Food safety controls and governance structure varieties in China's vegetable and fruit sector

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Abstract

This study addresses the food safety control practices adopted by firms with various governance structures in China. Food safety control is expressed by the certification of products, establishment of production files, and pesticide residue inspection. Three types of governance structures that engage in agricultural production are distinguished: farmer cooperatives, agricultural companies, and family farms. The food safety control practices of various governance structures are investigated based on a database that comprises 600 vegetable and fruit enterprises in China's Zhejiang. The results show that (1) pesticide residue inspection is adopted by the most firms, followed by product verification, and production files are adopted by the fewest firms, and (2) agri-companies adopt more food safety control practices than do family farms, while farmer cooperatives adopt the fewest. A cooperative governance structure's features in terms of ownership, decision-making, and income distribution are the main reasons for lower levels of food control.

Key words: Food safety control; Governance structure; Farmer cooperative; Agricultural company; Family farm

1. Introduction

China has frequently experienced food safety scares. According to a survey based on an empirical study, 1,460 food safety events in China from 2001 to 2010 occurred mostly at the stages of secondary processing, production, and primary processing, in that order (Liu et al. 2011).[a] Among all stages, production is the source and the most critical stage because of the transmission of food safety issues along a supply chain. Most emphasis, therefore, has been focused on agricultural production source management as well as first-stage processing (Wei 2004). Individual and small-scale production by farmers in China is considered to be one of the main causes of food safety problems (Jin and Zhou 2011). First, most farmers in China are not sufficiently educated and do not fully understand the importance of food safety. Second, small-scale farmers are not able to afford the costs associated with implementing food safety and quality standards. Third, small farmers lack the power to gain the value added from additional investments in food safety control, and downstream participants, rather than these farmers, reap the benefits (Ye 2012). Compared with individual farmers, firms have various advantages in practicing food safety and quality control as a result of their positions as the congruent points of both commodity flow and information flow. Firms engaged in agricultural production and marketing are currently the main adopters of food safety controls in China.

Adoption of food safety and quality control by firms is influenced by various factors. There is evidence of (private-based) firm characteristics (Arora and Cason 1995; Jayasinghe-Mudalige and Henson 2007; Herath et al. 2007) and (public-based) regulations and governmental support (Henriques and Sadorsky 1996; Henson and Northen 1998; Nakamura et al. 2001)—factors that affect the adoption of food safety and quality control. The former type of factors mainly refers to size of firms, the level

[a] The five stages of the entire supply chain are distinguished by Liu et al. (2011): production, primary processing, secondary processing, transportation and marketing, and consumption.

of innovativeness, the level of export orientation, and so on. A few scholars argue that the variance in food safety and quality control practices by different types of firms is also associated with governance structure features (Ordóñez et al. 2006; Wang 2008; Zhou and Jin 2009).

A governance structure delineates ownership, decision, and income rights (Baker et al. 2008). Ownership rights specify the formal rights regarding the residual control of assets, decision rights address the question of 'who has control regarding the use of assets' and 'who directs the firm's activities', and income rights are associated with the allocation of benefits and cost. Different governance structures are observed at the stages of agro-food production and marketing, ranging from spot markets, contract farming and farmer cooperatives to investor-owned firms (Hendrikse 2007).

Empirical evidence on the food safety control practices of firms with different governance structures can be found in a small number of papers. Higher levels of vertical integration result in better food safety control effects on production (Hu et al. 2006; Liu 2013). Zhou and Yan (2014) compare the self-inspection behaviours of three types of producers—large farmers, farmer cooperatives, and agricultural companies—in China's aquaculture sector. The results reveal the highest levels of self-inspection among cooperatives, followed by agricultural companies; large farmers adopt the lowest levels. However, alternative observations exist as well. One study based on a sample of vegetable firms in China finds that cooperatives adopt fewer quality standards compared to investor-owned firms (IOFs) (Zhou and Jin 2009). IOFs are more likely to have product brands and certifications (Huang and Yu 2010). Hua's (2011) comparison of a farmer cooperative and an agricultural company shows differences in their food safety management practices, but it is difficult to tell which of the two governance structures adopts more food safety control measures. Therefore, this paper seeks to investigate the food safety control practices of firms

with different governance structures, i.e., family farms, farmer cooperatives, and agricultural companies, by analyzing a database of firms in China.

The present study makes several contributions. First, we contribute to the empirical literature on the three governance structures' food safety control practices in product production and marketing: farmer cooperatives, agricultural firms, and family farms. Although there is an extensive body of literature that compares cooperatives and IOFs, little attention has been focused on family farms. In addition, comparisons of food safety control practices between different governance structures are found in the literature mainly in terms of qualitative and descriptive analysis. There is a paucity of statistical studies based on large samples. Second, food safety controls are expressed in three dimensions, i.e., product verification, production files, and pesticide residue inspections before sales. The number of adoptions is counted to evaluate the levels of food safety control. This method of measurement does not yet exist in the literature on this topic. Related previous studies generally focus on one dimension of food safety control or measure food safety control in a qualitative manner (Pouliot et al. 2008; Jin et al. 2008; Herath et al. 2007; Jayasinghe-Mudalige and Henson 2007). We innovatively and comprehensively evaluate food safety control with three indicators covering before, during, and after production.

