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Information, trust and pesticide overuse: Interactions between retailers and cotton farmers in China

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ABSTRACT

In the absence of adequate extension services, retailers have become the major information source for farmers' pesticide use in rural China. Pesticide application for smallholders is rather complex, and mistakes can lead to significant crop losses. Farmers, therefore, seek sources of information regarding pesticide use. This paper first explores how different kinds of retailers may employ different strategies of providing information to farmers. We find that for village, town, and county retailers, the more familiar they are with farmers, the more likely they are to amplify the recommended dosage of pesticide use. In cooperatives, who buy pesticides from an extension station, the information is directly transferred to member farmers without information distortion. Apart from examining retailers' different strategies of information provision, this paper also asks in how far farmers' trust in retailers may affect pesticide use. It finds that trust in different kinds of retailers indeed varies and plays a critical role in converting information into farming behavior. Members of the cooperative show rather high levels of trust in their retailer, while farmers who are not members of a cooperative show low levels of trust in retailers. Pesticide use is a joint result of retailers' information provision strategies and farmers' trust. The lowest pesticide use occurs when accurate information is provided and when farmers highly trust the information provider. Overuse occurs with either information distortion or low levels of trust. Cooperatives have advantages both in terms of information provision and trust, thereby leading to the lowest use of pesticides.

1. Introduction

1.1. Problem statement

Recently, agricultural pollution has drawn additional attention to China. Most attention is paid to pollutants, such as NH_3-N and COD, which are mainly caused by the overuse of fertilizers and emissions from animal manure. However, the massive use of pesticides exerts considerable impacts on health and the environment. China is the largest pesticide user in the world; in 2012, its pesticide consumption was over 1.8 million tons [1]. A major portion of sprayed pesticides pollute the soil, water and air [2].

Furthermore, the health risks that are caused by pesticides are more directly harmful than are those of chemical fertilizers. First, in China as well as in other developing countries, many farmers spray pesticides without any protection measures (e.g., masks or long-sleeve shirts). The period for the occurrence of pests and diseases is generally during the hottest season when pesticides diffuse well. Therefore, it is very common for farmers to become contaminated by pesticides during spraying. Exposure to pesticides can cause health problems, such as hormone disruption, damages to the brain, and cancer [3]. Second, pesticide residues seriously pollute the soil. For example, although China has forbidden the use of organic chloride since 1983, DDT is still the first organic pollutant for soil pollution. As indicated by the *Report of the National Survey on Soil Pollution*, 1.9% of surveyed areas were polluted by DDT [4]. Third, the cleaning of spraying instruments causes water (both surface and groundwater) and atmospheric pollution, which can cause serious damages to the ecosystem. Fourth, when farmers dilute pesticides, they often discard pesticide packages on the spot, which has become an additional serious environmental problem in rural China. It is estimated that, annually, more than 3.2 billion pesticide packages are discarded in China. The total package waste weighs more than 100,000 tons, with the residue pesticide from

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these packages accounting for 2%∼5% of the total weight of pesticides [5]. Therefore, because of environmental concerns and to prevent health threats, more attention should be paid to China's pesticide problems.

Pesticide overuse in crop production is a common problem in developing countries. As one of the most important cash crops of China, cotton follows the classic 'pesticide treadmill' [6]; namely, once the pests become resistant, even more pesticides will need to be used [7]. China is the largest cotton-planting country in the world, accounting for approximately 25% of total global yield. In China, cotton producers are among the largest pesticide users in terms of both aggregate and per hectare use, and pesticide use increased more rapidly than that of other agricultural inputs [8]. If environmental and health impacts are considered, the economic returns from pesticide use cannot compensate for its impacts [9–12].

1.2. Analytical framework

Existing literature provides various explanations for pesticides (over)use. We can group these explanations into four categories. (1) *Household and farm characteristics*. Damalas and Hashemi [13] found that young cotton growers care more about health hazards with regard to pesticides than do elder farmers, and elder cotton growers usually spray more frequently. Furthermore, the farm scale matters. Cameron [14] found that large-scale farmers are more likely to adopt environmentally sound technology and management systems. Farmers' low perceptions, as well as their lack of knowledge of pesticides risk, were also positively correlated with overuse [15,16]. (2) *Market factors*. Grovermann's [17] observation from Thailand shows that crop prices can influence pesticide application. In this case, farmers apply larger amounts of pesticides to crops (e.g., bell peppers) that can be sold at higher price. (3) *Technical application and extension*. Research so far has demonstrated that some technologies have the potential to reduce the use of pesticide; however, to make these technologies effective, extension services are needed to overcome pesticide overuse. Kumar and colleagues [18] found that foliar application was in general more effective than were other ways of spraying (e.g., stem application) when dealing with sucking pests on cotton. Huang and colleagues [8] found that in China, the introduction of GMO technology has dramatically reduced pesticide use in cotton in terms of quantity, spraying times and costs. However, GMO technology has only had short-term effects on pesticide reduction. A long-term observation (1998-2009) in Northern China describes the outbreak of a secondary pest that led to a re-increase in pesticide use [19]. Currently, pesticide use in cotton is even higher than it was in 1997 [20]. Therefore, to support effective pesticide use, extension services are crucial. Sun and colleagues [21] conclude that inadequate agricultural extension services have been considered the most important external factors for the overuse of chemical inputs, including pesticides. The lack of extension services is also stressed in studies in African countries as an obstacle to reduce pesticide use with better methods of pest control, e.g., by Integrated Pest Management (IPM) or Integrated Crop Management (ICM) [22,23]. (4) *Institutional constraints*. Togbé and colleagues [23] hold that a lack of alignment among key actors within the cotton sector is the main obstacle to employing more environmentally friendly pest-management strategies in Benin.

