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Doing But Not Knowing:

How Apple Farmers Comply with Standards in China

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Abstract

Are public and private standards affecting farmer knowledge and moving farm practices toward food safety and environmental sustainability in China? We surveyed a total of 355 apple farmers, involved in chains supplying a diversity of retailing points, including supermarkets. Using a multivariate regression model, we find no measurable evidence that the certification schemes of farm bases and agribusiness companies lead to improved apple growers' knowledge regarding pest and disease management. The behavioral changes were mainly prompted by delegated decision-making towards farm bases, which raises questions on the long-term changes in farmers' practices.

Key-words: standards, pest management, food safety, apples, China, supermarkets, chain governance

1. Introduction

In many countries of the world, including China, food consumption is increasingly characterized by quality and safety awareness, in parallel with emerging social and environmental concerns. In this context, standards governing agricultural production and processing methods are proliferating and becoming more and more specific (Giovannucci and Ponte, 2005, Henson and Reardon, 2005). This is associated with changes in the governance of the agri-food chain, with the rising role of supermarkets (Reardon et al., 2003). Agricultural standards refer to specifications pertaining to the production and processing methods relating to safety (pesticide residues or levels of toxins), authentication of origin (geographic indication), environmental (organic) and socio-economic conditions, e.g., fair trade. Both public and private standards are used in the agri-food chain. Public authorities generally set minimum quality standards (MQSs) where dangerous products are prohibited and maximum dosages set. Private standards are specified by food processors and retailers; they go beyond MQSs and are used to distinguish the product as a strategy for firms to increase their competitive advantage (Fulponi, 2007, Jaffee and Masakure, 2005). For example, half of retailers in Europe established the Eurepgap standard in 1997 (Codron, et al., 2005).

China started to establish and develop its national system of agricultural standards in the early 2000s in response to the emerging demand for food safety both in the domestic and export markets (Wang et al., 2008; Ortega et al., 2012; Xu et al., 2012). From 2005 to 2015, establishing and enhancing standards in agricultural production and marketing has been highlighted every year in the No. 1 document of the State Council. The Chinese government urges its public sector to develop four standards through a variety of campaigns (called *san-pin-yi-biao* in Chinese), *hazard-free*, *green food*, *organic food* and *geographic labeling* (see their specifications in Table 1). In the private sector, the emerging supermarkets and agribusiness enterprises endeavor to establish their competitiveness by specifying standards of quality and safety to their suppliers, although the business strategies are variant in practices (Gale and Hu, 2012; Hu et al., 2004). Seeing its potential to enhance food safety and improve supply chain efficiency, China's ministries launched a government-sponsored program to link supermarkets with production, either directly or through farm bases that are often simply referred to as farmer cooperatives. A handful of international and domestic entities participated as "pioneer enterprises" in the initial pilot stage of the program. Nevertheless, a recent study of the farm bases that supply fresh fruits and vegetables to a supermarket chain show that the formation of farm bases seems to present significant heterogeneity in strengthening traceability (Ding et al., 2015).

Table 1– Main specifications of standards in China

	Hazard-free	Green Food	Organic food	Geographic labeling
1 Allow for using chemical fertilizers	√	√		√
2 Specified storage and logistics facilities	√	√	√	√
3 Forbidden use of chemical insecticides	√	√	√	
4 Allow for using chemical herbicides	√			√
5 Allow for using pesticide of low-and medium toxicity	√			√
6 Limited use of plant regulator	√			√
7 Unpolluted environment of production		√	√	
8 Distant from production of other standards (or no standards)			√	
9 No use of pesticide and chemical fertilizer in recent three years			√	
10 No burned films and residuals in field			√	
11 To work within natural systems and cycles throughout all levels from the soil to plants			√	
12 No soil and water erosion			√	
13 Be produced in specific regions				√
14 Identified culture and environment of production origin				√
15 Must be using specific varieties of crop				√

Source: Fan et al., 2009; Li et al., 2010; Jin and Zhou, 2011; and authors' interviews

