Private Enforcement Mechanisms and Contract Stability in Agri-food Supply Chain: An Empirical Evidence from China

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Abstract: Contract enforcement is regarded as an important pre-condition for efficient exchange and investment in market-guided economies in general and the agri-food sector in particular. Despite many benefits associated with the participation of contract farming, researchers have demonstrated that the contractual relationship between firm and farmers is not stable, and there is a high rate of contract breach in practice. The instability of contractual relationship has been cited as one of the major stumbling blocks in the sustainable expansion of contract farming. This paper empirically investigates the relationship between contract arrangements and their enforcement, and the risk preferences of farmers are specially considered. The data is derived from a household survey and economic field experiment of Chinese farmers participating in contract farming. We measure farmers' risk preferences by using an economic field experiment, and examine how contract arrangements and risk preferences affect farmers' contract performance decisions with a probit model. The results show that private contract enforcement mechanisms play an important in affecting farmers' decisions to perform contracts. Contract arrangements with floor pricing, bonus, and long duration are related to a higher rate of farmers' contract performance. Additionally, we find that farmers with greater risk aversion and loss aversion are more likely to perform a contract.

The findings of the study may be conducive to formulating relevant agricultural policy to influence farmers' decision-making and promote the stability of contract farming.

Keywords: private enforcement mechanisms; contract stability; contract arrangements; risk preferences; China

1. Introduction

Driven by the fierce competition in the food market and the growth of human food consumption, contract farming has rapidly become the dominant form of vertical coordination in developed countries (Vukina and Leegomonchai, 2006). FAO defines contract farming as "agricultural production carried out according to an agreement between a buyer and farmers, which establishes conditions for the production and marketing of a farm product or products" (FAO, 2017). In agri-food supply chain, contract farming is conducive to regulating farmers' production behavior, ensuring food quality and safety, and promoting public health (Wang, Moustier, and Loc, 2014; Niu, Jin, and Pu, 2016). Additionally, participating in contract farming can protect farmers against downside price, reduce transaction costs, and help farmers to receive higher returns (Hou and Hou, 2019). In recent decades, contract farming has become increasingly popular in developing countries including China. However, researchers find that the contractual relationship between agribusiness firm and farmer is not stable, and the performance rate of contract farming is very low in China (Liu, 2003; Guo, 2008). For example, Guo (2008) found that the farmers' contract performance rate was only 38 percent in a survey made in China. Contract enforcement is regarded as an important pre-condition for efficient exchange and investment in market-guided economies and the agri-food sector (Gow, Streeter, and Swinnen, 2000; Guo and Jolly, 2008). The instability of contractual relationship has been cited as one of the major stumbling blocks in the sustainable expansion of contract farming.

In China, contract arrangements between smallholders and processing or distribution firms are the main types of vertical coordination (Guo and Jolly, 2008). Generally, contracts can be enforced through public and private mechanisms. Farmers prefer and perform differently based on different contract farming models (i.e., they have autonomous choice in enforcement) (Anh et al., 2019). In such view, public institutions such as the legal system are ineffective not sufficiently effective or absent in ensuring contract enforcement, particularly in developing and transition countries such as China. Under such conditions, private enforcement mechanisms (e.g., contract arrangements) may provide a suitable replacement for weak public enforcement mechanisms (Gow, Streeter, and Swinnen, 2000; Beckmann and Boge, 2004). The existing literature has studied impact factors of contract stability, which include reputation mechanism (Kreps and Wilson, 1982), specific investments (Williams and Karen, 1985; Kumar et al., 2013), contract terms (Guo, Jolly, and Zhu, 2007; Guo, H.; Jolly, 2008;), and transaction costs (Haji, 2010; Zylbersztajn and Nadalini, 2004). However, the literature mainly focuses on the impact of external factors on contract performance and generally presupposes that the behavioral agents are rational, ignoring the agents' personality traits such as risk preferences (Petrolia, 2016; Jin et al., 2017). In reality, decision-making is a process of complex cognitive operations influenced by personal as well as environmental variables (Drichoutis and Nayga, 2015). Researchers suggest that risk preferences play an important role in farmers' investment decisions and agricultural production decisions (Liu, 2013; Liu and Huang, 2013). Beyond decisions, risk perceptions may determine farmers health and coping behaviors, both toward the business and the environment (Cui et al., 2019; Yazd, Wheeler, and Zuo, 2019; He et al., 2020). Thus, it is more appropriate to incorporate private enforcement mechanisms and farmers' risk preferences into the study of contract stability. In determining the relationship between risk preferences and agricultural decisions, most empirical researches in the literature typically use two methods when estimating individual risk preferences (Liu and Huang, 2013). One is to depend on the assumption of

objective function and advanced econometric technique to impute the coefficient of risk aversion that will fit the model; however, the assumption of a utility function form and arbitrary heuristics could cause bias. The other method is using wealth as a proxy for risk aversion; but this method could be problematic as it could potentially undermine the role of risk preferences in farmers' decisions. One contribution to the existing literature is that all risk preference parameters used in the analysis of farmers' contract performance decision are being elicited from economic field experiments.