In addition to these conventional factors, pests and diseases change quickly depending on the weather and seasons, and it is difficult for smallholders to select the best and most effective pesticides from hundreds of active ingredients. As reported by the Ministry of Agriculture, at the end of 2012, there were 627 active ingredients with 27,273 registered pesticides in China [24]. Smallholders face considerable difficulties in understanding which pesticides to use and how, making these farmers more dependent on external information sources, e.g., from those who sell pesticides or extension technicians. Insufficient levels of spraying, the use of wrong pesticides or improper application might result in the outbreak of pests and diseases, with the consequence of lower or even no harvest. Thus, farmers can be assumed prudent regarding pesticides use and may be tempted to use more pesticides than are actually needed, both in terms of quantity and varieties, to mitigate the risk of disease outbreak.

As previously mentioned, the lack of extension services is a common problem in developing countries. In China, since the late 1980s, the central government started a reform aiming at the commercialization of the agricultural extension system aiming to reduce the financial burden for both the central and local governments and to make agricultural extension stations financially self-sufficient. As investigated by Hu and colleagues [25], after this reform, many extension staff quit their positions in the extension stations and run their own business, e.g., selling pesticides and fertilizers. The remaining extension staff are frequently called on for duties that have nothing to do with agricultural extension (e.g., family planning, budget management, elections, and fire protection), and only 31% of their working days were spent on providing extension services. In comparison, before the reform, in 1985, 85% of their working days were spent on providing extension services [26]. In contemporary China, a common saying that is used to characterize the agricultural extension system is "*The network destroyed, the lines are broken, and people went away*" (*wang po, xian duan, ren san*) [27], which means that the system is ruined, the connection between the technical staff and farmers is broken, and the staff has left (and, as a connotation that comes with the saying, does its own business).

With this absence of governmental extension services, the information sources for smallholders regarding the correct use of pesticides are rather limited. Existing literature suggests that smallholders may gain knowledge from their own experiences by learning from other farmers, by reading manuals/information provided with pesticides, or by learning from pesticide sellers [28–30]. In China, a limited number of studies suggest that the major information source for smallholders regarding pesticide application is retailers [31]. Nevertheless, until now, the influence of retailers' advice on pesticide use has barely been studied. In rural areas of developing countries, different kinds of retailers exist. Mom-and-pop stores in the village may sell pesticides together with everyday commodities; township-level shops will sell pesticides together with other agricultural inputs and technologies; and more specialized shops on the county-level will provide a wider portfolio of pesticides. We can assume that depending on this degree of professionalization across shops, their strategies of information provision will vary in consulting on pesticide use. Therefore, this research will focus on the influence of different kinds of retailers' information provision strategies on farmers' pesticides use.

In addition to this focus, a further factor will be explored in its impact on pesticide use. While there is only limited research on trust as a factor for information use and farmers' behavioral change, this limited research suggests that trust plays an important role in translating information into knowledge that can be used and acted upon by farmers [32–34]. Therefore, another and equally important factor is farmers' trust in the information provider, which is assumed to determine the extent to which farmers will make use of the information in their actual pesticide use. Generally speaking, trust refers to the confidence that someone will not disappoint the expectations or exploits the vulnerabilities of the other [35,36]. As a binding element for communities and societies, trust can promote cooperation and efficiency, not only for economic exchange but also for public goods, such as environmental protection [37–39]. The general level of trust differs across societies.

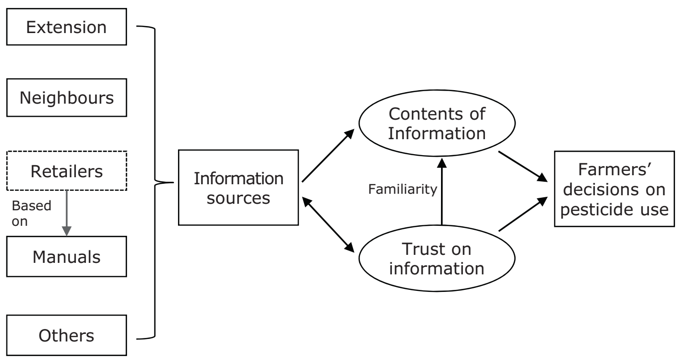

Fig. 1. An analytical framework on information and trust in farmers' pesticide use.

According to Fukuyama [40], trust in group-oriented societies, such as Germany and Japan, is greater than is trust in family- and/or acquaintance-oriented societies, such as China. Being largely dominated by Confucian values (e.g., "keeping face"/*mianzi*, *guanxi*) for thousands of years, Chinese people build mutual trust on personal relationships, particularly in rural areas [41].

With the focus on the information providers and their information-provisioning strategies, as well as on the trust of farmers in information providers, pesticide use is not considered a result of independent decision-making by an individual farmer. Farmers' decision-making regarding pesticide use, in this research, is mainly based on both the information they receive and their trust in the information providers. However, as denoted in the above term "information provision strategies", we assume that if farmers and retailers are familiar with each other, the information that is delivered by the retailers will differ. Furthermore, links are assumed among different sources of information, e.g., the retailers may recommend the dosage based on the manuals. The analytical framework underlying this study is shown in Fig. 1. While the above-mentioned different kinds of retailers are not shown in this figure, we will further specify, in the following, retailers based on our survey data.