This article is organised as follows. The next section examines the various governance structures and food safety control practices implemented in China. Section 3 specifies the study's methodology. Section 4 presents the results regarding the food safety control behaviours of the different governance structures, and section 5 discusses the results. We conclude and discuss possibilities for future research in section 6.

2. Governance structures and food safety control in China

The different governance structures (2.1) and food control practices (2.2) in China are delineated in this section.

2.1 Agricultural production governance structures in China

China has shifted from collective to household-based farming since 1978, when eighteen farmers in Xiaogang Village in An'hui province initiated the household contract responsibility system (HRS) (Xu et al. 2013). Agricultural land operation rights are assigned to farmer households, whereas ownership rights remain with the state. Because of the HRS, farmers began to have ownership rights over the yields from their land. The economies in China's rural areas grew significantly thereafter. However, the system also requires that farmers market their products themselves. Challenges emerged in smallholders' entering large markets and obtaining reasonable benefits. Farmers are faced with multiple challenges, such as small, marginal profits and industrialisation, specialisation, informatisation and globalisation by other participants in the agricultural supply chain. Small farmers are incapable of negotiating effectively with other supply chain participants, and they rarely benefit from products' value added. In addition, small farmers find it difficult to meet quality standards in consideration of the increasing food safety concerns (Jia et al. 2010).

Numerous institutional innovations were consequently implemented to help smallholders access markets. Currently, the governance structures engaged in food production in China are diverse, including family farms, farmer cooperatives, agricultural companies, associations, and others (Huang and Yu 2010); among these, the first three are directly involved in production and marketing.

2.1.1 Family farms

Family farms are owned and managed by family labour, and their control transfers to the next generation in the family (Gasson et al. 1988). Pallak (1985) observes that family farms are managed jointly by couples and their children or by relatives of the family. Farms are grouped into family farms, intermediate farms, and non-family farms, depending on the composition of the labour input (Hill 1993). Family farms are characterised by having more than 95% of labour provided by family members. A

farm is considered to be intermediate if half to 95% of labour is supplemented with hired labour, and it is a non-family farm if hired labour accounts for more than half of all labour. Therefore, family farms are typically small farms because of the limited supply of family labour. Academic debates regarding family farms in the 1980s and 1990s mainly addressed whether family farms were sustainable or whether they would decline and be replaced by alternative-scaled agribusinesses under the changing environment and competition (Bowler et al. 1996; Damianos and Skuras 1996; Kimhi and Bollman 1999).

However, family farms in China are defined alternatively from the perspective of production size. They are economic enterprises that engage in agricultural production, processing, and marketing, that are operated mainly by family members, and that feature large-scale market and profit orientations (Gao et al. 2013).[b] The emergence of family farms stemmed from both internal demand and the external environment. Rapid urbanisation and industrialisation in China led many farmers to migrate from rural to urban areas and to shift from being agricultural producers to adopting non-agricultural labour; this shift led to the demand for rural land transfers, agricultural entrepreneurs, and technical progress (Gao et al. 2013). Based on the demands of institutional innovation and the increase in entrepreneurial farming, China's government began to propose developing family farms in 2008, and by the end of 2012, there were 877,000 family farms in China.[c] Governmental support for

[b] Data source: The first statistical survey of family farms by the Ministry of Agriculture in China in 2013. There are no production size standards for family farms to date. Some provinces require that family fruit, vegetable, and other cash crop farms have land areas larger than 30 hectares and that cereal crop farms be larger than 50 hectares. Some areas require a minimum land area of 100mu (15mu equal to 1 hectare).

[c] Data source: Three problems need to be solved to develop family farms. Financial Times, Mar. 31, 2104.

family farms is multidimensional, addressing rural land transformation, credit financing, and machinery subsidies, among other factors. Family farms have advantages over small farms because they are large in scale, have standardised production and marketing, and invest in product verification and branding (Gao et al. 2013).

2.1.2 Farmer cooperatives

Theoretically, increasing farmers' production scales could alleviate their difficulty in competing with other supply chain participants. However, increasing scale is not always feasible; it is costly and difficult to expand production scales by renting additional land. It is not always efficient to hire and supervise labourers other than family members. Collective action via farmer cooperatives is often recognised as an effective response to market failure (LeVay 1983; Hansmann 1996; Valentinov 2007; Huang 2011). Farmer cooperatives arose in China in the 1980s and developed slowly, but they began to grow rapidly in the 2000s (Xu 2005; Chen and Scott 2014). Following the promulgation of the National Farmer Cooperative Law (Law afterwards) in 2007, farmer cooperatives developed even more rapidly, and by the end of 2013, there were 982,400 farmer cooperatives[d] with 74.12 million members in China. Approximately 28.5% of farmers have joined cooperatives.[e]

Cooperatives are expected to emerge to address problems such as small-scale production challenges, powerful intermediaries and retailers, food safety issues, and missing markets by purchasing inputs, providing technique trainings, and supervising

[d] According to an estimate, more than one-third of cooperatives in China exist "on paper", approximately one-third have developed beyond cooperative principles, and the remaining third function properly (Sultan and Wolz, 2012).

