact, there has been an intense debate in the literature, with some researchers and policymakers comparing contract farming to bonded labor (Singh 2002; Ghosh 2003; Sivaramkrishna and Jyotishi 2008) and others heralding it as a positive facilitator of agricultural commercialization while the other group perceives contract farming as the way out for promoting agricultural commercialization. Findings from this study suggest that contract farming can substantially increase incomes for small broiler-farming households and lead to significant improvements in FSM compliance at the farm level.

Several challenges arise in relation to small farmers. In practice, small growers have encountered problems concerning manipulation of quality standards, poor technical assistance, and sometimes outright cheating and deliberate default by integrators (Glover 1987). The gain to farmers, remain empirical questions regarding the conditions under which contract farming can operate and benefit the small farmer. If poultry producers are unable to meet food safety challenges, then they risk exclusion from the markets and the loss of opportunities brought forward by contract farming. The adoption of

comparatively costly measures is generally not associated with a hedonic price premium. Most FSMs are adopted under contract to promote the benefits of good agricultural practices, including increased productivity and risk mitigation."

Most FSMs are adopted under contract to draw benefits of good agricultural practices with rising productivity and reduction in risks.

If contract farming is profitable, is inclusive of small farmers, and delivers on food safety, what could be done to encourage more farmers to participate? The extent of contract farming is determined by the size and type of the market. The final demand determines the number of farmers who could be contracted. At the same time because of the need to provide attributes like food safety, there are entry barriers. The firm would like to keep an optimal size to be able to monitor and deliver on product quality (see Narrod et al. 2009 for optimal group sizes for contracting to provide on food safety). The prime driver for contracting is risk-sharing apart from technical inputs and these vary by both the nature of the contract as well as characteristics of the farmers.

Appendix: Supplementary Tables

Table A.1. Composition of costs in broiler production in Bangladesh (%)

Cost heads	All	Contract	Independent
Housing of birds	1.6	1.7	1.6
Labour	3.6	3.5	3.6
Day Old Chicks	31.3	31.7	31.0
Feed	55.4	54.9	55.8
Drugs, vaccination and veterinary services	5.7	5.7	5.6
Equipment costs	0.4	0.4	0.5
Electricity cost	0.5	0.6	0.5
Litter cost	0.5	0.5	0.5
Polythene, Sterilization and other costs	0.5	0.5	0.4
Transport costs (DOC, feed and equipment)	0.4	0.4	0.4
Marketing costs (including transport)	0.2	0.2	0.2
Total cost	100.0	100.0	100.0

Source: Field survey (2016).

Table A.2. Components of costs in production of broiler in Bangladesh

Particulars of costs	Cost incurred in broiler production							
	Per kilogram of bird sold (Taka/kg)				Per broiler farmer (Taka/farm)			
	All	Contract	Independent	Difference	All	Contract	Independent	Difference
Housing of birds	2.4	2.5	2.3	0.2	34,716	33,764	35,621	-1,858
Labour	4.8	4.5	4.9	-0.4**	76,011	71,205	80,582	-9,376
Day Old Chicks	38.9	38.8	38.9	-0.1	667,442	640,650	692,923	-52,273
Feed	69.3	68.1	70.5	-2.4**	1,181,387	1,111,915	1,247,462	-135,546
Drugs, vaccination and veterinary services	6.8	6.8	6.9	-0.1	120,634	114,932	126,057	-11,124
Equipment costs	0.6	0.5	0.8	-0.3***	9,307	7,122	11,385	-4,263***
Electricity cost	0.7	0.8	0.7	0.1***	11,623	12,522	10,768	1,754
Litter cost	0.7	0.7	0.7	0.0	10,190	9,738	10,620	-882
Polythene, Sterilization and other costs	0.6	0.7	0.6	0.1	9,606	10,218	9,024	1,194
Transport costs (DOC, feed and equipment)	0.5	0.5	0.6	-6.6	8,310	7,483	9,097	-1,613*
Marketing costs (including transport)	0.3	0.2	0.3	-0.1	3,863	4,023	3,711	311
Total cost	125.7	124.2	127.1	-2.9*	2,133,091	2,023,573	2,237,251	-213,677

Source: Field survey (2016).
Notes: ***, ** and * represent significance at 1%, 5% and 10% levels, respectively.

Table A.3. Status of adoption of food safety practices (FSI) in broiler production (%)

Batch-size	All	Contract	Independent	Difference	*t*-Test value
Small (up to 1200 birds)	53.9 (25.1)	55.9 (27.5)	52.0 (22.5)	3.9	0.9274
Medium (1201 – 2000 bird)	48.8 (27.7)	50.9 (27.9)	46.6 (27.4)	4.3	0.9613
Large (> 2000 birds)	47.9 (28.6)	56.2 (24.4)	42.7 (30.0)	13.5*	1.8816
All	50.7 (26.9)	53.7 (27.2)	47.9 (26.3)	5.7**	2.0232

Source: Field survey (2016).
Notes: ***, ** and * represent significance at 1%, 5% and 10% levels, respectively. Figures in bracket represent standard deviation.