The main research questions are as follows: (1) From whom do farmers buy pesticides? What are the differences among farmers with regard to the way they obtain information and also in regard to the contents of information? (2) How does trust function when farmers convert the information into actual behavior regarding pesticide use? This study also aims to provide policy recommendations regarding where intervention is needed aiming at more efficient and environmentally sound pesticide use.

2. Methodology

2.1. Defining pesticide use

When collecting data on active ingredient use among larger numbers of smallholders in rural China, a major difficulty exists. Due to their low education level and their lack of documentation, it is difficult for farmers to correctly collect information regarding, among others, active ingredients, concentration, and dosage of spraying. A more practical but less precise method for collecting data regarding pesticide use is to use the costs of pesticides as a proxy for the physical quantities of active ingredients used. This method has been applied previously in studies in the fields of environmental/agricultural economics and rural policy/extension, usually complemented with data on the frequency of spraying.

For example, Huang and colleagues [8] used costs as the indicator for pesticide use when comparing pesticide use for Bt and non-Bt cotton across time and regions (e.g., between Zhejiang Province and Hunan Province). However, these authors also used quantitative data when comparing the same counties and at the same time (e.g., between Bt and non-Bt cotton growers in Xinji County with a dataset from 1999). In other studies, pesticide overuse was defined as the amount of pesticides that were used in excess of an economic optimum, and the costs of pesticides were used as an indicator to represent the amount of pesticides [17,42].

The assumptions underlying such a proxy are that with increases in costs, the amount of active ingredients in the pesticides increases, and environmental impacts will accordingly increase. This assumption may be acceptable if two preconditions apply. First, in terms of toxicity, the same or similar active ingredients must be used by farmers, which will, in general, be the case when the targeted crop is the same. In the case at hand, farmers are from the same location, i.e. are facing similar problems in terms of pests and diseases, and work under similar environmental conditions. The second, and often ignored, precondition is that price differences need to be considered when comparing farmers who buy pesticides from different retailers.

In this study, we, therefore, will also use costs as a proxy for pesticide quantity. However, we further consider the two above-mentioned preconditions:

(1) We conducted our survey among cotton farmers within one county. A county is not large enough for a variety of pests to occur. Farmers, therefore, will be dealing with similar problems in terms of pests and diseases in cotton plantations and are likely to choose pesticides within a similar range.
(2) We tried to obtain information on the price differences across different retailers. We first identified the most commonly used pesticides (i.e., *Avermectins*, *Emamectin Benzoate*, and *Acetamiprid*). By fixing a certain concentration and volume (or weight) for each pesticide, we requested the prices from different retailers (at the village, township and county levels), to determine the price differences across retailers. On average, farmers buying from the county retailers buy at the lowest price, while those buying from the village retailers pay the highest price. The largest price difference is 8%∼10% between farmers buying from county retailers and farmers buying from village retailers. Thus, if the cost difference is greater than 10% across farmers, we will assume a difference in terms of the pesticide amount.

2.2. Method of data collection

We conducted our survey in Quzhou County, Hebei Province, China. Hebei is the third largest cotton-planting province of China, after the Xinjiang Uygur Autonomous Region and Shandong Province. In 2012, the cotton-sown area of Hebei was 578,000 ha, accounting for 12.3% of the total sown area of China [1]. Quzhou County is located in Southern Hebei Province. Cotton is the major cash crop of Quzhou County. As estimated by the County Agricultural Bureau, in 2012, the cotton sown area was 15,000 ha, accounting for 31% of the total farming area of the county.

We conducted this research by means of interviews and a survey in January 2013. Interviews with pesticide retailers from the village level to the county level aimed at qualitatively determining the bilateral relationship between farmers and different retailers built on information and trust. We interviewed 28 retailers, among which 2 retailers were at the county level, 10 were town retailers (in 4 towns), and 16 were village retailers (in 8 villages). A survey was furthermore carried out among cotton growing households to collect detailed information on pesticide use. 160 household questionnaires were collected from the

Table 1
Data collection strategy.

Level	County	Towns	Villages	Households
Sites	Quzhou	4 out of 10 towns in the county	2 villages for each selected town	Randomly selected from the selected villages
Sampling for retailers and households	2 major retailers in the county capital	2-3 retailers from each town	2 retailers from each village	15-30 for each village*
Total valid respondents	2 retailers	10 retailers	16 retailers	160 households

* mainly based on the size of the village; for villages with a larger population, we selected a bigger sample.

8 villages in which cotton is the main cash crop. The households were selected based on random sampling, resulting in the unintended consequence that some of the farm households are members of a cooperative. Table 1 shows the strategy of our data collection.

For the survey, we targeted the heads of the households, regardless of gender. However, only 6 out of the 160 respondents were female, which might be due to a misinterpretation in the questionnaire. 'Head of household' was meant to refer to the one who makes decisions regarding agricultural or/and other economic activities in the family. Farmers might have understood 'head of household' as the one whose name carries the *hukou* of the family, and, in most cases in rural China, this is the husband. We have no indication from our study or from other studies on pesticide use in China [see 26, 8, 31] that gender is a major factor in explaining pesticide use or information collection. Our random sample brought about a rather representative distribution of education levels: 3.1% of the respondents were illiterate, 16.3% had a primary school education, 52.5% had a middle school education, and 28.1% had a senior high-school education. The distribution in the sample is similar to that of other survey samples in rural China [43–45].