[e] Data source: The Ministry of Agriculture of the People's Republic of China. Available at http://www.moa.gov.cn/

product production, processing, and marketing for members collectively (Huang 2010). Farmer cooperatives play an essential role in food product safety control (Wei and Lu 2004; Ren and Ge 2008; Narrod et al. 2009). Training, uniform input purchasing, and mutual supervision among members are typical ways that cooperatives control members' product quality (Jiang and Xu 2013). Branding strategies also constrain members' food safety control activities. Specifically, most farmer cooperatives in China control quality with five uniformity measures, i.e., uniform input supply, technique training, marketing, packing, and branding.

2.1.3 Agricultural companies

The emergence of agricultural companies in China occurred in the early 1990s, and their development increased rapidly in the 2000s. Nearly half of products were delivered to agricultural companies in 2008 (Xu et al. 2013). Three types of links between farmers and agricultural companies are observed: loose linking based on random purchasing, payment based on protective prices, and contract farming (Sun and Wei 2000). Companies may provide inputs and technical assistance to contracted farmers in order to control quality. In exchange, companies benefit from stable product supplies and reduced transaction costs by offering farmers protective prices specified in purchasing contracts (Guo and Liao 2007; Huang et al. 2013). However, Jia et al. (2010) find that there are nearly no written contracts; the transactions between companies and farmers are generally maintained via long-running business relationships.

Agricultural companies have advantages in adapting to the changing market and fierce competition (Shao et al. 2012). They are more flexible and more efficient in terms of value added efficiency than are farmer cooperatives because cooperatives make decisions collectively and target members' benefits, whereas companies are focused on profit and are efficiency oriented (Liang 2011). Technical innovation and extension, capital aggregation and utilisation, and scale efficiency are the fields in

which agricultural companies play an important role (Peng and He 2005). They therefore help to increase the value added and may provide farmers with protective prices from the micro perspective and promote structural agricultural adjustments, industrialisation, and increased farmers' incomes from the macro perspective (Jiang and Han 2003).

2.2 Food safety control practices

In the context of food safety control practices, traceability, HACCP, food safety certification, environmental inspection, standardisation and certification, inputs and production management, and pesticide residue inspections before sales are frequently discussed. Nevertheless, there are no standardised indicators of food safety control practices because of different products' divergent production technologies and critical control points. Production, first-stage processing, and secondary processing are all critical food safety control points (Liu et al. 2011). The current paper focuses on data from the vegetable and fruit industries, which incorporate very little secondary processing. We therefore emphasise firms' food safety control practices in production and first-stage processing. Production is the source and the most critical stage as a result of the transmission of food safety problems along a supply chain. Liu et al. (2011) find that the most common problems in production are the inappropriate use of fertilisers and pesticides and agro-ecological environmental pollution. As such, food safety control practices at the production stage essentially entail three dimensions, i.e., environmental inspection, input and production management, and pesticide residue inspections before sales.

Pesticide residue in the vegetable and fruit sectors is a more serious problem than it is in other sectors, and it is the most important issue that consumers are concerned about. Pesticide residue inspection by firms and sample inspections by the government are the two screenings that alleviate potential food safety hazards. Pesticide residue inspection has always been the most stringent food safety control

measure required by the Chinese government. The Food Safety Act of the Republic of China, promulgated on November 1st, 2006, explicitly requires that firms that engage in agricultural production inspect pesticide residue themselves or hire third-party testing organisations. Pesticide residue inspection is therefore one of the food safety control practices studied in the current paper.

Nevertheless, the pesticide residue inspection system in China is not perfect. Furthermore, it is not sufficient to completely eradicate food safety problems only by pesticide residue inspection. Creating a traceability system that helps to quickly identify faulty products is of great necessity to firms. To date, a number of firms in China have established sales account systems, and consequently, it is possible to trace firms that provide faulty products. Production files that contain inputs and production management measures and are recorded by farmers are needed to further and more accurately trace exact responsibility to the appropriate subjects. In addition, one of the main problems in products' first-stage processing is the inappropriate use of chemical preservatives, which can be effectively traced by establishing production files. Hence, the current paper also studies the establishment of production files as a food safety control practice.

