# Role of Risk Preferences, Incentives, and Governance Structures on Pesticide Use in Vegetable Production in China

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## Acknowledgment


Whether Yangyi Zeng can successfully submit the thesis is determined by the following model:

$$Y = \beta_0 + \beta_1 age + \beta_2 income + \beta_3 social + \beta_4 working + \beta_5 supervision + \beta_6 colleagues + \beta_7 friends + \beta_8 family + \beta_9 interest$$

Data description

| Variable | Definition |
|---|---|
| *Dependent variable* | |
| $Y$ | =1 if Yangyi Zeng can successfully submit thesis |
| *Independent variable* | |
| age | age of Yangyi Zeng in years |
| income | scholarship from China Scholarship Council (CSC) and Leibniz Institute of Agricultural Development in Transition Economies (IAMO) in euros |
| social | social time in hours per week |
| working | working time in hours per week |
| supervision | =1 if supervised by Prof. Dr. Thomas Herzfeld |
| colleagues | =1 if getting help from other colleagues in IAMO and Sichuan Agricultural University |
| friends | =1 if getting help and support from friends |
| family | =1 if getting help and support from family members |
| interest | =1 if having interest in doing research |

Results of the Probit regression

| Variable | Coefficient | Average marginal effect | [90% Confidence Interval of Average Marginal Effect] | |
|---|---|---|---|---|
| age | -0.099<br>(0.744) | -0.010<br>(0.077) | -0.137 | 0.117 |
| income | 0.092<br>(0.054) | 0.016<br>(0.010) | 0.000 | 0.032 |
| social | -0.193<br>(0.868) | -0.020<br>(0.089) | -0.166 | 0.126 |
| working | 0.060<br>(0.003) | 0.010<br>(0.0004) | 0.009 | 0.011 |
| supervision | 0.608<br>(0.065) | 0.321<br>(0.037) | 0.260 | 0.382 |
| colleagues | 0.961<br>(0.303) | 0.099<br>(0.031) | 0.051 | 0.150 |
| friends | 0.193<br>(0.068) | 0.020<br>(0.009) | 0.005 | 0.035 |
| family | 0.724<br>(0.408) | 0.128<br>(0.071) | 0.011 | 0.245 |
| interest | 0.881<br>(0.149) | 0.165<br>(0.025) | 0.124 | 0.206 |
| Constant | 0.203<br>(0.502) | | | |

*Note: Data from own experience and simulation. Standard errors are shown in the parentheses.*

Halle (Saale), Dezember 2020 Yangyi Zeng

# Summary

A total of 1.773 million tons of pesticides were used in 2017 in China, which accounts for approximately one-third of total global pesticide use. One of the main reasons farmers overuse pesticides is to reduce yield risk. In order to synchronize pesticide application with good practices, incentives, such as a price premium and a subsidy for certain pesticides, are considered as the main measures. Yet, it has been shown a poor association between pesticide use and incentives. Governance structures, in addition, play an important role in the functioning of supply chains. The imposition of pesticide restrictions and the corresponding implementation to achieve a certain level of food safety differs between governance structures and might have important consequences for food safety control. Besides, a highly fragmented set of small individual producers, producer cooperatives are regarded as one of the main governance structures of agricultural production in China.

In order to have a better understanding of the above questions, it is better to integrate behavioral economic approaches. Therefore, this thesis aims to gain a better understanding of farmers' pesticide use by integrating the theoretical assumptions of prospect theory in China, followed by a study of whether and how mental budgeting can explain differences in farmer's reaction to different incentives from different sources to use low-toxicity pesticides. In addition, this study finally aims at understanding whether and how far cooperatives and food safety instruments such as training and control measures can affect the choices of restricted and recommended pesticides.