The average age of the household heads was 48 years, with the youngest being 25 years old and the oldest 83 years old. Many of the heads had long-term experience in cotton cultivation, with an average of more than 14 years. More detailed information on the households is provided in Table 2. Agriculture is the main source of income, accounting for an average of 62.6% of the total income. Cotton is the major crop of the households, accounting for more than 66% of the total farming area.

The average area under cotton was 7.94 *mu* (15 *mu* = 1 ha), of which 19.7% was rented land, almost the same as the average national land circulation rate [20%, see 46]. Fig. 2 shows the distribution of the cotton-sown area. Most of the cotton-growing households cultivate areas ranging from 1 to 10 *mu* (125 out of the 160 surveyed households), which is consistent with the general characteristics of Chinese smallholders' agriculture.

Based on these characteristics of the survey sample, we may conclude that most indicators are consistent with the average values for the whole country, and thus, the sample may be considered representative.

3. Results

3.1. General picture of pesticide use

Although we did not record the quantity of pesticide use for previously mentioned reasons, to generally test to what extent farmers are overusing pesticides, we followed a similar method as that of Dasgupta and colleagues [15] in Bangladesh by setting the dosage that is recommended by the manual as a baseline. The manual is part of the package (for powder) or label (for liquid), so farmers receive the manuals when they buy pesticides. The manual contains information on the trading name, active ingredients, concentration, toxicity level, dosage (or times of dilution), the advised interval between two sprays, targeted crops and pests, individuals particularly sensitive to harm by the pesticide, protective measures needed, and impacts on non-targeted animals. In China, the *Regulation for Pesticides Administration* [47] requires that '*any new pesticides before its registration must be experimented with field crops under the supervision of local agricultural bureaus to test its effective dosage and impacts on the environment and non-targeted pests, birds, and animals*'. Thus we assume the dosage that is recommended by the manual is basically technically sound.

In our sample, the survey respondents were asked, among others, the question "Did you read the manual before using pesticides?", followed by the question "Compared to the dosage that is recommended by the manual, how much do you usually use?". Among 143 respondents who ever read the manuals before spraying, 12.6% used more or less the same as the manual recommended; 73.4% used up to double the recommended dosage; and 14.0% use more than double of the manual's recommended dosage.

However, only 13.2% of the respondents realized that they were overusing pesticides and thought that pesticide use should be reduced to some extent, while 79.2% thought that as long as cotton is planted, they must use as much pesticides as current levels, no matter how high the price. A total of 7.6% of the respondents even would like to use more pesticides if the prices decreased, demonstrating that in cotton planting, a strong perceived dependence on pesticide exists among farmers.

Regarding the way farmers spray, most of the farmers mixed several types of pesticides in one spray. A total of 88.4% of

Table 2
Descriptive data of the survey households (N = 160).

	Minimum	Maximum	Mean	Std. Deviation
Total household members	1	10	4.8	1.7
Labor staying at home	1	6	2.7	1.2
Total income (*yuan**)	1,000	230,000	33,490	23,072
Percentage of non-farm income (%)	.0	96.7	37.4	27
Total farm area (*mu***)	2	65	12	7.7
Area under cotton plantation (*mu*)	0.5	40	7.9	6.6
Ratio of rented land for cotton (%)	0	100	19.7	33.3

Source: Field data 2013.
* During the survey (Jan. 2013), 8.2 *yuan* = 1 euro.
** 15 *mu* = 1 ha.

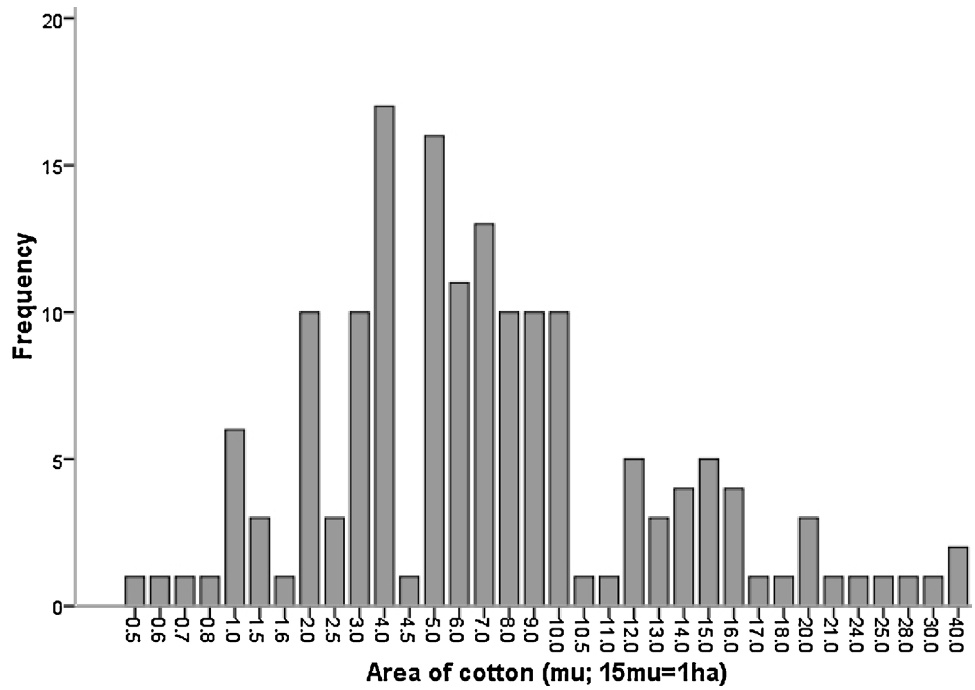

Fig. 2. Distribution of the surveyed farmers according to cotton field size (N = 160).