The agro-ecological environment also has an essential influence on food safety. Inspecting agro-ecological environments is needed to verify the environments' viability for agricultural production. Eco-labelling systems, which are broadly applied in Western countries, have yet to be adopted in China. Environmental inspection of production areas in China is included in the verification of pollution-free, green, organic, and geographical indication products. Thus, product verification is considered to be a food safety control practice. Although the requirements for the verification of the production areas for the four types of products—pollution-free, green, organic, and geographical indication—are quite different (Scott et al. 2014),

this paper is concerned only with the primary attributes of food safety and therefore does not further distinguish between the four types of product verification.

Based on the preceding statements regarding food safety control practices, three indicators are applied to represent these practices. First, inspecting the environment is included in **the verification of** pollution-free, green, organic, and geographical indication products. Second, managing inputs and production is accomplished mainly by establishing **production files by farmers**. Third, **pesticide residue inspections** before sales, whether self-inspection or third-party inspections, comprise the third indicator of food safety control.

3. Methods

This section begins by presenting the data used for empirical analysis (3.1). A model of the association between food safety control and different governance structures is established (3.2). Then, the values of the measurements of food safety control practices as well as the independent variables are presented in 3.3.

3.1 Data

Zhejiang is a leader in quality standardisation extension and promotion. The provincial government has spent approximately 15 to 40 million Chinese Yuan on product standardisation and food safety each year since 2003.[f] Through the end of 2009, a total of 200 million Chinese Yuan had been invested in the pursuit of product standardisation and food safety. Both provincial and city-level bylaws regarding agricultural production and product standards have been put into practice, covering traditional, facility, ecological, and tourism agriculture as well. A system to promote product standardisation based on the joint work of producers, the market, and the government has been established. We therefore choose Zhejiang as the study's survey

[f] One Chinese Yuan was approximately equal to 0.16 USD in 2013.

area. There were 37,428 farmer cooperatives, 7,492 agri-companies, and 9,401 family farms in Zhejiang at the end of 2013.[g]

In addition, we choose vegetable and/or fruit firms as the study subjects for a number of reasons. First, Zhejiang specialises in high-value products such as vegetables and fruits because of its scarcity of land and its well-developed economy. The average arable land area per capita in Zhejiang is less than one-third of the national level. Zhejiang is one of the most developed provinces in China in terms of GDP per capita, which implies a high consumption of vegetables and fruits. Second, the quality standards and food safety control practices for different products differ greatly. It is not feasible to compare the food safety control practices of a pork firm and a fruit firm because they have very different production technologies and processing methods. We therefore focus on vegetables and fruits to ensure homogeneity and comparability.

Pre-investigations were conducted in early May 2013, before sampling. We interviewed the head of a family farm, the chairperson of a farmer cooperative, and the general manager of an agricultural company to discuss each question of the questionnaire, and the questionnaire was revised based on the responses from these interviewees. Random sampling was then used to survey cases from each city in Zhejiang. Questionnaires were distributed to the heads of each firm by either face-to-face interviews or email during May and September 2013. We ultimately obtained a database that comprised 600 cases of the different governance structures.

There are 383 cooperatives, 141 agri-companies, and 76 family farms, accounting for 63.8%, 23.5%, and 12.7% of the sample, respectively. Among the cases surveyed, 257 delivered vegetables and 343 delivered fruits, 42.8% and 57.2%, respectively. All

[g] Data source: Statistical data from the Agricultural Department of Zhejiang.

firms conduct fresh marketing, rather than secondary processing, of their vegetables or fruits.

3.2 Model

An orderly logit regression model is established because the dependent variable is defined as an orderly variable and measured by the number of food safety control practices adopted. Denote firms' food safety control practices as y and independent variables as $x_i = x_1, x_2, ..., x_n$. Assume that the probability of $y = j(j = 0,1,...,k)$ is $P(y = j \mid x)$ and the probability of $y \geq j$ is $P(y \geq j \mid x) = P(y = j \mid x) + \cdots + P(y = k \mid x)$. The equation after logit conversion[h] is

$$Logit(P(y \leq j \mid x) = In\frac{P(y \leq j \mid x)}{1 - P(y \leq j \mid x)} = -\alpha_j + \sum_{j=1}^{k} \beta_j x_i \,, \tag{1}$$

where $y = j(j = 0,1,...,k-1)$ and β_j is the parameter.

To examine the impact of governance structure on food safety control behaviours, we apply a dummy variable to represent the governance structure variety. Denote g as the dummy variable, i.e., governance structure, and $g = 1,2,3$ to represent a farmer cooperative, an agri-company, and a family farm, respectively. We then obtain

$$LogitP_j = LogitP(y \geq j \mid x) = -\alpha_j + \sum_{j=1}^{k} \beta_j x_i + g \,, \tag{2}$$

where β_j is the parameter.

3.3 Variables and measurements

[h] Logit conversion converts the dependent variable the dependent variable to its logit, in order to convert the nonlinear equation to a linear equation.