A myriad of studies has investigated the benefits of various certification schemes in developing and emerging countries. Their results are ambiguous. The adoption of standards is documented to vary according to the level of human capital (education and age); physical assets (land, credit) and social capital (Lemeilleur, 2013, Kleemann, 2014). Some studies demonstrate clear economic benefits thanks to new outlets and technology transfer, as in green bean production in Senegal (Maertens and Swinnen, 2009) and Madagascar, where composting has been developed (Minten et al., 2009), vegetables in Kenya (Minten et al., 2009, Rao and Qaim, 2011), coffee in Uganda grown under fair trade standards, but not for UTZ and organic, mostly because of cost constraints (Chiputwa et al., 2015). These studies commonly mix the effects of changes in products, chain governance and quality standards. And they do not pay much attention to the impact of standards on changes in agricultural practices influencing food safety.

The objective of the paper is to investigate whether the implementation of standards driven by the public and private sector in China is effective, results in improved knowledge and corresponding changes in farm practices such as adopting food safety management. The hypothesis is that farmer knowledge acquisition and adoption of production standards is conditional on internal factors (i.e., farmer characteristics in terms of human, physical and social capital) and external factors such as chain governance, marketing environment and availability of extension services. Importantly, we would like to investigate the role of knowledge and control in the impact pathway leading to changes in agricultural practices stimulated by standards: Do farmers acquire knowledge of standards when they adopt them?

2. Method

2.1. Data collection

Throughout 2013 and 2014, the research team investigated the apple chain of two international retailers from downstream to upstream. For each of the retailers, the chief fresh produce procurement manager was interviewed about the general procurement of fresh produce. Then we asked the manager to provide us with a full list of their fresh apple suppliers. Through coordination by the manager and the department of procurement, we contacted all the suppliers and inquired about their procurement of apples from farm bases (FBs).

The term of farm bases (called *sheng-chan-ji-di* or *ji-di* in Chinese) has been widely used in both scholarly documents and public narratives about agribusiness in China but is often vaguely defined. A farm base is considered here as a special form of organizing production and farm management within an identifiable and potentially traceable location, typically a village or contiguous group of villages (Ding et al., 2015). It can be managed by either the villagers themselves in an out-grower scheme or by outside firms using wage labor or sub-leasing contracts. For the purposes of this study, a farm base (FB) is defined by two criteria. First, it has an identifiable and potentially traceable location, typically a village or contiguous group of villages. Second, the vendor establishes a contractual relationship with the farming community or invested on its own. He participates in production via pre-planting planning and, in some cases, the provision of inputs, technical assistance and fixed investment.

A face-to-face survey on farm bases was conducted in the field. We focused on farm bases in two provinces (Shandong and Shaanxi), where apple production accounts for 75% of the national portfolio. As part of the agreement with the retailers, the research team insisted on conducting an independent on-site survey with the farm base managers without the presence of other chain partners (such as vendors or supermarkets). During the survey, farm base managers were asked detailed information regarding the history, size, production, marketing, farm management, decision-making and relationships between the farm base and the chain partners. As the primary objective of the study, we asked whether the farm base had the production certified to any of the four agricultural standards (*hazard-free*, *green food*, organic product and geographic labeling) and the private standards of GAP in agricultural production.

We also surveyed farmers in FBs not supplying international supermarkets. We interviewed the officer(s) of the Agricultural Bureau at the county level and requested a list of cooperatives or production entities in the form of farm bases. After understanding the purpose of the study and the definition of farm bases, the officer shortlisted ideally three farm bases, from which we chose one that was not a neighbor of the chosen farm base supplying international retailers. It is unknown whether the additional identified farm bases supplied supermarkets or not. To verify this, an identical survey form of farm bases was used in a face-to-face interview. The farm base managers were surveyed about their sales to supermarkets in a previous year, the identity of the supermarkets and the marketing share for all the marketing channels. We also asked the farm base managers about their certification as compliant with any of the agricultural standards. The additional samples of farm bases allow us to mitigate estimation problems from possible selection bias related to the chain governance driven by the studied international supermarkets.