the respondents mixed three or four types of pesticides in one spray, 7.1% mixed two types, and 4.5% used one type. In terms of the concentration of active ingredients, for the same active ingredient, 72.4% of the respondents preferred to use higher concentrations, which are more environmentally unfriendly but less labor-consuming. A total of 2.6% of the surveyed farmers used lower concentrations, while 25% chose the concentration depending on the severity of the pests.

3.2. *From whom do farmers buy pesticides?*

In the analysis of our data, we make an analytical distinction in from where farmers buy pesticides and from where they may obtain information on proper pesticide use. In this section, we present from where survey farmers buy pesticides.

Fig. 3 combines information from both qualitative interviews with the retailers and the household questionnaires. The direction

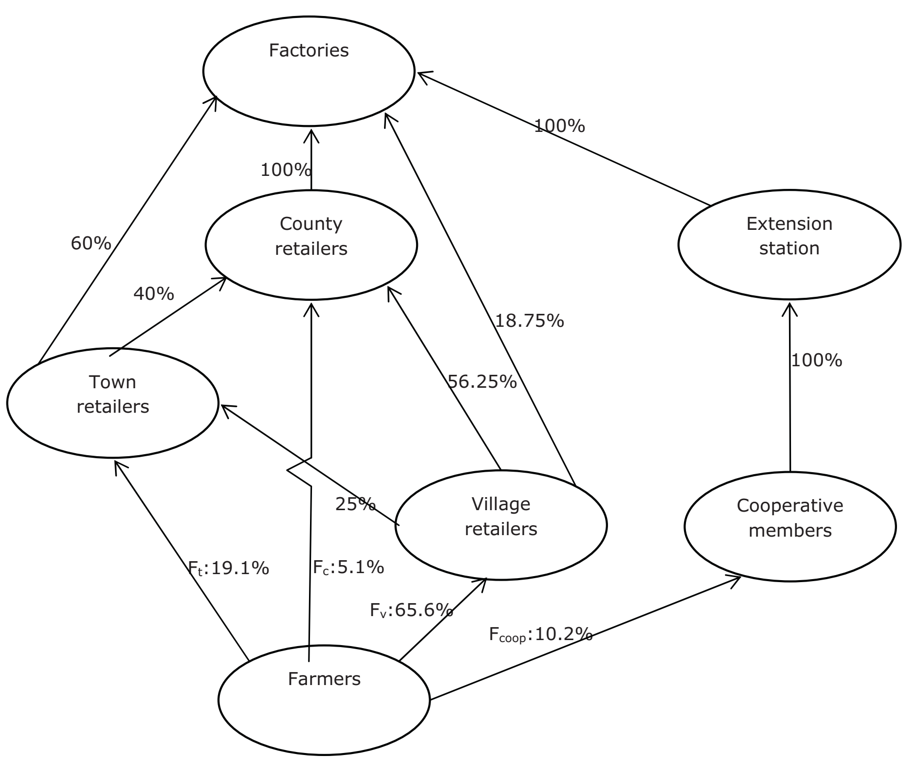

Fig. 3. Distribution of pesticide buy–and-sell relationships.

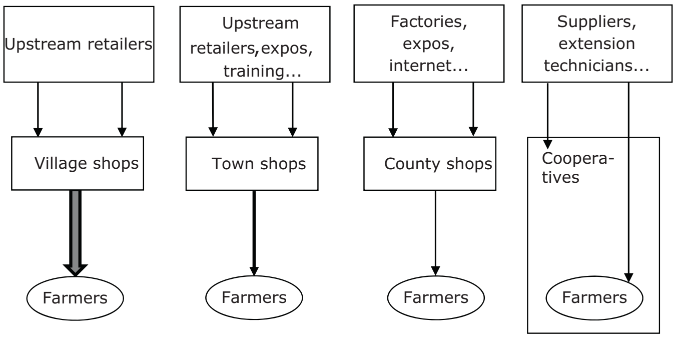

Fig. 4. Methods of information delivery for different farmers.

of the arrows indicates 'who buys from whom'. Apart from the 3 households who buy pesticides from a visiting retailer or other sources, we obtained four groups of farmers based on the suppliers from whom they buy. Among the remaining 157 households, the largest part (65.6%, equaling 103 farmers) bought pesticides from the village retailers, the retailer with the most diversified sources of pesticides.

Retailers can buy pesticides from either factories or retailers on a higher administrative level. Our interviews indicate that the higher level the retailers, the more likely it is that they buy directly from factories. At county level, both the county retailers and the extension station buy pesticides from factories. Also 60% of township retailers, and 18.75% of village retailers buy pesticides from factories.

The figure also shows that members of a cooperative (F_{coop}) buy pesticides from the shop that is operated by the county extension station, directly or through the cooperative. Therefore, retailers also serve as extension technicians. F_{coop} all buy pesticides from the extension station, while F_c, F_t, and F_v buy from retailers only. Farmers, however, do buy from different pesticide retailers.