The objective of this paper is to examine whether contract arrangements and risk preferences explain the low rate of contract performance in contract farming. Our data is from a household survey and economic field experiment conducted in Jiangsu and Anhui provinces of China. In our study, we first measure farmers' risk preferences from economic field experiments, and then extend their experiment results to the contract performance decisions. We believe that the findings from this study bridge the gap between field experiments and real world behavior. The rest of the paper is structured as follows. In Section 2, the conceptual framework is discussed. Section 3 describes the data and methods. In Section 4, the empirical results are discussed. Section 5 concludes the paper.

2. Conceptual Framework

When the market price exceeds the contracted price, farmers may conceal a portion of products to reduce the delivery quantities and sell the hidden portions to the market. The contract performance or default decision is a tradeoff between the revenues and the costs (Gow, Streeter, and Swinnen, 2000). The farmer's default revenues (R) are determined by the default quantity (Q) times the wedge between the contracted price (p_c) and the actual market price (p_m); thus, we can express it as: $R = Q*(p_m - p_c)$. We assume the contractor will not trade with a farmer over some period of time if farmers' default behavior has been exposed. The farmer's default costs (C) depend on the value of losses (l) that result from

termination or non-renewal of the contract, the damage of the farmer's reputation in local business, and the probability of exposure and punishment for defaulting contract (*P*). Thus, we can express these default costs as: $C = f(P) * \sum_{i}^{n} c_i / (1+\delta)^i$, where c_i is the value of farmer's losses in the period *i*, δ is the discount factor, and *P* is the probability of exposure and punishment that is affected by the efficiency of legal system and supervision and farmer's risk preferences. Particularly, given the inefficient supervision and ineffectiveness of public performance in reality, *P* is mainly affected by farmers' risk preferences. The probability that the smallholder is forced to pay compensation for losses resulting from contract default is determined the cost of contract enforcement for the agribusiness firm and the adequacy of the legal system. The costs of contract enforcement are time, effort, and money that must be spent to take legal action; these are affected by efficiency of the legal system, contract provisions and design, and characteristics of the firm or smallholder (Guo and Jolly, 2008). Following the above discussion, we can specify the smallholder's contract enforcement strategy. When the market price exceeds the contracted price, the farmer will weigh the short-term benefits achieved by defaulting contract (i.e., the default revenues) and the future utility stream of losses (i.e., the default costs); one has incentive to default the contract only when the default revenues exceed the default costs. Considering that the default quantity is relatively small in reality, the decision-making in contract default or fulfillment mainly depends on the default costs; the higher the costs, the greater the probability of contract performance.

From the above discussion, we can infer that the value of *l*, *P*, and the wedge between p_m and p_c will affect smallholders' contract performance rate. Given the state of the legal system and market conditions, these values are determined by contract provisions, such as contract form, contract type, or contracted price (Guo and Jolly, 2008). Notably, the determining factor influencing contract performance or default will be whether or not the

benefits outweigh the costs, but farmers' risk preferences may affect the subjective utility of costs resulting from contract default and thus influence the decision of whether to fulfill or breach a contract. For example, if farmers are risk loving or fail to accurately evaluate probability information, they tend to undervalue the probability that the contractor will discover their default behavior. Consequently, the potential default costs decrease, leading to a substantial increase in the likelihood of contract default.

To analyze the effect of contract arrangements and farmers' risk preferences on contract stability, we develop a straightforward reduced form model as follows:

$$CB_i = F(risk_i, arrangements_i, Z_i; \eta) + \varepsilon_i \quad (1)$$

where *CB* refers to contract stability and measures farmers' contract performance decisions; *risk* and *arrangements* denote key explanatory variables and *Z* represents a vector of control variables that are factors influencing farmers' contract performance decisions. The variables are defined below.

The dependent variable, *CB*, is indicated by a discrete value of 0 or 1 and is derived from contracted farmers' response to the survey questions. The value is 1 if farmer *i* fulfills the contract, and 0 otherwise.

The independent variable, *arrangements*, is defined as contract arrangements or private enforcement mechanisms, which is an important factor influencing farmers' decision-making (Guo and Jolly, 2008; Kumar et al., 2013). In this paper, we include four indicators that describe the contract arrangements: (a) the form of contract (*form*), (b) contract pricing mechanism (*pricing*), (c) contract duration (*duration*), and (d) bonus clause (*bonus*). The variable *form* measures the form of contract established between the contractor and the farmer; it takes on the value of 1 if the contract form is oral, and it is 0 if the contract form is written contracts. If a farmer signs an oral contract with an agribusiness firm, the court is difficult to determine the responsibility of default, which may lead to a decrease in farmers' default costs (Guo and Jolly, 2008); thus, we assume that the probability of contract

performance is higher with written contracts than with oral contracts. The variable *duration* denotes the length of the contract between the contractor and farmers. The variable *pricing* refers to the contract pricing mechanism specified in the contract; it has a value of 1 if the mechanism is floor pricing[1], and it is 0 if the mechanism is fixed pricing. We expect that the floor pricing mechanism is associated with a high rate of contract performance because it provides farmers with income guarantees (Guo and Jolly, 2008). Farmers who sign long-term contracts with the contractor tend to consider the adverse effects of contract default from their own long-term interests (Kunte, Wollnia, and Kesera, 2017); the longer the duration of the contract, the greater the losses from defaulting contract. Thus, we assume that contract duration is positively related to the probability of contract performance. The variable *bonus* is binary, and has a value of 1 if the contractor offered a bonus to farmers who complied with the contract, and 0 otherwise. We expect that contract terms with a bonus are associated with a high rate of contract performance, because such bonus clause will increase the farmers' income and improve the enthusiasm of farmers cooperating with contractor (Kumar et al., 2013).