A household survey was conducted on farmers who were members of the farm base sample and those who did not join any farm organization in the community (see Table 2). The farm base managers were asked to list the member farms; we randomly chose six of them. In the same village, we conducted a community survey by interviewing the village head and collected information about the village characteristics, its agricultural production and organizations. We also showed the village head the list of members provided to us by the farm base manager and, on the basis of this information, the village head helped to list apple

farmers who did not participate in any farm organization in the village, from which we randomly chose four non-FB farmers.

Table 2. Sample characteristics

	Total	Supermarket-supplying FBs		FBs not supplying supermarkets
		International	Domestic	
Number of FB	42	18	12	12
DF	8	4	4	n.a.
Non-DF	22	14	8	n.a.
Number of farmers	355	153	101	101
FB	238	107	71	60
Non-FB	117	46 ^a	30 ^a	41 ^a

^a represents the farmers nearby the FBs. FB: Farm base; DF: direct farm (i.e. direct from farm base to supermarkets); n.a.: not applicable.

Source: Authors' survey.

Finally, we constructed a hierarchical dataset consisting of 238 apple farmers who were identified as members by 42 farm bases—an average of six farmers for each of the farm bases—and 117 non-FB farmers in the same and neighboring communities. Among the 42 farm bases, 30 of them supplied supermarkets and the remaining 12 farm bases did not supply any supermarket either directly or through vendors.

As the primary objective of the research, in the household survey, each of the surveyed farmers was asked to complete a knowledge test regarding agricultural standards for apple production. We focus mainly on the agricultural and environmental components of the standards. The research team contacted the state administrations of the four public standards and requested the details of the specifications. Then a group of technical experts was consulted to formulate questions about the four public standards and their application to China's apple production. A pretest was conducted in the study area (Shandong and Shaanxi) to phrase the questions so that they suited the local context and were consistent in different regions. Finally, in the formal survey, the number of questions was reduced to 15 to avoid survey fatigue; each of the statements was read out by the enumerators one by one and the farmers were asked to identify the correct ones. On the basis of the farmer responses, we summed the score of correct answers and generated the variable score of farmer knowledge of the standards. For each of the standards, we averaged the correct answers into certain scales so that they added up to a full score of 100.

We also conducted a survey of farmer knowledge regarding the suitability of pesticides. In each of the surveyed counties, the research team conducted a canvas survey by collaborating with local entomologists and extension experts in the field of plant protection. On the basis of their years of field experience, the local experts listed typical pest and disease problems and ten pesticides that were used widely in the local region. During the household survey, the enumerators presented the ten pesticides in the local area to the interviewed farmer, asking him to choose the disease(s) that the pesticide is supposed to control. On the basis of the answers, we generated the variable of farmer knowledge on pesticide suitability. Similar to the variables in the knowledge score of standards, we scaled the score of pesticide suitability into a full mark of 100 on the basis of the answers to the ten questions.

As regards the assessment of ecological practices, we focused on farmer use of inputs (such as fertilizers and pesticides) and adoption of biological and ecological control for pests and diseases in the previous production season. For example, we asked whether farmers applied chemicals and composted manure in their production. For pesticide use, we included two variables, the number of applications and whether the farm applied pesticides within the fruit harvesting period. Lastly, we included a dummy variable that

indicated whether the farm had used, during the previous harvest season, any type of biological or physical pest control measure, such as a moth-killing lamp, pheromones, natural enemies such as predatory mites.

2.2. Model specification

We specify a multivariate regression model that seeks to identify the correlation between standards along which farm bases are certified, farmer knowledge and eco-friendly practices in apple production (including ecological practices and proper use of pesticides). In estimating the impacts of farmer certification as compliant with agricultural standards on individual farmer knowledge, our basic model is:

$$Score1_{ijk} = a_0 + \theta Standards_j + \beta GOV_j + \delta HH_{ij} + e_{ijt} \quad (1a)$$

$Score1_{ijk}$ are outcome variables that measure the knowledge of farm i in farm base j of the hazard-free standard ($k=1$), green food ($k=2$), organic food ($k=3$), geographic labeling ($k=4$) and the suitability of pesticides ($k=5$), respectively. For example, when we measure a farmer's knowledge of green food, $Score_{ij2}$ indicates the figure. Each of the variables are scored against a full mark of 100. Besides knowledge scores, we also specify outcome variables for eco-friendly practices, $EcoPractice_{ijq}$. It includes several measurements, such as *the number of pesticide applications* ($q=1$), *farmer use of pesticides within the fruit harvesting period* ($q=2$, binary variable), and *farmer ecological practices* ($q=3$, binary variable).