3.3. Are there differences in the information provision and content?

To first verify the dependency of farmers on retailers' information provision, survey findings are presented regarding farmers' consultation of extension services. Our data confirm that farmers seldom obtain information from the governmental extension system. Among the 160 respondents, 135 (84.4%) farmers never contacted extension services, and only 26 (15.6%) farmers had access to extension services, in terms of announcements for pests (12 respondents, 7.5%), phone contact with extension technicians (4 respondents, 2.5%), regular field visits by extension staff (4 respondents, 2.5%), or farmer schools (5 respondents, 3.1%). Therefore, for most of the farmers, retailers are indeed the primary source of information among the professional organizations dealing with pesticides.

As the most important intermediates for information transformation, different retailers have different sources of information (see Fig. 4). According to our interviews, the county retailers participated in several agricultural expos and, as they tend to have better access to the internet, turn to online information. Some of the township retailers also participated in such expos (6 out of 10) and have also taken some technical training courses (5 out of 10). The village retailers, however, mainly obtained their information and knowledge from the upstream suppliers. The retailers of the extension station that is affiliated with the cooperative are extensively trained in technology application and are more professional than other retailers.

The content of information that retailers receive is similar; most of the time the information is the same as in the manual, although there is variance depending on the sources and on the methods of information access (e.g., upstream retailers, expos, or training). The question arises whether different retailers deliver the same information (from the manual) in the same way? Based on the interviews with the retailers, the answer is no. The findings suggest that the closer is the relationship between the buyers and retailers, the more distortion of information exists in terms of pesticide use quantity, - except for the cooperative, which differs from others in terms of information delivery.

For the county retailers, the below citation is indicative of their information provision strategies when farmers buy pesticides.

> We mainly sell our pesticides to the retailers at town and village levels. Farmers are actually not the main buyers and source of revenue for us. When farmers come to buy pesticides, we will let them look at the manual. Or if they ask, we will tell them the same information as written on the manual. But I know that it is common for them to use more for each spray, or to use in shorter intervals between two sprays.
> County retailer in Quzhou, 16-01-2013

Among the 10 township retailers that we interviewed, 7 suggested farmers to use pesticides as indicated on the manual or as their own upstream suppliers told them, and 3 suggested farmers to use, based on their own experiences, a bit more than was indicated in the manual.

Village retailers have less access to information and are less knowledgeable on pesticides than are their counterparts in the township and county. Consequently, these retailers do not feel very self-confident when farmers consult them on pesticide dosage and spraying. To maintain a good relationship and trust within their "acquaintance community", village retailers often intentionally amplify the advised amount of pesticide use, "just to be safe". Some of these retailers will amplify the dosage for each spray; some will recommend a shorter interval between two sprays. The following quote from one village retailer can clearly reflect why these retailers amplify the recommended quantity.

> We've been living in this village for hundreds of years, and everyone knows each other very well. We all even have the same family name. It is not a one-shot deal to sell pesticides within the village. So firstly, I do not dare to sell fake pesticides, otherwise, they will curse my grandfather and I will not have face in front of the village mates. Secondly, I would like to recommend them to use more than the upstream retailer told me, normally 1.5 times, not to sell more, but to ensure the pests can be killed as soon as possible. Otherwise, they will not trust me and will go to buy from other shops.
> Shop owner in Liuzhuang village, Quzhou, 16-01-2013

Cooperatives know better what is the actual required pesticide quantity for their members' crops and how to reach them [48]. Farmers are integrated in the process of information transfer, e.g., members can directly obtain first-hand information from the extension technicians from where the cooperative buys pesticides.

From these findings, we summarize information provision mechanisms as depicted in Fig. 4. The width of the arrows represents the degree of information distortion for pesticide dosage.

3.4. How does trust function in converting information to pesticide use?

As we argued earlier, farmers' final decisions on pesticide use are assumed to depend on both the information provision strategy of different kinds of retailers and the degree that the farmers trust the informants.

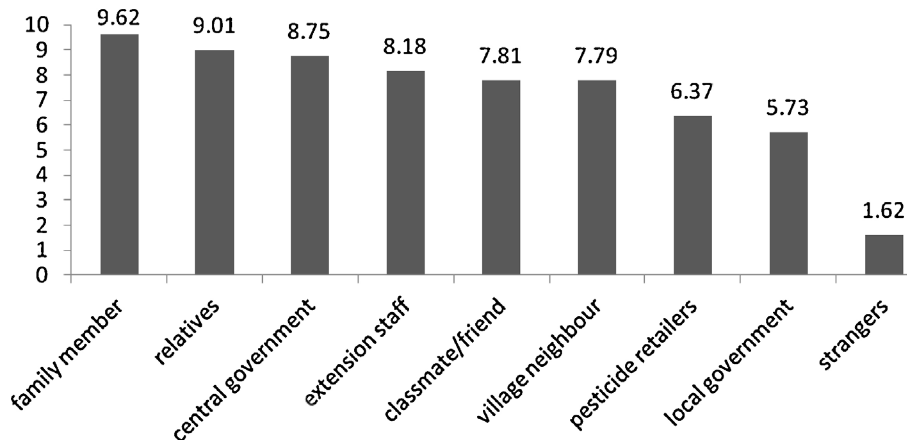

Fig. 5. Scores of trust in different groups of people.