The independent variable, *risk*, is defined as farmers' risk preferences. Previous work indicates that risk preferences play a role in farmers' agricultural decision-making (Liu, 2013; Liu and Huang, 2013; Brick and Visser, 2015). Therefore, we also carefully measure and model farmers' risk preferences—including risk aversion, loss aversion, and probability weighting—to use as control variables in our regressions. Notably, the common approach uses expected utility (EU) to measure individual risk preferences, in which risk aversion is the sole parameter that determine the shape of the utility function; however, the existing literature suggests that farmers' risk preferences are better captured by prospect theory rather

[1] Contract with a floor pricing mechanism offers farmers a minimum price at the beginning of planting; at the time of the delivery, the contractors will use the minimum price if the market price is lower than the minimum price, otherwise they will use the market price.

than expected utility theory in the context of agricultural decision-making (Liu, 2013). As Liu (2013) points out, Chinese farmers generally have an expected income level they want to achieve, and they are more sensitive to losses than to gains at the expected income level; thus, parameters other than risk aversion, such as loss aversion, should also be considered in the research.

In prospect theory (PT), three variables (i.e., *risk aversion*, *loss aversion, and probability weighting*) jointly determine the shape of the utility function (Tversky and Kahneman, 1992). A farmer's utility under PT is defined below:

$$PT(x, p; y, 1-p) = \begin{cases} v(y) + \pi(p)(v(x) - v(y)) & , x > y > 0 \quad or \quad x < y < 0 \\ \pi(p)v(x) + \pi(1-p)v(y) & , x < 0 < y \end{cases} \tag{2}$$

In equation (2), $PT(x, p; y, 1-p)$ denotes the expected value over binary monetary outcome x and y with corresponding probabilities p and 1-p, respectively. Furthermore, a two-part power function assigns a value for gains ($x > 0$) and losses ($x < 0$) separately:

$$v(x) = \begin{cases} x^{\sigma} & , x \geq 0 \\ -\lambda(-x)^{\sigma} & , x < 0 \end{cases} \tag{3}$$

where σ reflects the curvature of the value function and can be interpreted as a proxy for risk aversion;[2] λ reflects the degree of loss aversion. Additionally, we assume that farmers place a decision weight on probability information p that reflects the desirability of uncertain events. Thus, the probability weighting function is defined as follows:

$$\pi(p) = \exp\left[-(-\ln p)^{\alpha}\right] \tag{4}$$

[2] Following Liebenehm and Waibel (2014), the terms "risk aversion" and "curvature" are used interchangeably in our paper. The higher the value function curvature (σ), the lower the levels of risk aversion. The individual is risk-averse if $\sigma < 1$, risk-loving if $\sigma > 1$, and risk-neutral if $\sigma = 1$. We expect that the value function is s-shaped, concave above the reference point, convex below the reference point, and steeper for losses than for gains, that is, $\sigma < 1$ and $\lambda > 1$.

where α represents a proxy for probability weighting (Prelec, 1998).[3] The smaller α is, the larger the departure from linear probability weighting and hence, the stronger the tendency to overweight small probabilities and underweight large probabilities. Specially, if $\alpha = 1$ and $\lambda = 1$, the above specification reduces to the standard expected utility specification.

We assume that a more risk-averse farmer has a higher tendency to fulfill the contract; defaulting contracts is risky behavior for farmers because farmers may suffer a large loss resulting from contract breach. The loss aversion parameter is assumed to be positively related to contract performance. Farmers with higher levels of loss aversion tend to attach more value to the penalties and losses resulting from contract default, and thus have a higher tendency to fulfill the contract. Additionally, we expect that probability weighting parameter is positively related to contract performance. Based on the results of several studies, individuals tend to underweight likely but undesirable events and to overweight unlikely but desirable events (Tanaka, Camerer, and Nguyen, 2010; Nguyen, 2011; Liebenehm and Waibel, 2014). Given that contracting firms regularly send technicians to inspect and sample products, the probability of being discovered by the firm is relatively high. Driven by such psychological characteristic, farmers who are unable to correctly appraise probability information are prone to underestimate the probability of exposure and punishment by contractor, and thus have a low likelihood of contract performance.

In addition to contract arrangements and risk preferences, farmers' contract performance decisions may be influenced by other factors such as demographic and socio-economic characteristics. The rest of the control variables consist of the age of household head (*age*), the education of household head (*education*), household labor (*labor*), family asset (*asset*)[4],

[3] α reflects the accuracy of assessing probability events, and is associated with overweighting small probability events and underweighting large probability events. $\alpha < 1$ implies that individual does not correctly estimate probabilities, resulting in an inverted s-shaped probability weighting function.

[4] Farmers are usually subjected to the constraint of family assets when making decisions in contract default. If farmers choose to default contracts in a favourable market condition, they will obtain a short-

farm scale (*scale*), planting experience (*experience*), the distance to contractor (*distance*), the fluctuation of market price (*fluctuation*), and regional differences (*region*).