$$EcoPractice_{ijq} = a_0 + \theta Standards_j + \beta GOV_j + \delta HH_{ij} + e_{ijt} \quad (2)$$

On the right side of our regressions, *Standards* is a set of dummy variables with a value of 1 or 0 that indicates the farm base's strategy to become certified as compliant with various standards. To compare with different certification schemes, we include *hazard-free only*, *green food only*, *organic food only*, *multiple public standards (and no GAP)*, and *GAP and other public standards*. Farm bases that were not certified as compliant with any standard were used as the reference (omitted) category in the regressions. The coefficient of vector θ thus denotes the marginal difference in the farmer knowledge score for farm bases certified as compliant with the standards and those not, holding all else constant. We estimate the impacts of farm base certification schemes on farmer knowledge and practices of using pesticides.

Other control variables include the vector HH_{ij} reflecting household demographics and the chain governance. For example, *Farm size* is measured in hectares per household. *Age* and *Education* measures the age and the surveyed farmer obtaining formal education of more than nine years. Moreover, we include two variables of control for farmers who received technical advice and training from the public and private sectors. We also include several variables about the chain governance in the vector GOV_j , such as *farm bases supplying supermarket directly*, *farm bases supplying supermarkets through vendor intermediaries*, *farm bases supplying non-supermarket outlets*. The three variables are binary and we set non-FB farmers as the reference (omitted) category in our regressions.

To estimate the relationship between farm bases that were certified as compliant with various public standards in apple production and farmer knowledge acquisition regarding standards and pesticide use, we estimate the models by using Ordinary Linear Square regressions (OLS) and LOGIT regressions.

3. Main findings

3.1. Agrifood chain characteristics

The apple agrifood chain is rarely a direct flow from farmer to retailer, even for supermarket provisioning. As shown in Table 1, for the 30 farm bases supplying supermarkets, only eight directly supplied fresh apples to supermarkets. Surprisingly, the percentage of direct farm supplying is lower for international retailers than for domestic retailers, although local retailing chains are often perceived to be less "modernized" than the international ones.

3.2. Compliance with agricultural standards

The majority of farm bases are certified along public standards of agricultural production, but their strategies are quite diversified. For the 42 farm bases surveyed, only 10 did declare any of the four public standards. Three farm bases are certified only as hazard-free, which is the minimum requirement for quality and safety assurance. Eighteen farm bases complied with a higher level of standards, such as green food or organic food, respectively. None of the farm bases were certified as compliant with geographic labeling alone, and seven farm bases were certified as compliant with multiple public standards.

Farm bases that were certified as compliant with public standards of agricultural production differ depending on the chain characteristics. A striking finding is that farm bases that do not supply any supermarket are not less compliant with agricultural standards. For example, the percentage of farm bases that were certified as compliant with organic, which supply supermarkets, either international or domestic, is even lower ($40\% = 12/30$) than those not supplying supermarkets ($50\% = 6/12$). Geographic labeling is favored by farm bases that supply domestic supermarkets, and this is interesting because it seems that international and domestic retailers adopt different marketing strategies when diversifying through multiple certification.

Recourse to private standards is rare and it is combined with recourse to public standards. Only one farm base obtained GAP certification without additional certification schemes. The remaining five were certified as compliant with both GAP and other public standards such as geographic labeling and green food. Surprisingly, farm bases supplying domestic supermarkets seem to favor private standards such as GAP; four farm bases had GAP certification. For the 18 farm bases that supplied international supermarkets, only one was certified as compliant with GAP, and this farm base was not certified as compliant with any other public standards.