As stated in the first section, three practices are studied as indicators of food safety control, i.e., verification of pollution-free, green, organic, or geographical indication products; establishing production files; and pesticide residue inspections before sales. Denote the value of a food safety control practice as 1 if a firm adopts it and 0 otherwise. Four levels of food safety control are therefore distinguished, depending on the number of practices a firm adopts. The food safety control value is 0 (1, 2, or 3) if a firm adopts none (one, two, or three) of the three practices. Weights for the importance of the three indicators are not considered in the current study because this process is not straightforward. Different firms differ in the amount of investments they make in alternative practices of food safety control.

Regarding the independent variables, abundant studies concern the incentives, both internal and external, for agricultural firms to adopt food safety control practices (Holleran et al. 1999；Karipidis et al. 2009). Among the internal incentives, the two most important are establishing firm reputation and reducing the risks and costs of quality incidence (Caswell1998；Starbird 2000); meanwhile, food safety laws and bylaws, as well as consumer demand, are considered to be key external incentives (Henson et al. 1995；Henson and Heasman1998; Henson and Caswell 1999). Laws and bylaws dictate what firms at various levels can or cannot do, which therefore directly influences their food safety control activities. Caswell (1999) indicates that the potential consumer response to food safety risks is an essential driver of firms' use of appropriate food safety control measures. Golan et al. (2004) demonstrate that consumers' stringent food safety demands are a major driver of safety control innovations in the US meat-processing sector. In addition, firm characteristics may have impacts on food safety control practices. Differences have been found in the food safety control measures of firms of differing sizes (Herath et al., 2007).

Based on the theory in the previous paragraph, we choose factors from both the internal and external dimensions as the influencing factors of firms' food safety

adoption: brand establishment, motivation to reduce food safety risk, laws and bylaws, government support, and pressure from consumers. In addition, firm characteristics, such as years of operation, the number of food safety control technicians, membership size or the number of employees, and production size, may affect a firm's incentive to supply safe products and are chosen as the control variables (Shavell 1987). The variables and their measurements are presented in table 1.

table 1

4. Results

The values of the variables are presented in table 2. Nearly 85% of firms adopt two or more food control practices. Most have brand names and a strong motivation to reduce food safety risks. Laws and bylaws and pressure from consumers' demands are considered to be important drivers of adopting food safety control measures. Most firms have a history of four to nine years. More than 85% of firms have fewer than 3 food safety control technicians, and more than 60% of firms surveyed have a membership size of fewer than 50 people. The average production size of the surveyed firms is just over 1000 mu.

table 2

The three food safety control practices adopted by firms with differing governance structures are displayed in table 3. A proportion of 90.5% of firms adopt pesticide residue inspection, and 76.17% of firms have certificates of pollution-free, green, organic, and/or geographical indication products; however, only 50.33% of firms have established production files.

table 3

A parallel test is first conducted to test the feasibility of ordinal regression. The results show a P value of 0.318 (P>0.05), implying that the regression equations are parallel and that ordinal regression is feasible.[i] In addition, the F-test results demonstrate that the partial regression coefficient of at least one independent variable is non-zero, which indicates the model's significance.[j]

The differences in food safety control adoption by firms with different governance structures are estimated by setting family farms as the reference group. The estimation results are displayed in table 4. The food safety control practices of firms with different governance structures are significantly different. The coefficient of farmer cooperatives is significantly negative, while that of agri-companies is significantly positive, which implies that farmer cooperatives adopt fewer food safety controls than do family farms, whereas agri-companies have the highest levels of food safety control. This observation is in line with Zhou and Jin's results (2009) for a sample of firms in the vegetable sector, while it contradicts Zhou and Yan's finding (2014) that cooperatives in the aquaculture sector adopt the highest level of self-inspection. The sector category therefore matters to firms' adoption of food safety control. In addition, laws and bylaws, government support, pressure from consumers, brand establishment, and membership size have significant impacts on firms' food safety control practices.

table 4

5. Discussion

This section addresses the adoption of each food safety control practice by firms in China's vegetable and fruit sector (5.1) and the relationship between governance

[i] The result is provided in table 5 in the Appendix.

[j] The result is provided in table 6 in the Appendix.

structure and the adoption of food safety control measures (5.2).

5.1 Adoption of each food safety control practice

Pesticide residue inspection is adopted by the most firms, followed by product verification; establishing production files is adopted by the fewest firms. The different extents of food safety control have much to do with both food safety bylaws and the cost of adopting controls.

Pesticide residue inspection before sales is one of the key elements of government supervision. The establishment and optimisation of the inspection system is emphasised in the "12th Five-Year Planning of the State Food Safety Supervision System". The Zhejiang government provides preferential measures to promote firms' adoption of pre-sale inspections, such as subsidising firms to purchase inspection equipment and providing free inspection at local public service centres. These measures push firms to practice food safety control during production and produce savings in firms' inspection costs.

There are also preferential policies for the verification of pollution-free, green, organic, and geographical indication products. For example, governments at different levels provide subsidies and rewards to firms with food quality certifications. Take the case of Zhejiang province as an example: firms' expenses for the verification of pollution-free products are paid completely by the government, while the financial subsidies and rewards for a firm's verification of organic products amount to 200,000 Yuan. Various subsidies are available from city-level governments as well. Moreover, firms with product quality certification prioritise product promotion and financial support for the construction of banding and standardisation. However, the continuous costs per year and complicated verification procedures limit firms' use of this practice to some extent.