3. Data and Methods

3.1. Data Collection

The data was derived from a household survey and economic field experiments of Chinese fruit farmers conducted by our research team in 2017. We chose apple and pear, two popular and common fruit in China as representative commodities. China produces more than 20 million tons of apples per year, making it the largest producer in the world. China's pear production reached 18.7 million tons in 2016, accounting for 75% of world pear production. Therefore, the study on Chinese fruit industry has an important meaning.

Our study was in Jiangsu province and Anhui province. The study county in each province was selected based on a random pre-selection, which was followed by the purposive selection of counties with high rate of contract participation. In each county that was selected, we randomly picked two towns. In every town, we randomly picked two villages, and in each village we sampled 30 households growing apples or pears. The survey included demographic and socioeconomic information such as age, education, household labor, family asset, farm scale, production and marketing, and contractual details. In addition, we conducted risk preferences' experiments at the end of the questionnaire. In total, 235 usage observations were obtained, of which 118 farmers growing apples and 117 farmers growing pears. Among the 235 farmers, 85 have been involved in defaulting a contract. The rate of contract performance in our survey is 64%.

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term speculative profit. Thus, we expect that poorer households tend to increase short-term incomes by defaulting contracts due to their immediate survival needs.

Table 1 provides the description and summary statistics of variables. As shown in Table 1, the average household head was 49 years old and had seven years of formal schooling. The average years of planting fruit for contracted farmers were about fifteen years. With respect to the contract terms, only about 10% of the respondents used oral contracts; approximately 69% of the respondents used a float pricing mechanism; the average length of contract was about 2 years; and about 78% reported that contractors offered a bonus clause. Additionally, an average distance to contractors of 21 km was observed.

Table 1. Description and summary statistics of variables.

Variable	Variable Definitions	Mean	SD
Form	If contract form is oral = 1, else = 0	0.102	0.303
Pricing	If contract offers a floor price = 1, else = 0	0.689	0.464
Duration	The length of contract between the contractor and farmers (years)	2.332	1.173
Bonus	If firm offers a bonus to farmers who complies with the contract = 1, else = 0	0.779	0.416
Risk aversion (σ)	The curvature of the value function	0.564	0.326
Loss aversion (λ)	The degree of loss aversion	2.585	2.542
Probability weighting (α)	The accuracy of assessing probability events	0.655	0.303
Age	Age of household head in years	49.098	9.279
Education	Years of formal education of household head	7.119	2.658
Labor	Number of household labor force	2.953	1.014
Asset	Area of house or apartment (10^2 square meters)	2.248	1.953
Scale	Area of planting (mu)	5.177	3.871
Experience	Years of planting fruit	14.598	8.841
Fluctuation	The regional market prices variance over the past five years	0.323	0.044
Distance	Distance from farm to contractor (km)	20.983	11.610
Region	1 denotes Jiangsu province, and 0 denotes Anhui province	0.502	0.501

3.2. Experimental Measure of Risk preferences

The fruit farmers were asked to participate in a field experiment addressing risk preferences after completing the questionnaire survey. The experiment uses well-established approaches that have been shown to effectively reveal risk preferences in lab and field settings (Tanaka, Camerer, and Nguyen, 2010; Nguyen, 2011; Liu, 2013; Liu and Huang, 2013; Liebenehm and Waibel, 2014). We use "switching Multiple Price List" (sMPL) design, which enforces monotonic switching that participants can't switch back and forth within one series.

The risk preferences experiment is designed to estimate three prospect theory parameters. The experiment is illustrated in Table 2. There are three series of paired lotteries. Each paired lottery consists of a safe reward (Option A) and a risky reward (Option B). Take Row 1 for example: if farmers choose option A, they have a 30% probability of winning 20 Yuan and a 70% probability of winning 5 Yuan; if farmers choose option B, there is a 10% probability of winning 34 Yuan and a 90% probability of winning 2.5 Yuan. Farmers must make a choice between two options in each series.

Across the risk experiment, farmers aggregately completed 35 decision tasks. At the end of the experiment, one pair of lotteries was randomly chosen to be paid with real monetary reward. The real monetary reward was expected to encourage participants to reveal their true preferences (Andersen et al., 2006).[5] Specifically, we prepared two pairs of numbered cards. After making all 35 choices in the experiment, participants were asked to first draw one card out of the first pair that contains 35 numbered cards. The number on that card determines which row will be paid the real money. They then drew another card out of the second pair

[5] Notably, the experimental tasks took an average of 10 minutes; the average reward was 35 Yuan, equaling approximately half a day's income in the study area.

that contains 10 cards numbered 1 through 10. Depending on the lottery they had chosen for that particular row, their rewards were determined by the second numbered card.

Table 2. Design of risk preferences experiment.