3.3. Farmer knowledge of agricultural standards

3.3.1 Descriptive analysis

Farmers appear to have limited knowledge of the public standards for apple production. The hazard-free standard, which is compulsory, has minimum requirements in specifying environmental conditions and agricultural inputs. Nevertheless, out of a possible 100 points, the average score for farmers in the study area is only 30 and the figures are not significantly higher than scores of standards for green food and organic food. The farmer knowledge score of organic standards is slightly lower than that of hazard-free and green food, and this can be understood given the difficulty in complying with organic standards. The lowest knowledge score is for geographic labeling, with less than ten points.

Farmer knowledge of using pesticides suitable for certain diseases and pests is also limited. For example, the average score for non-FB farmers is 40 and the figure is not significantly different from FB farmers who may or may not have supplied supermarkets. By further breaking down farmers into FB farmers who supplied domestic supermarkets, we find that FB farmers who supplied domestic supermarkets displayed a better knowledge of appropriate pesticide use.

The results of farmer ecological practices in apple production in the studied area are mixed. Nearly all farmers (99%) use chemical fertilizers in apple production. Meanwhile, a high percentage of farmers (82%) use composted manure that potentially increases soil fertility and organic matter. The average application of pesticides is 7.5 times and the figure is much lower than that in other countries. For instance, in France, the frequency of spraying was 35 on average in 2012 (Agreste, 2014). While a substantial number of farmers adopted ecological pest control practices, with a higher ratio for FB farmers than non-FB farmers, the number of farmers who used pesticides within the pre-harvest period of 15 days is sizeable.

3.3.2. Results of multivariate analysis

The results reveal that the certification of farm bases as compliant with public standards in apple production has no effect on farmer knowledge. None of the variables are significant (Table 3). The coefficient of geographic labeling is positive and somewhat significant (and the results are consistent with the descriptive analysis). However, the average knowledge score of farmers regarding geographic labeling is extremely low (9.7 point).

Table3. Multivariate analysis of farmers' knowledge on standards and pesticide suitability, OLS model.

	The score of standard				The score of pesticide suitability
	Hazard free	Green Food	Organic	Geographic labeling	
<i>Agricultural standards of FBs (Yes=1; No=0)</i>					
Hazard-free only	-3.61 (0.63)	-7.42 (1.18)	-4.72 (0.67)	-7.41 (1.49)	8.67 (1.47)
Green Food only	1.46 (0.35)	2.18 (0.48)	8.34 (1.64)	4.31 (1.20)	4.84 (1.14)
Organic food only	1.63 (0.42)	-4.91 (1.17)	1.17 (0.25)	-2.48 (0.74)	5.73 (1.45)
Multiple public standards (and no GAP)	-1.41 (0.35)	-6.83 (1.57)	-1.47 (0.30)	-2.33 (0.67)	-2.60 (0.64)
GAP & other public standards	4.71 (1.14)	0.25 (0.06)	5.01 (0.99)	4.60 (1.28)	0.34 (0.08)
<i>Chain characteristics (Yes=1; No=0)</i>					
FBs supplying supermarkets	1.65 (0.59)	4.16 (1.36)	3.28 (0.96)	2.24 (0.92)	5.01* (1.75)
FBs not supplying supermarkets	2.12 (0.56)	3.20 (0.78)	4.10 (0.89)	-0.51 (0.16)	-2.96 (0.77)
<i>Control variables of households, individuals and regions</i>					
Farm size (hectare)	0.50 (0.60)	0.58 (0.64)	1.06 (1.05)	1.09 (1.52)	1.25 (1.47)
Age of farmer	-0.27* (1.82)	-0.17 (1.08)	-0.62*** (3.42)	-0.20 (1.58)	0.10 (0.63)
Education (dummy for primary school and above)	17.43** (2.32)	30.90*** (3.76)	17.03* (1.85)	1.29 (0.20)	22.03*** (2.85)
Farmers received technical services and advice from the public sector in the past	6.44**	6.66**	10.30***	1.83	5.39**

three years (Yes=1; No=0)	(2.53)	(2.40)	(3.32)	(0.83)	(2.07)
Farmers received technical services and advice from agro-chemical sellers in the past three years (Yes=1; No=0)	6.31** (2.37)	-0.37 (0.13)	1.36 (0.42)	0.92 (0.40)	6.00** (2.20)
Shandong province dummy	-0.62 (0.22)	-2.32 (0.74)	-0.95 (0.27)	2.10 (0.85)	16.34*** (5.58)
Constant	18.98* (1.68)	9.16 (0.74)	31.89** (2.32)	14.18 (1.45)	-4.61 (0.40)
R ²	0.080	0.091	0.113	0.057	0.210

Note: Absolute values of t-ratio in parentheses; *, **, *** indicate statistically significant at the 10%, 5%, and 1%, respectively. The sample size used in regression is 355.