To determine the farmers' general trust level as well as to determine where the retailers rank in such a trust assessment, based on a method applied by World Values Survey [49], we asked farmers to score their trust in different groups of people, with scores of 0 to 10, indicating distrust to full trust, respectively. The results (see Fig. 5) provide additional evidence for Fukuyama's postulation of China being a family-based society [38], where kinship-based trust is rather high, and generalized social trust is low. We carried out independent-sample *t* tests between every two neighboring groups (the closest in terms of scores). The *t* tests demonstrate that trust in family members is significantly higher than trust in all of the other categories ($p = 0.000$), and trust in strangers is significantly lower than in all of the other categories ($p = 0.000$). The differences in the trust in the central government and trust in extension staff, trust in village neighbors and trust in retailers, and trust in retailers and trust in local government are statistically significant ($p = 0.0057$, 0.000, and 0.0012, respectively). Figure 5 also demonstrates that, although extension staff is hardly accessible, those farmers who have the chance to access extension staff have a relatively high level of trust in them (8.18). Furthermore, farmers who can easily access extension services, cooperative members for example, have even greater trust in the extension staff (with an average score of 9.81). These scores may reflect farmers' need for extension services. Farmers' trust in retailers is relatively low, with an average score of 6.37, ranking as the third-last, with only the local government and strangers being less trusted in.

Given our differentiation in retailers, we further examined farmers' trust across pesticide retailers. Results show that F_{coop} give rather high scores (8.4) for their trust in retailers, followed by F_v (6.3), F_t (6.0), and F_c (5.9). The two-samples *t* test reveals a significant difference between F_{coop} and non-F_{coop}'s trust in retailers ($p = 0.002$).

However, in China, most farmer cooperatives, especially crop-planting cooperatives, are organized based on villages. Members of a cooperative are also village mates, which is also the case in our sample. With random sampling, all of the F_{coop} are farmers from Dajie Village of Henantuan Town. We, therefore, cannot totally exclude that the high trust levels in the cooperative's retailer may also be a function of a general greater-than-average trust level among villagers of these villages.

Once we verified that farmers' levels of trust in retailers indeed differ, we examine the potential effects of these differences on pesticide use. Table 3 is based on answers to the question "Based on what do you decide the actual quantity of pesticides to use?". The answers are highly consistent with farmers' trust levels in different retailers, namely the less farmers trust the retailers, the more likely the farmers decide based on their own judgment.

As shown in Table 3, the cost differences between any two types of farmers are greater than 10%, meaning that the relative order of costs can reflect the amount of pesticides used (see section 2.1). Thus, F_{coop} use the least amount of pesticides, and farmers who buy from the county shops use the most. F_t use the second least, and F_v use the third least amount of pesticides. F_{coop} show less pesticide use both in terms of cost and times of spraying. We carried out independent-sample *t* tests between every two groups of farmers. Differences in the pesticide costs between F_{coop} and F_v, F_{coop} and F_c, F_v and F_t, and F_t and F_c are statistically significant ($p = 0.0003$, 0.0001, 0.0067, and 0.0255, respectively) but not between F_{coop} and F_t or F_v and F_c ($p > 0.05$). The spray times of F_c, F_v, and F_t were almost the same, meaning that these three groups of non-cooperative farmers follow a similar interval between two sprays.

We can also test information distortion by comparing the costs between farmers who decide based on the manual and those who decide based on retailers' advice. Because there is only one F_t, and no F_c who decide based on retailers' advice, we only included F_{coop} and F_v for such a test. As presented in Table 4, for F_{coop}, there was no significant difference in the costs between manual-based and retailer-based decisions. However, for F_v, a two-sample *t* test revealed that pesticide costs were significantly higher among farmers who decide based on retailers' advice than among farmers who decide based on manuals (=0.0155), further demonstrating that information is largely distorted by the village retailers. Additionally, among those farmers who decide based on manuals, the costs of F_v are greater than those of F_{coop}, demonstrating that, even though both groups make decisions with the same information, the extent to which they follow the information differs.

To sum up, for the four groups of farmers, their pesticide (over)use can be interpreted as follows:

(1) F_{coop}: As members of a cooperative, F_{coop} can directly obtain more accurate information from the retailers, who are at the same time extension technicians, in whom the farmers highly trust. Thus, the farmers may strictly follow what they learn from the retailers, leading to the lowest use of pesticides.
(2) F_v: The familiarity between F_v and the village retailers is a double-edged sword. While, compared to F_c and F_t, F_v have more trust in retailers, to maintain face, the retailers amplify the pesticide dosage when farmers consult them. The outcome is pesticide overuse, which even outpaces F_t, who have lower trust in retailers but rely on more accurate information.
(3) F_c and F_t: Both obtain information with less distortion than F_v. However, for F_c, the lowest trust trades off the

Table 3
Decision basis for pesticide use.

	Based on what do you decide the quantity of pesticides to use					Costs (*yuan/mu*)*	Sprays (times)
	Own judgment	Manual	Retailers	Extension	Neighbor		
F_{coop}	0	9 (56.3%)	Equal to extension	7 (43.7%)	0	56.7	8.6
F_v	54 (52.4%)	34 (33%)	12 (11.7%)	0	3 (2.9%)	85.6	16
F_t	20 (66.7%)	7 (23.3%)	1 (3.3%)	0	2 (6.7%)	68.5	16.4
F_c	7 (87.5%)	0	0	1 (12.5%)	0	95.6	16.3

Source: Field data 2013.
* During the survey (Jan. 2013), 8.2 *yuan* = 1 euro; 15 *mu* = 1 ha.

advantage of less information distortion, and they use the most pesticides.