Series	Row	Option A		Option B	
		30% probability	70% probability	10% probability	90% probability
1	1	20 Yuan	5 Yuan	34 Yuan	2.5 Yuan
	2	20 Yuan	5 Yuan	37.5 Yuan	2.5 Yuan
	3	20 Yuan	5 Yuan	41.5 Yuan	2.5 Yuan
	4	20 Yuan	5 Yuan	46.5 Yuan	2.5 Yuan
	5	20 Yuan	5 Yuan	53 Yuan	2.5 Yuan
	6	20 Yuan	5 Yuan	62.5 Yuan	2.5 Yuan
	7	20 Yuan	5 Yuan	75 Yuan	2.5 Yuan
	8	20 Yuan	5 Yuan	92.5 Yuan	2.5 Yuan
	9	20 Yuan	5 Yuan	110 Yuan	2.5 Yuan
	10	20 Yuan	5 Yuan	150 Yuan	2.5 Yuan
	11	20 Yuan	5 Yuan	200 Yuan	2.5 Yuan
	12	20 Yuan	5 Yuan	300 Yuan	2.5 Yuan
	13	20 Yuan	5 Yuan	500 Yuan	2.5 Yuan
	14	20 Yuan	5 Yuan	850 Yuan	2.5 Yuan
Series	Row	90% probability	10% probability	70% probability	30% probability
2	1	20 Yuan	15 Yuan	27 Yuan	2.5 Yuan
	2	20 Yuan	15 Yuan	28 Yuan	2.5 Yuan
	3	20 Yuan	15 Yuan	29 Yuan	2.5 Yuan
	4	20 Yuan	15 Yuan	30 Yuan	2.5 Yuan
	5	20 Yuan	15 Yuan	31 Yuan	2.5 Yuan
	6	20 Yuan	15 Yuan	32.5 Yuan	2.5 Yuan
	7	20 Yuan	15 Yuan	34 Yuan	2.5 Yuan
	8	20 Yuan	15 Yuan	36 Yuan	2.5 Yuan
	9	20 Yuan	15 Yuan	38.5 Yuan	2.5 Yuan
	10	20 Yuan	15 Yuan	41.5 Yuan	2.5 Yuan
	11	20 Yuan	15 Yuan	45 Yuan	2.5 Yuan
	12	20 Yuan	15 Yuan	50 Yuan	2.5 Yuan
	13	20 Yuan	15 Yuan	55 Yuan	2.5 Yuan
	14	20 Yuan	15 Yuan	65 Yuan	2.5 Yuan

Series	Row	50% probability	50% probability	50% probability	50% probability
3	1	12.5 Yuan	–2 Yuan	15 Yuan	–10 Yuan
	2	2 Yuan	–2 Yuan	15 Yuan	–10 Yuan
	3	0.5 Yuan	–2 Yuan	15 Yuan	–10 Yuan
	4	0.5 Yuan	–2 Yuan	15 Yuan	–8 Yuan
	5	0.5 Yuan	–4 Yuan	15 Yuan	–8 Yuan
	6	0.5 Yuan	–4 Yuan	15 Yuan	–7 Yuan
	7	0.5 Yuan	–4 Yuan	15 Yuan	–5.5 Yuan

We estimate risk preferences parameters based on the farmers' choices made in the risk preferences experiment. Specifically, experiment results from Series 1 and Series 2 are used to jointly estimate the curvature of the utility function in the positive domain (σ) and the probability weighting parameter (α); experiment results from Series 3 are used to estimate the loss aversion parameter (λ). For any participant who switch at row N, we can determine whether he or she prefers Option B over Option A at Row N and prefers Option A over Option B at row N-1. Thus, a set of two inequalities from this switching point can be obtained. For instance, if a participant switches from Option A to Option B at row 7 for both Series 1 and Series 2, then the following inequalities should be satisfied:

$$\begin{aligned}
&5^{\sigma}+\exp[-(-\ln 0.3)^{\alpha}](20^{\sigma}-5^{\sigma})>2.5^{\sigma}+\exp[-(-\ln 0.1)^{\alpha}](62.5^{\sigma}-2.5^{\sigma})\\
&5^{\sigma}+\exp[-(-\ln 0.3)^{\alpha}](20^{\sigma}-5^{\sigma})<2.5^{\sigma}+\exp[-(-\ln 0.1)^{\alpha}](75^{\sigma}-2.5^{\sigma})\\
&15^{\sigma}+\exp[-(-\ln 0.9)^{\alpha}](20^{\sigma}-15^{\sigma})>2.5^{\sigma}+\exp[-(-\ln 0.7)^{\alpha}](32.5^{\sigma}-2.5^{\sigma})\\
&15^{\sigma}+\exp[-(-\ln 0.9)^{\alpha}](20^{\sigma}-15^{\sigma})<2.5^{\sigma}+\exp[-(-\ln 0.7)^{\alpha}](34^{\sigma}-2.5^{\sigma})
\end{aligned} \tag{5}$$

We can calculate the intervals of σ and α that satisfy this pair of inequalities by using the combination of switching points from Series 1 and Series 2; then, we follow Tanaka, Camerer, and Nguyen (2010) and Liu (2013) to take the midpoint of each interval as the point estimate. After completing the estimate of σ and α, the inequalities involving λ can be written out by using the switching point from Series 3. For instance, if a participant switches from Option A to Option B at row 7 for Series 3, then the following inequalities should be satisfied:

$$\exp[-(-\ln 0.5)^{\alpha}](-4^{\alpha}\lambda + 0.5^{\alpha}) > \exp[-(-\ln 0.5)^{\alpha}](-7^{\alpha}\lambda + 15^{\alpha})$$
$$\exp[-(-\ln 0.5)^{\alpha}](-4^{\alpha}\lambda + 0.5^{\alpha}) < \exp[-(-\ln 0.5)^{\alpha}](-5.5^{\alpha}\lambda + 15^{\alpha}) \quad (6)$$

Thus, we can obtain the range of λ by solving for the above inequalities. Similarly, we use the midpoint of the interval as the point estimate of λ.