Multiple schemes to grant certification of compliance with public standards do not seem to yield beneficial effects on farmer knowledge acquisition. *Ceteris paribus*, the members of farm bases that certify compliance with multiple standards have an even lower knowledge score regarding the standards and pesticide suitability. The catch phrase “the more the better” is not applicable in the case of agricultural standards in China.

Neither do the chain characteristics affect farmer knowledge of standards in apple production. None of the estimated coefficients is significant and this implies that farm bases supplying supermarkets, whether international or local, are not different from non-FB farmers in their knowledge of production standards. Chain governance is neutral regarding farmer knowledge acquisition in standards and pesticide use.

Among several control variables with significance for the estimated coefficient, rural advisory services seem to be effective. For example, the coefficients of “Farmers received technical services and advice from the public sector in the past three years” are significant and this indicates that the public extension system is indeed a pipeline to convey knowledge of agricultural standards to individual farmers, after controlling other variables. What is interesting is that when farmers purchase agro-chemicals from village dealers, they also receive technical advice and know-how. However, such is only evident for knowledge regarding the hazard-free certification, which specifies a minimum requirement of safety and quality. Similar evidence is observed for knowledge of pesticide suitability; the magnitude of estimated coefficient is slightly lower ($1.80=6.00*0.3$) than that of the public extension services ($3.2=5.39*0.6$). Such a finding is valuable. The private sector has been commonly considered to be distorted by commercial interest. This study shows that the private sector can potentially play a positive role in delivering knowledge to farmers.

3.4. Farmers’ practices

While the certification off-farm bases as compliant with production standards does not seem not improve grower knowledge, we do observe positive effects on farmer practices, including adoption of ecological control in pest and disease management (Table 4). The estimated coefficients are significantly negative (column 1) and positive (column 3), showing decreased pesticide application and increased use of ecological practices when farmers belong to farm bases that are certified compliant with hazard-free or organic only. Similar to the evidence of knowledge, multiple certification schemes of compliance with public standards do not yield significant different results when compared with no standard.

Table 4. Multivariate analysis of farmers' ecological practices in apple production.

	Number of pesticide application	Use of pesticides within withdrawal period	Use of ecological practices of pest control
	(1)	(2)	(3)
<i>Agricultural standards of FBs</i> (Yes=1; No=0)			
Hazard-free only	-1.11*** (2.66)	0.09 (0.76)	0.24** (2.12)
Green Food only	0.02 (0.07)	-0.09 (1.04)	0.10 (1.23)
Organic food only	-0.18 (0.64)	-0.00 (0.01)	0.16** (2.13)
Multiple public standards (and no GAP)	0.32 (1.11)	0.06 (0.74)	0.01 (0.13)
GAP & other public standards	-0.64** (2.14)	0.18** (2.03)	0.09 (1.10)
<i>Chain governance (Yes=1; No=0)</i>			
FBs supplying supermarket	0.34* (1.68)	-0.05 (0.83)	0.12** (2.13)
FBs supplying non-supermarket	-0.08 (0.30)	-0.00 (0.03)	0.16** (2.20)
<i>Control variables of households, individuals and regions</i>			
Farm size (hectare)	0.05 (0.82)	0.01 (0.74)	0.04** (2.43)
Age of farmer	0.03** (2.41)	0.00 (0.47)	-0.00 (0.61)
Education (dummy for primary school and above)	0.92* (1.67)	-0.10 (0.66)	-0.12 (0.84)
Farmers received technical services and advice from the public sector in the past three years (Yes=1; No=0)	-0.11 (0.57)	-0.06 (1.11)	0.10** (2.09)
Farmers received technical services and advice from agro-chemical sellers in the past three years (Yes=1; No=0)	0.08 (0.41)	-0.07 (1.30)	-0.00 (0.08)

Shandong province dummy	2.20*** (10.57)	0.00 (0.06)	-0.20*** (3.56)
Constant	3.91*** (4.76)	0.45* (1.89)	0.42* (1.89)
R ²	0.357	0.043	0.117

Note: Absolute values of t-ratio in parentheses; *, **, *** indicate statistically significant at the 10%, 5%, and 1%, respectively. The sample size used in regression is 355.