Based on the data collected during a farm-level survey and experiments conducted in cooperation with vegetable farmers in Sichuan Province, China, this study firstly provides quantitative estimates of the degree of risk preferences in a sample of 393 farmers through three parameters in prospect theory (risk aversion, loss aversion, and probability weighting parameter). An Ordinary Least Square (OLS) model is, then, applied to understand the effect of risk preferences on the use of pesticides where two measures, the amount of pesticides and the cost of pesticides, are selected as dependent variables. This thesis, then, tests whether farmers engage in mental budgeting from a Likert Scale Points followed by an analysis of how mental budgeting affects farmers' intentions towards switching to use low-toxicity pesticides through a Probit model. The results from the Probit model are robustly tested by using Receiver Operating Characteristic (ROC). This study finally analyzes the effect of a farmer's membership in a cooperative on the revealed use of restricted and recommended pesticides through Propensity Score Matching (PSM). The influence of existing food safety related instruments within and outside cooperatives are also estimated through a Logit model based on the matching samples from the PSM.

The results of risk preferences support a rejection of the neoclassical model of decision-making under risk for most of the vegetable farmers regarding loss aversion and probability weighting. 68.4% of farmers are risk-averse with respect to yield risk while 59.8% of farmers show aversion to yield loss. 98.5% of farmers show cognitive biases in probability weighting. The regression results show that farmers with a higher degree of loss aversion and a greater weighted probability of potential hazards, which could incur yield loss, tend to apply more pesticides and spend more on pesticides.

The analysis regarding mental budgeting shows that the majority of farmers categorize agricultural inputs into different groups and that 26.46% of the investigated farmers engage in mental budgeting for pest control practices. In addition, farmers who engage in mental budgeting report a higher willingness to switch to low-toxicity pesticides when they face a specific subsidy compared to other farmers. Furthermore, if offered an agricultural revenue with a price premium for quality, the willingness to switch to low-toxicity pesticides for farmers who engage in mental budgeting is negative.

The results of the PSM show that around 12.5% more vegetable farmers would reveal the use of recommended pesticides if they would join a cooperative. Regarding the effect of instruments, the results show that members of a cooperative who do not receive any instrument are more likely to use restricted pesticides. The results also show that training programs would have the biggest effect on limiting the use of restricted pesticides, participating farmers are predicted to reduce restricted pesticides by 13.5% and

12.4% for cooperative members and non-members, respectively. Although the effect is quantitatively small, quality tests are predicted to increase the probability of using restricted pesticides. In addition, a certification program would increase the probability of using recommended pesticides by 21.4% and 24.6% for cooperative members and non-members, respectively, while obligations for record-keeping would decrease this probability. For all interventions, the results don’t support that their effect would differ between members and farmers outside of cooperatives. Thus, besides training and certification, additional instruments to reach a more sustainable use of pesticides need to be reconsidered and made more effective.

Key words: Yield risk preference; Pesticide use; Loss aversion; Risk aversion; Probability weighting; Mental budgeting; Cooperatives; Incentive; Vegetable farmer; China

## Zusammenfassung

Im Jahr 2017 wurden in China 1,773 Millionen Tonnen Pestizide eingesetzt, fast ein Drittel des gesamten weltweiten Pestizidverbrauchs ausmacht. Ein geringeres Produktionsrisiko ist einer der Hauptgründe für den Missbrauch von Pestiziden durch Landwirte. Finanzielle Anreize, wie ein Preisaufschlag und eine Subvention für bestimmte Pestizide, gelten als die wichtigsten Strategien, um den Pestizideinsatz mit guten Praktiken zu synchronisieren. Trotzdem gibt es keine Belege für einen Zusammenhang zwischen Pestizideinsatz und Anreizen. Darüber hinaus spielen Governance-Strukturen eine wesentliche Rolle für den Betrieb von Lieferketten. Pestizidbeschränkungen werden unter verschiedenen Governance-Systemen unterschiedlich auferlegt und umgesetzt, um einen bestimmten Grad an Lebensmittelsicherheit zu erreichen, was erhebliche Auswirkungen auf die Regulierung der Lebensmittelsicherheit haben kann. zusätzlich ist eines der Governance-Struktur der landwirtschaftlichen Produktion in China ein stark fragmentiertes Netzwerk von kleinen Einzelbauern und Erzeugergenossenschaften.