We carefully estimate each individual's risk preference parameters. The average individual estimates of parameters are presented in Table 1, and the kernel density estimation plots of the risk preferences' parameters are shown in Figure 1. With respect to risk preferences parameters, our estimate of the risk aversion parameter (σ = 0.564) was less than 1, suggesting that average Chinese fruit farmer is risk-averse in the gain domain. Notably, the estimate of σ was higher than that obtained in similar study in Africa (Liebenehm and Waibel, 2014). This comparison implies that the average Chinese fruit farmer in our sample is less risk-averse in the gain domain than the average cattle farmer in West Africa. Furthermore, the estimates of the loss aversion parameter (λ = 2.585) indicates that the average Chinese fruit farmer in our sample appears to pay more attention to losses than gains. Additionally, the estimate of the probability weighting parameter (α = 0.655) was less than 1, which suggests that the average Chinese fruit farmer in our sample is unable to correctly assess probability information.

Figure 3 shows the distributions of choices made by farmers in Series 1 and 2. The numbers in the axes correspond to the switching points in Series 1 and 2. The height of a cone denotes the number of farmers who switched at that particular combination of switching points in Series 1 and 2. We observe that farmers in this study have a wide range of risk preferences.

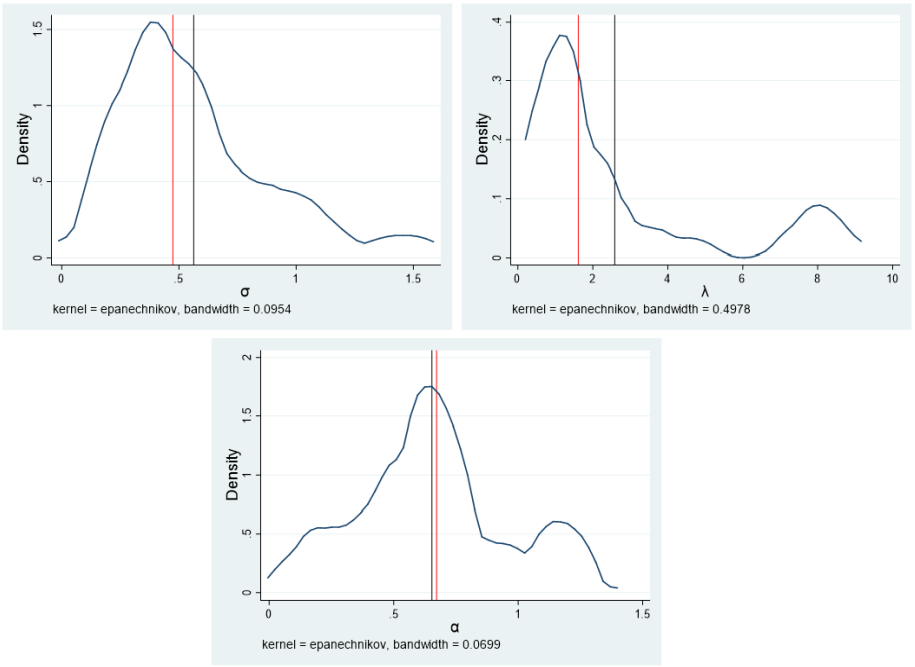

Figure 1. Kernel density estimation plots of risk preferences' parameters.

Notes: In the figure, the black line represents the mean value, and the red line represents the 50th quantile (i.e., the median).

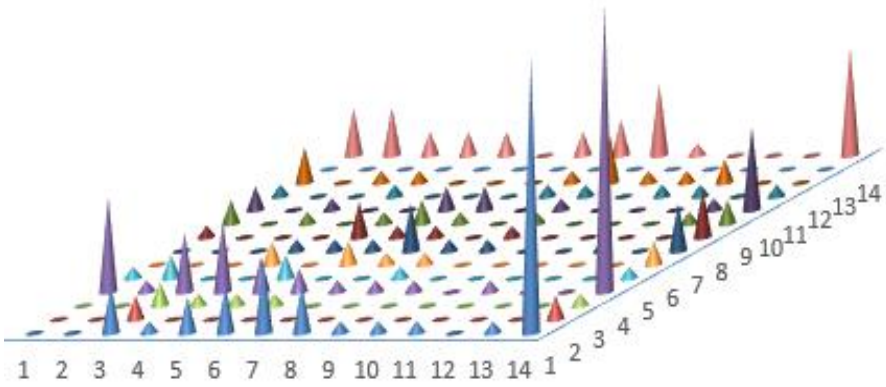

Figure 3. Distribution of switching point in series 1 and 2.

3.3. Empirical Methods

We use a probit model with a maximum likelihood estimator to explore the effect of contract arrangements and farmers' risk preferences on contract stability. The dependent variable refers to farmers' contract performance decisions (*CB*). The independent variables include the key explanatory variables associated with farmer *i*'s risk preferences and contract

arrangements, and a vector of control variables related to farmer *i*'s demographic and socio-economic characteristics.