Private standards of GAP indeed reduce pesticide application by farmers and introduce ecological pest and disease control practices, although the estimated coefficients are not significant for the latter. However, the positive and significant coefficients indicate that FBs certified as compliant with private standards (such as GAP) have a higher possibility of using pesticides within the fruit harvesting period. The role of private standards such as GAP in enhancing environmental and sustainable farm practices in apple production seems to be inconclusive.

It is necessary to understand and explain the discrepancy between apparent farmer ignorance, yet complying with production standards. As a market intermediary, farm bases along with vendor companies play an important role in centralizing the purchase and application of pesticides. For example, almost 62 percent of FB farmers were asked to purchase specified pesticides through farm bases and 51 percent of FB farmers were required to operate according to certain instructions; the ratio is much lower for non-FB.

The investigation further raises inquiries on farmer motivation to comply with standards in the context of China's agricultural production. Half of the farmers are willing to comply with standards in apple production (and the ratio is higher for farm base farmers). 92% of the non-complying farmers indicated that undifferentiated price was the major cause for noncompliance.

4. Conclusions

Is the emerging organization of farm bases and their certification strategy affecting farmer knowledge acquisition and moving farm practices toward safety and environmental sustainability? We study the issue in the context of China's agri-food chains supplying (or not) supermarkets. A total of 355 farmers were surveyed, including 238 belonging to production bases (42 in total, 30 supplying supermarkets). We find no measurable evidence that the certification schemes of farm bases and agribusiness companies lead to improved knowledge acquisition for apple growers. Neither do we find a correlation between membership in SM supply chains and farmer knowledge acquisition in China. While farmers did adopt ecological practices in controlling pests and diseases, the behavioral changes were mainly prompted by delegated decision-making towards farm bases. The results reveal insufficient motivation for farmer compliance with agricultural standards in production.

The disconnection between public standards in China's agricultural production and supply chain governance reflects the challenge that China's agriculture sector is facing and has to overcome. Public standards have been promoted by China's policymakers to modernize agri-food chains and to help local smallholder producers capture more value. Nevertheless, a vast body of evidence shows that it is difficult for farmers to benefit from agricultural standards, and agricultural standards in many countries protect the interest of local traders and enterprises (Gopalakrishnan et al., 2007). The organization of farmer cooperatives potentially

tackles the problems, but creating and maintaining collective action is not always easy. The farm bases in China—most of which are referred to as cooperatives—function as intermediaries or brokers, with low farmer participation in decision-making.

The study confirms the crucial role of transferring adequate technical knowledge to farmers for them to adopt more environmentally friendly practices. Public extension seems more effective than private extension, even though the role of village input dealers should not be minimized. Farmer bases are a good vehicle for knowledge transfer, whether they supply wholesale markets or supermarkets. Our evidence does not show any impact from supermarkets in the provision of extension services to apple farmers. Hence, a sound policy to favor more environmentally friendly practices should focus on public extension services transmitted through farm bases. Supermarket managers should be made aware of the necessity to ensure adequate access to extensions services for farmers' practices to change in the long term.

Lastly, the findings of the study do not negate the regime of public standards in agriculture. The proliferation of existing standards and established capability of laboratory analysis and inspection play an important role in strengthening the institutions. In the long run, multiple certifications of compliance with both public and private standards may be a sensible strategy, as there should be no inherent contradiction between schemes.

Some research limitations are listed, as follows: We did not investigate the actual safety risks related to farmer practices, which would imply collaboration with agricultural specialists and the costly testing of pesticide residues in fruit samples. So the comparison between the actual farmer practices and recommended practices should not be considered as a rigorous assessment of food safety risks.

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