Establishing production files is mainly aimed at supporting traceability, but it entails substantial time and labour costs, and it was included in the food safety control system by the government only recently. There are no specific rewards or punishments for having or not having established production files, which gives firms relatively little incentive to adopt this measure. Producers' ages and limited education may also increase their difficulty in establishing and maintaining production files.

5.2 Governance structures and food safety controls

A cooperative is a user-owned, user-controlled, and user-benefitted governance structure, whereas agri-companies are owned, controlled, and benefitted by shareholders and family farms by family members. Different levels of food safety control are observed in the different governance structures. We attempt to explain the different food safety control behaviours from the perspective of governance structure characteristics.

5.2.1 Ownership rights

Farmer cooperatives, agri-companies, and family farms vary in their ownership rights, which determine different organisational goals. Both agri-companies and family farms maximise profits, whereas cooperatives maximise the joint benefits to members. Because consumers attach more value to product quality, for-profit firms tend to provide high-quality products to seek more benefits. However, many cooperatives in China attempt to provide inputs to farmers at lower prices and are relatively less profit-oriented (Liang 2011), which leads to lower levels of food safety control.

Adopting food safety control practices requires investing in both financial and human capital. The patronage-based financing[k] that is characteristic of farmer

[k] Patronage-based financing of cooperatives indicates that cooperatives' financial capital is acquired

cooperatives leads to the horizon problem[1] and underinvestment in long-term strategies, which bring disadvantages to product quality enhancement (Fulton and Sanderson 2002). For example, a cooperative's branding strategy is considered by members as a public good for the entire membership. As such, there are fewer incentives for cooperatives to establish and maintain brands than there are for other governance structures. Family farms emerged recently and are challenged by a shortage of financial capital (Huang and Yu 2010). Food safety control practices adopted by family farms may be limited. Agri-companies are relatively competitive in terms of financial and human capital. Peng (2011) argues that agri-companies should play a dominant position in China's food supply chain in terms of quality enhancement. However, agri-companies in China still have limited cognition of and capacity for investing human or financial capital in food safety practices (Wang et al. 2009; Liu et al. 2011).

5.2.2 Decision rights

Decision-making in agri-companies is managed by either the board or the management team, whereas a family farm's decision-making power is monopolised by the head of the family. Cooperatives are distinguished by their collective and democratic decision-making, which is generally slow and costly (Liang 2011). Different decision-making strategies may contribute to firms' different levels of food safety control.

The tendency to pursue projects differs across governance structures. Cooperatives

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from members rather than external investors (Sexton 1984). The limited sources of financing may result in a low level of capital investments in farmer cooperatives.

[1] The horizon problem refers to members' restricted residue claim rights when they cease to patronise an organisation (Vitaliano, 1983). That is, a member's invested capital in a cooperative would not be sufficiently returned when he/she exits the cooperative. The member is therefore reluctant to conduct long-term investment in the cooperative.

are less likely to adopt innovation or new projects because of members' diverging interests during decision-making (Hendrikse, 1998). Agri-companies tend to adopt projects that cover various stages, including production, processing, transportation, and sales, which contribute to the more vertical integration of companies over family farms and cooperatives.

The supervision costs of food safety control measures across governance structures also vary because of their different control mechanisms. The farmers who deliver to agri-companies must produce according to the standards required by the company; otherwise, their products will be rejected. Companies are therefore able to supervise farmers at lower costs. Cooperatives provide a "home" for members (Fulton and Sanderson 2002), and coordination and supervision within them depend mainly on informal regulations, such as relationships (Liang 2011). Traditional cooperatives have disadvantages in meeting markets' demands for quality. (Nilsson 1998). Opportunistic behaviours and free-riding occur in cooperatives. The larger the cooperative, the higher its costs of practicing food safety control and supervising members' production. Both decision-making and supervision costs are the lowest for family farms. However, the short history of family farms in China is a key factor in the underdevelopment of food safety control.

5.2.3 Income rights

The differing quality provision measures of cooperatives vs. investor-owned firms are explained by many scholars from the perspective of income rights (Fulton and Sanderson 2002; Hoffmann 2005; Liang and Hendrikse 2013). Hoffmann (2005) examines the quality provision of firms with different governance structures. Cooperatives and IOFs have different objective functions and face different costs; IOFs maximise the profit from processing, whereas cooperatives maximise members' joint profits. The results show that the cost of quality has an impact on the choice of quality levels and on total welfare. When there are fixed quality costs at the primary

level, IOFs generate larger consumer surpluses and produce higher-quality products, whereas cooperatives generate larger producer surpluses. When there are variable quality costs at the primary level, cooperatives produce higher-quality products and generate larger profits, larger consumer surpluses, and greater social welfare. The results of our empirical study confirm Hoffmann's theoretical observations. As reported above, the food safety control practices we studied are product verification, establishing production files, and pesticide residue inspection. The costs of both verification and inspection are essentially fixed, but the costs of establishing production files are both fixed and variable. IOFs, therefore, are likely to produce higher-quality products.