The estimating equation is expressed below:

$$\Pr(CB_i = 1) = F(\eta' x_i) = \int_{-\infty}^{\eta' x_i} \frac{1}{\sqrt{2\pi}} \exp(-\frac{z^2}{2}) dz \quad (7)$$

where *F( )* follows a cumulative normal distribution function giving the probability of contract performance and x_i is the hypothesized explanatory variables. The individual likelihood for farmer *i* is described as follows:

$$p(CB_i) = F(\eta' x_i)^{CB_i} [1 - F(\eta' x_i)]^{(1-CB_i)} \quad (8)$$

Thus, we are able to obtain the likelihood function for all observations by assuming independence across individuals:

$$L = \prod_{i=1}^{n} p(CB_i) = \prod_{i=1}^{n} F(\eta' x_i)^{CB_i} [1 - F(\eta' x_i)]^{(1-CB_i)} \quad (9)$$

The probit model is estimated by Stata 15.0 software.

4. Empirical Results

4.1. Main Findings

The probit estimates are reported in Table 3. In order to ascertain the magnitude of the effects of the independent variables on contract performance, we calculate and present the marginal effects. We focus first on the coefficient estimates of the private enforcement mechanisms. We observed that the variable *pricing* was significantly and positively related to farmers' contract performance decisions. Farmers who signed a contract with floor pricing were almost 10% more likely to fulfill the contract than farmers who signed a contract with fixed pricing. The variable *duration* was observed to have a significant positive effect on farmers' contract performance decisions. The result implies that the longer the duration of the contract, the more likely the farmers are to fulfill the contract, as every additional year of

contract duration was associated with a 3% increase in the probability of contract performance. Additionally, the variable *bonus* had a significant positive effect on farmers' contract performance decisions. Farmers who signed a contract with bonus clause were 15% more likely to fulfill the contract than farmers who signed a contract without bonus clause. These results are consistent with our conceptual framework regarding contract arrangements. Notably, the variable *form* showed no significant positive effect on the farmers' contract performance decisions, which seems contrary to our expectation. In China, the enforcement of oral contracts may rely on the farmers' network and norms as the majority of cooperatives are organized by the farmers themselves; many middlemen live in rural areas and belong to the same rural social networks as farmers, so they are able to assess the farmers' reliability. From this point of view, an oral contract does not necessarily decrease the rate of contract fulfillment.

With respect to the risk preferences, we observed that the risk aversion parameter (σ) had a significant negative effect on farmers' contract performance decisions. A smaller σ is associated with greater risk aversion. Consistent with our expectations, the result indicates that farmers with higher levels of risk aversion were more likely to fulfill the contract, as every unit decrease in σ was associated with a 67% increase in the likelihood of contract performance. In view of the risk uncertainties in the market, particularly in the market price and market channel, it is risky for farmers to default a contract; thus, a risk-averse farmer tends to fulfill the contract in the sales phase. Also in accordance with our expectations, the loss aversion parameter (λ) showed a significant positive effect on farmers' contract performance decisions. For every additional unit of λ, farmers were almost 6% more likely to fulfill the contract. If a farmer has lower levels of loss aversion, he or she will pay less attention to contract default costs such as penalties; this may cause farmer to undervalue the consequences, leading to a high probability of defaulting contract. We also found a significantly positive correlation among probability weighting parameter (α) and farmers'

contract performance decisions: every additional unit of α would increase the probability of contract performance by 33%. This result supports the theoretical hypothesis regarding probability weighting. Farmers who fail to accurately evaluate probability information tend to underestimate the probability that the contractor may discover their default behavior and thus have a higher motivation of contract default.

Table 3. Estimation results of farmers' contract performance decisions.

Variable	Marginal effect	(Std. Err.)
Form	0.086	(0.064)
Pricing	0.105**	(0.045)
Duration	0.029**	(0.015)
Bonus	0.154***	(0.042)
Risk aversion (σ)	–0.674***	(0.035)
Loss aversion (λ)	0.058***	(0.012)
Probability weighting (α)	0.333***	(0.053)
Age	0.006**	(0.002)
Education	0.005	(0.007)
Labor	–0.003	(0.015)
Asset	0.005	(0.007)
Scale	–0.001	(0.004)
Experience	–0.004*	(0.002)
Fluctuation	0.087	(0.480)
Distance	–0.001	(0.001)
Region	–0.089**	(0.037)
Observations	235	
Pseudo-Log likelihood	–49.376	

Notes: Single, double, and triple asterisks (*, **, and ***) denote significance level of 0.10, 0.05 and 0.01, respectively.

The other statistically significant results in Table 3 are also consistent with our expectations. The variable *age* had a significant positive effect on the farmers' contract performance decisions. Every additional year of age would imply a 0.6% increase in the probability of contract performance. The variable *experience* showed a significant negative effect on farmers' contract performance decisions: every additional year of planting fruit was associated with a 0.4% increase in the probability of contract performance. Additionally, the

variable *region* was observed to have a significant negative effect on farmers' contract performance decisions.

4.2. Robustness Checks

4.2.1. Robustness Check by Excluding the Outlier of Preferences

In this survey, about 7.2% of farmers chose either only Option A or only Option B during the experiment. In the risk preferences experiment, there were cases of "never switch" or "switching at row 1" for all of the three series. One concern that arises is that these farmers may not treat the experiments seriously, or have been innumerate and thus not understand how the experiments work. If this is the case, they add noise to the estimates. As a robustness check, we exclude those individuals from the full sample. The regression results are reported in Table 4.