Table A.4. Distribution of farmers by level of adoption of food safety practices

FSI	% of farmers		
	All	Contract	Independent
< 40 (Low)	35.9	34.3	37.5
40 – 70 (Medium)	34.5	33.1	35.9
≥ 70 (High)	29.5	32.6	26.6

Source: Field survey (2016).

Table A.5. Status of adoption of different components of food safety practices

Dimensions	Food Safety Adoption Index			Difference	t-value
	All	Contract	Non-contract		
Assessment and protection of environment & natural resources	49.4 (31.7)	55.1 (30.7)	43.9 (31.3)	11.2***	3.3940
Establishment of housing structure for broilers	50.9 (27.8)	53.3 (29.0)	48.6 (26.4)	4.8	1.6331
Availability of facilities for broiler rearing	50.9 (29.3)	52.2 (29.7)	49.6 (28.9)	2.6	0.8249
Protection from infection and diseases	59.9 (25.3)	60.4 (27.4)	59.5 (23.1)	0.9	0.3534
Appropriate use/handling of facilities for broiler rearing	48.1 (27.8)	51.4 (26.5)	44.9 (28.7)	6.4**	2.1984
Overall food safety adoption index	50.7 (26.8)	53.7 (27.2)	47.9 (26.3)	5.7**	2.0232

Source: Field survey (2016).
Notes: ***, ** and * represent significance at 1%, 5% and 10% levels, respectively. Figures in bracket represent standard deviation.

Table A.6. Hausman test for endogeneity in the profit and FSM equations

Dependent variable:	**Unit profit in production of broiler (Taka/kg)**		**Food Safety Adoption Index (FSI)**
Variable	**IV:** Risk preference x variation in price in last two years	**IV:** Intensity of information on contracting facility received from farmer organization	**IV:** Intensity of information on contracting facility received from farmer organization
Contract Farming (Yes = 1, 0 otherwise)	-15.24	-2.355	16.61*
	(17.26)	(8.006)	(8.572)
Socio-Demographic variables			
ln(Age of the household head) (Years)	-63.28	-63.21	-111.9
	(113.1)	(113.8)	(123.4)
Square of ln(Age of the household head)	7.973	7.855	16.41
	(15.25)	(15.37)	(16.55)
Religion (Islam=1, 0 otherwise)	-2.712	-2.800	4.311
	(4.746)	(4.777)	(5.611)
ln(Years of education of the household head)	9.941	11.03	10.54
	(7.737)	(7.609)	(7.993)
Square of ln(Years of education of the household head)	-2.267	-2.643	-3.241
	(2.227)	(2.188)	(2.312)
ln(No of economically active household members)	-1.693	-1.998	1.882
	(2.667)	(2.686)	(2.917)
ln(Owned farm land)	1.424**	1.388**	-0.0758
	(0.681)	(0.682)	(0.764)
Economic variables			
Member of community organization (Yes=1 , 0 otherwise)	-0.857	0.169	5.543
	(4.011)	(4.211)	(6.654)
ln(Amount of credit) (Taka)	-0.239	-0.312	0.242
	(0.229)	(0.235)	(0.326)
Asset index (%)	0.0407	0.0225	0.270***
	(0.116)	(0.120)	(0.0711)
ln(Experience in broiler farming) (years)	-2.096	-1.770	-4.123***
	(1.483)	(1.407)	(1.476)
Type of broiler-housing structure (*Pucca*=1, 0 otherwise)	8.544*	7.933*	8.217**
	(4.306)	(4.493)	(3.558)
Extension visits by government extension officer (Yes=1, 0 otherwise)	-4.856	-4.550	5.046
	(3.044)	(3.006)	(4.043)
Extension visits by private extension officer (Yes=1, 0 otherwise)	0.766	0.743	8.649**
	(3.117)	(3.498)	(3.548)
ln(Batch-size of broiler) (number)	4.561**	4.244**	-1.893
	(1.965)	(1.969)	(2.683)
Owning Agricultural Transport (Yes=1 , 0 otherwise)	5.485	5.439	-5.879
	(4.513)	(4.658)	(5.429)
Ehat	20.63	7.253	-10.01
	(17.45)	(8.560)	(10.16)
Constant	95.99	93.03	228.4
	(204.4)	(205.1)	(239.5)
No. of observations	359	359	359
R-squared	0.191	0.188	0.226
Root MSE	20.878	20.921	24.428
Sub-district Fixed Effect	Yes	Yes	Yes

Source: Field survey (2016).
Notes: ***, ** and * represent significance at 1%, 5% and 10% levels, respectively. Figures in bracket represent standard deviation.

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