Traditional cooperatives are characterised by the equal treatment of their members (Nilsson 1998), which entails that allocating revenues and costs may be independent or partially independent of quality. This pricing mechanism or income rights allocation places cooperatives at a disadvantage in product quality enhancement (Fulton and Sanderson 2002; Bijman et al. 2012; Theodorakopoulou and Iliopoulos 2012; Pennerstorfer and Weiss, 2013). Members who provide high-quality products are not sufficiently paid by cooperatives, which causes adverse selection. Farmers who produce high-quality products tend to deliver to agri-companies, whereas farmers producing low-quality products prefer to join cooperatives (Liang and Hendrikse 2013). Cooperatives may then adopt appropriate payment schemes to motivate heterogeneous members to join and stay with them. Cooperatives' bylaws have the flexibility to design income rights structures that are tailored to the heterogeneity of the membership. Some cooperatives move towards high-quality product provision based on incentive payments for quality (Hendrikse 2011).

6. Concluding remarks and further research

The food safety control practices of various governance structures are investigated in this paper based on a database that comprises 600 vegetable and fruit enterprises in

China's Zhejiang, which is a leader in both the development of industrial organisations in agriculture and the emphasis on food safety control during the production stage. Food safety control is expressed by three indicators, i.e., verification of pollution-free, green, organic, or geographical indication products, the establishment of production files, and pesticide residue inspection. Three types of governance structures that engage in agricultural production are distinguished: farmer cooperatives, agricultural companies, and family farms. The results show that (1) pesticide residue inspection is adopted by the most firms, followed by product verification, and production files are adopted by the fewest firms, and (2) agri-companies practice more food safety control measures than do family farms, and farmer cooperatives adopt the fewest food safety control practices. This does not mean that farmers producing unsafe products tend to deliver to cooperatives, but rather that cooperatives have some disadvantages in controlling food safety.

The features of cooperative governance structures in terms of ownership, decision-making, and income distribution are the main reasons for the lower levels of food safety control. As a result of the imperfection of the high-quality, high-price mechanism, the benefits of food safety control practices are not sufficient to offset their costs, and food safety control therefore has conspicuous externalities. Because of cooperatives' democratic management, collective decision-making, and member benefit maximisation, rational members tend to refrain from practicing food safety control. Food safety control in farmer cooperatives faces a collective action dilemma, which leads to their adopting fewer food safety control measures than agricultural companies and family farms. Despite the cooperatives' disadvantages in food safety control practices observed in the current paper, there are possibilities to alleviate them. First, creating collective action depends to a large extent on driving and supervision by cooperatives' critical internal members (Oliver et al. 1985). It is therefore helpful to enhance critical members' consciousness and food safety control management

levels and to provide subsidies for practices such as product verification and production file establishment. Second, the key benefits of food safety control for farmer cooperatives are the creation of mutual member supervision mechanisms and quality premiums. Brand building helps to realise quality premiums and the value added from food safety control practices. The costs can then be offset by the benefits, which is key to the sustainable adoption of food safety control practices in farmer cooperatives. Third, clear specification of the governance mechanisms, such as general member meetings, financial information disclosure, and membership rules, rewards and penalties are important factors of creating an institutional environment that supports food safety control in farmer cooperatives.

There are a number of possibilities for further research. First, we focus on the food safety control practices of three governance structures: farmer cooperatives, agricultural companies, and family farms; however, the intra-group differences in food safety control for each governance structure are not addressed because we lacked data. The structure of ownership rights, the allocation of decision rights, and the distribution of income may be important for firms' food safety control practices as well. It is therefore desirable to further investigate whether the governance of various firms has an effect on food safety control practices.

Second, the influence of product outlets on food safety control is not included in the current model. Firms that deliver to different buyers may choose different food safety control measures (Zhou and Hu 2009; Chen and Tan 2013). For example, supermarkets likely have higher quality standards than do wholesale or wet markets. The exclusion of certain outlets may have led to bias in the empirical results. An additional research avenue is to examine the relationship between different governance structures' product outlets and their food safety control practices.