Table 4. Robustness check by excluding the outlier of preferences.

Variable	Marginal effect	(Std. Err.)
Form	0.096	(0.069)
Pricing	0.111**	(0.047)
Duration	0.032**	(0.016)
Bonus	0.166***	(0.046)
Risk aversion (σ)	–0.709***	(0.042)
Loss aversion (λ)	0.062***	(0.013)
Probability weighting (α)	0.354***	(0.055)
Age	0.006**	(0.003)
Education	0.005	(0.007)
Labor	–0.003	(0.016)
Asset	0.004	(0.008)
Scale	–0.001	(0.005)
Experience	–0.004*	(0.002)
Fluctuation	0.097	(0.509)
Distance	–0.001	(0.001)
Region	–0.097**	(0.040)
Observations	218	
Pseudo-Log likelihood	–49.075	

Notes: Single, double, and triple asterisks (*, **, and ***) denote significance level of 0.10, 0.05 and 0.01, respectively.

From Table4, we found that the interpretations of the coefficients did not vary too much from regression results with the full sample. Particularly, the estimates of contract arrangements parameters and risk preferences parameters (σ, λ, and α) remained robust to exclude the outlier. These results suggest a strong role of contract arrangements and risk preferences in farmers' contract performance decisions.

4.2.2. Robustness Check by Using the Survey Questions of Preferences

In this study we measure farmers' risk preferences by using field experiment. A concern regarding this study might be that we impose too strong a functional form assumption on the value function when deriving the risk preferences. Therefore, we conduct a robustness check by using the survey questions of risk attitude.

During our survey, in addition to eliciting farmers' risk preferences by experiment, we also asked farmers to rank their risk attitude from most risk averse to most risk loving on a 1–5 Likert scale. The smaller the value, the higher the degree of risk aversion. We found that, on average, the level of risk aversion is 2.221 (SD = 1.122). This result may suggest that the average fruit farmer in our sample is risk averse.

Table 5 presents the regression results of survey questions. We observed that the variable *risk attitude* had a significant negative effect on farmers' contract performance decisions. A smaller *risk attitude* is associated with greater risk aversion. The result indicates that the probability of contract performance increase as the levels of risk aversion increase, which is consistent with our main findings. Additionally, the results showed a significant relationship between contract arrangements (the variables *pricing*, *duration*, and *bonus*) and farmers' contract performance decisions.

Table 5. Robustness check by using the survey questions of risk attitude.

Variable	Marginal effect	(Std. Err.)
Form	0.130	(0.080)
Pricing	0.086*	(0.049)
Duration	0.030*	(0.018)
Bonus	0.179***	(0.046)
Risk attitude	–0.245**	(0.017)
Age	0.006**	(0.003)
Education	–0.0002	(0.007)
Labor	–0.036	(0.023)
Asset	0.006	(0.011)
Scale	0.001	(0.006)
Experience	–0.003	(0.003)
Fluctuation	–0.262	(0.608)
Distance	–0.004**	(0.002)
Region	0.036	(0.002)
Observations	235	
Pseudo-Log likelihood	–78.585	

Notes: Single, double, and triple asterisks (*, **, and ***) denote significance level of 0.10, 0.05 and 0.01, respectively.

5. Conclusions

The aim of the paper is to examine how private enforcement mechanisms and farmers' risk preferences affect their contract performance decisions in agri-food supply chain. A better understanding of contract arrangements and risk preferences is important for the design of more effective agricultural policy regarding contract stability. To achieve our objective, we conduct a survey and economic field experiment on Chinese fruit farmers and focus on estimating a probit model of contract performance to capture farmers' decision-making-behavior. The most important result is that contract stability is significantly affected by private enforcement mechanisms and farmers' risk preferences. Specifically, contract arrangements with floor pricing, bonus, and long duration are related to a high-performance level. Farmers with higher levels of risk aversion and loss aversion are more willing to fulfill

contracts; however, farmers who are less accurate in evaluating probability information are more likely to default a contract.

In China, mechanism design is an alternative to legal mechanisms. The combination of litigation costs, poor third party verifiability, and ineffective contract law make formal means of enforcement costly or ineffective (Guo and Jolly, 2008). The implication is that policy-making on improving farmers' contract fulfillment rate should pay attention to the role of private contract enforcement mechanisms. Contract arrangements such as floor pricing and bonus provided by the contractor are conducive to decreasing the contract default rate and promoting the stability of contract farming. Furthermore, the policy-making on contract enforcement should pay attention to the influence of farmers' risk preferences. Experimental studies from developing countries have demonstrated a negative relationship between wealth indicators and risk preferences; hence, government policies increasing farmers' income (e.g., providing farmers more income security and policy insurance regarding fruit planting) may mitigate their risk propensity and increase contract performance rate.

Contract stability in agri-food supply chain is a relatively less researched dimension of contract farming, and we expect the paper to be a good addition to the existing literature. Notably, our study may be limited as we only study the influencing factors of contract performance by farmers, but not by the contractor. Future research on contract performance should consider the factors influencing agribusiness firms' contract performance.

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