4. Discussion, conclusion and policy implications

This study demonstrates the interactions between farmers and retailers, in particular with regard to retailers' different information provision strategies and farmers' trust in retailers. Some of our findings are consistent with those of previous studies. For example, other studies also found farmers overusing pesticides [e.g., 20, 26], and that farmers seldom obtain technical support [e.g., 8, 25, 31]. China's extension system is widely criticized due to the very absence of any kind of extension system and due to local extension actually being accused of contributing to the overuse of agricultural chemicals by selling chemicals, as extension stations profit from their overuse [e.g., 25, 27]. However, while the survey supports the observation that only few farmers have access to extension staff, it also shows that farmers who buy pesticides from extension stations are actually using much less than are other farmers.

Our study sheds new light on the role of retailers in the absence of an effective extension system. We find that farmers buying pesticides from different retailers obtain information in different ways. Farmers from cooperatives directly obtain accurate information on pesticide dosage. For farmers who are not members of a cooperative, it seems that the more familiar the farmers are with the retailers, the more distorted is the information that retailers provide. Farmers then, again, deal with the information based on their trust in retailers; the greater the trust, the more strictly the farmers follow the retailers' advice. The lowest pesticide use occurs when accurate information is provided and when farmers greatly trust the information provider. Overuse will happen either with information distortion or low trust. Cooperatives had advantages both in terms of information provision and trust and thus lead to the lowest use of pesticides.

The limitations of this study are obvious. First, we only focused on smallholders. With the development of the land circulation system, large farmers have emerged in China, and these more professional farmers may have a different pesticide use. Hence, our findings do not automatically apply to these larger farmers. However, smallholders still provide the main contribution to China's agriculture. Currently, more than 80% of China's farming land is planted by smallholders [see 46]. Second, survey data are limited in scope, e.g., the survey only included one cooperative in one village. So the results for cooperative members might not be representative and we should be careful to generalize findings with respect to cooperatives. Still, the inclusion of this one cooperative in the study provided an insight on the potentials of cooperatives as a solution to reduce pesticide use. Third, we considered the recommended dosage in the manual as a benchmark for pesticide use and did not further examine or measure the reliability of the manuals. As elaborated in section 3.1, we assumed that factories will follow the *Regulation for Pesticides Administration* for their manuals. Future research needs to focus on the producers of pesticides to investigate and test the reliability of their manuals. Fourth, we did not discuss the relationship between trust and information. According to the literature [e.g., 32, 34, 35], there is no linear relation in the transformation process from information to knowledge, and further to an eventual decision and activities based on this decision. However, in the framework (Fig. 1), we linked trust and information with the intermediate variable of "familiarity" between information source and information user, based on the assumption that trust can best be achieved within a familiar world [35]. The results of this study adds evidence to support that more familiarity between information source and user leads to higher trust as widely recognized in rural China [41]. But we also revealed that higher trust does not lead to higher accuracy in information delivery. Instead, the village retailers in whom farmers have high trust, informed farmers to amplify the dosage of pesticide use beyond the amount considered adequate on pesticide manuals. Thus in our case, trust does not always promote efficiency, which largely differs from existing literature [e.g., 37-39]. And finally, to answer our research questions, our study focused on professional organizations as sources of information on pesticide use, and did not incorporate potential other sources like neighbors or family members.

Table 4
Comparison of costs across different decision bases.

	Average cost (*yuan/mu*)	Manual (*yuan/mu*)	Retailers (*yuan/mu*)	P value for *t*-test
F_{coop}	56.7	54.3	59.3	0.4208
F_v	85.6	73.8	101.7	0.0155

Source: Field data 2013.
During the survey (Jan. 2013), 8.2 *yuan* = 1 euro; 15 *mu* = 1 ha.

Nevertheless, the findings still allow us to derive some policy recommendations in regard to ways of reducing pesticide use. First, the capacity of the extension system should be further strengthened. Although since 2012, the Chinese central government has decided to rebuild the extension network, as represented in the goal "*the extension network should cover every town*", extension services are still hardly accessible for farmers. Apart from area coverage, the capacity of the extension system should also be improved by various measures, e.g., by enrolling young and professional technicians, by regular staff training, and by providing the necessary equipment (e.g., transportation vehicles) for extension stations. One program that can be integrated in the extension system is the "*university graduates village official program*" (*daxuesheng cun guan*), in which selected graduate students work as a village official. For selection of candidates for this program, priority should be given to students with a degree in agronomy, crop protection, and other agriculture-related disciplines, so that they can partly play a role as extension staff and solve more practical problems for farmers. At the same time, such "internships" will allow students to learn from farmers' hands-on experience, and how to communicate with farmers, - skills that are essential in an effective extension system.

Second, as farmers have a high level of trust in the cooperative in the case at hand, and information transfer is highly effective, cooperatives can also be considered a solution to reduce the overuse of pesticides, e.g., cooperatives may be approached by other extension agencies and be used as a platform to reach farmers. Potential policies can focus on encouraging either the establishment of farmers' cooperatives or cooperatives to increase their performance and service delivery to farmers.

Third, currently, village retailers are partly playing the role of technical advisors for many farmers. Thus, it is essential to provide training to village retailers, both to increase their knowledge (so that they can be at peace with providing accurate information), as well as to improve communication with farmers so that they will correctly deliver information to them.

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