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Appendix
Table 1

Variables and measurements

	Variables	Measurement
Dependent variables	Food safety control (y)	No practices=0; One practice=1; Two practices=2; Three practices=3.
Independent variables	Governance structure varieties (g)	Cooperative=1; Agri-company=2; Family farm=3.
	Brand (x_1)	With brand=1; No brand=0
	Intensity of motivation for food safety risk reduction (x_2)	Practices need to be adopted to reduce food safety risks. Completely disagree=1; Somewhat disagree=2; Neutral=3; Agree=4; Completely agree=5.
	Pressures from laws and bylaws (x_3)	The requirements of laws and bylaws concerning food safety are strict. Completely disagree=1; Somewhat disagree=2; Neutral=3; Agree=4; Completely agree=5
	Governmental support (x_4)	The government provides sufficient funding for the establishment of food safety control system. Completely disagree=1; Somewhat disagree=2; Neutral=3; Agree=4; Completely agree=5
	Pressure from consumers (x_5)	Consumers pay close attention to food safety issues. Completely disagree=1; Somewhat disagree=2; Neutral=3; Agree=4; Completely agree=5

Control variables	Years of operation	Years
	No. of food safety control technicians	Persons
	Production size	Production size of vegetables and/or fruits: mu[m]
	Membership size	Cooperative: number of members; Agri-company: number of shareholders and employees; Family farm: number of family members engaged and employees

Source: Authors.

Table 2

Descriptive statistics of variables

Variables	Value	Freq.	Percentage	Mean	Variance
Food safety control	0	18	3.0%	2.17	.572
	1	75	12.5%		
	2	294	49.0%		
	3	213	35.5%		
Governance structure varieties	1	383	63.8%	1.49	.504
	2	141	23.5%		
	3	76	12.7%		
Brand	1	426	71.0%	.71	.206
	0	174	29.0%		
Intensity of motivation for food safety	1	4	0.7%	4.55	.558
risk reduction	2	5	0.8%		
	3	54	9.0%		
	4	129	21.5%		
	5	408	68.0%		
Pressures from laws and bylaws	1	8	1.3%	3.86	1.328
	2	101	16.8%		
	3	94	15.7%		
	4	160	26.7%		
	5	237	39.5%		
Governmental support	1	4	0.7%	4.39	.647
	2	8	1.3%		
	3	74	12.3%		

[m] 1 hectare is equal to 15 mu.

	4	175	29.2%		
	5	339	56.5%		
Pressure from consumers					
	1	2	0.3%		
	2	6	1.0%	4.57	.476
	3	39	6.5%		
	4	156	26.0%		
	5	397	66.2%		
Years of operation (year)	≤ 3	109	18.2%		
	4-5	174	29.0%	6.43	11.992
	6-9	217	36.1%		
	≥10	100	16.7%		
No. of food safety control technicians	≤ 3	513	85.5%		
(person)	4-10	81	13.5%	2.42	21.265
	＞10	6	1.0%		
production size (mu)	＜100	52	8.7%		
	100-299	142	23.6%		
	300-499	114	19%	1,015.59	3,497,845.984
	500-999	116	19.4%		
	≥1000	176	29.3%		
Membership size (person)	＜10	73	12.2%		
	10-49	305	50.8%		
	50-99	99	16.5%	59.7	9,469.200
	100-499	115	19.2%		
	≥500	8	1.3%		

Source: Authors.

Table 3

Each food safety control practice adopted by firms

Food safety control	Product verification		Production file		Pesticide residue inspection	
	0	1	0	1	0	1
No. of agri-companies	28	113	45	96	11	130
Percentage	19.86%	80.14%	31.91%	60.09%	7.80%	92.20%
No. of family farms	7	69	32	44	6	70
Percentage	9.21%	90.79%	42.11%	57.89%	7.89%	92.11%
No. of cooperatives	108	275	221	162	40	343

Percentage	28.20%	71.80%	57.70%	42.30%	10.44%	89.56%
Total number of firms	143	457	289	302	57	543
Percentage	23.84%	76.17%	49.67%	50.33%	9.50%	90.50%

Source: Authors.

Table 4

Relationship between food safety control practices and governance structure varieties

		Coef.
Food safety control practices	Food safety control= 0	-4.372
		(.780)
	Food safety control = 1	-2.431
		(.761)
	Food safety control= 2	1.134
		(.757)
Control variables	Year	-.022
		(.028)
	No. of quality control technician	.024
		(.023)
	Production size	-4.742E-5
		(4.959E-5)
	Membership size	-.002**
		(.001)
Independent variables	Pressures from laws and bylaws	-.207**
		(.089)
	Gov. support	.261**
		(.126)
	Pressure from consumers	.429***
		(.161)
	Intensity of motivation for food safety risk reduction	.032
		(.148)
	Brand=0	-.566***
		(.208)
Governance structure varieties	Coop	-3.228***
		(.320)
	Company	1.075**
		(.367)

Note: ***, ** and * denote significance levels of 1%, 5% ,and 10%, respectively.

Table 5

Test of Parallel Lines

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	910.936			
General	886.368a	24.568b	22	.318

Note: The null hypothesis states that the location parameters (slope coefficients) are the same across response categories.

a. The log-likelihood value cannot be further increased after the maximum number of step-halving.

b. The Chi-Square statistic is computed based on the log-likelihood value of the last iteration of the general model. The validity of the test is uncertain.

c. Link function: Logit.

Table 6

F-test

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept only	1298.784			
Final	910.936	387.847	11	.000

Link function: Logit.