Um die oben genannten Probleme besser zu verstehen, ist es sinnvoll, verhaltensökonomische Techniken zu kombinieren. Ziel dieser Arbeit ist es daher, ein besseres Verständnis des Pestizideinsatzes von Landwirten in China zu erlangen, indem die theoretischen Annahmen der Prospect-Theorie integriert werden und anschließend untersucht wird, ob und wie die mentale Budgetierung Unterschiede in den Reaktionen der Landwirte auf verschiedene Anreize aus unterschiedlichen Quellen zum Einsatz von niedrigtoxischen Pestiziden erklären kann. Abschließend soll untersucht werden, ob und wie Kooperativen und Instrumente der Lebensmittelsicherheit wie Schulungen und Kontrollmaßnahmen die Auswahl von verbotenen oder empfohlenen Pestiziden beeinflussen können.

Diese Studie präsentiert zunächst quantitative Schätzungen des Grades der Risikopräferenzen in einer Stichprobe von 393 Landwirten unter Verwendung von drei Faktoren der Prospect Theory, basierend auf Daten, die während einer Umfrage auf Betriebsebene gesammelt wurden, und Experimenten, die in

Zusammenarbeit mit Gemüsebauern in der Provinz Sichuan, China, durchgeführt wurden (Risikoaversion, Verlustaversion und Wahrscheinlichkeitsgewichtungsparameter). Der Einfluss der Risikopräferenzen auf den Einsatz von Pestiziden wird dann mit Hilfe eines gewöhnliche Methode der kleinsten Quadrate mit zwei abhängigen Variablen untersucht: die Menge der eingesetzten Pestizide und die Kosten der Pestizide.

Diese Arbeit verwendet einen Likert-Skala Verfahren, um es festzustellen, ob Landwirte an der mentale Budgetierung teilnehmen, gefolgt von einem Probit Modell, welche untersucht, wie sich die mentale Budgetierung auf die Absicht der Landwirte auswirkt, auf Pestizide mit geringer Toxizität umzusteigen. Die Ergebnisse des Probit-Modells werden mithilfe der Betriebseigenschaften des Empfängers streng validiert. Schließlich untersucht diese Studie mit Hilfe von paarweise Zuordnung auf Basis von Neigungsscores den Einfluss (PSM) der Teilnahme eines Landwirts an einer Genossenschaft auf die offengelegte Nutzung. Ein Logit Modell, das auf Passende Stichproben aus dem PSM basiert, wird verwendet, um den Effekt aktueller lebensmittelsicherheitsbezogener Instrumente innerhalb und außerhalb von Genossenschaften zu bewerten.

In Bezug auf loss aversion und probability weighting deuten die Ergebnisse der Risikopräferenzen auf eine Ablehnung des neoklassischen Modells der Entscheidungsfindung unter Risiko für die Mehrheit der Gemüsebauern hin. 68,4 Prozent der Landwirte sind risikoscheu, wenn es um das Ertragsrisiko geht, gleichzeitig 59,8 Prozent risikoscheu sind, wenn es um den Ertragsverlust geht. 98,5 Prozent der Landwirte haben kognitive Abneigungen in Wahrscheinlichkeitsgewichtung gezeigt.

Nach den Regressionsergebnissen wenden Landwirte mit einem höheren Grad an Verlustaversion und einer größeren gewichteten Wahrscheinlichkeit möglicher Risiken, die zu Ertragsverlusten führen könnten, mehr Pestizide an und geben mehr für Pestizide aus. Die Mehrheit der Landwirte ordnete der Studie zufolge landwirtschaftlicher Betriebsmittel in verschiedene Gruppen ein, und 26,46 Prozent der untersuchten Landwirte nutzen mentale Budgetierung für Schädlingsbekämpfungspraktiken. Darüber hinaus sind Landwirte, die die mentale Budgetierung nutzen, sind eher bereit als andere Landwirte, auf niedrigtoxische Pestizide umzusteigen, wenn sie mit einer spezifischen Subvention konfrontiert werden. Wenn Landwirten,

die an der mentale Budgetierung teilnehmen, ein landwirtschaftliches Einkommen mit einem Preisaufschlag für Qualität zur Verfügung gestellt wird, sind ihre Meinung eher negativ auf gering toxische Pestizide umzusteigen.

Laut PSM würde der Beitritt zu einer Genossenschaft dazu führen, dass 12,5 Prozent mehr Gemüsebauern ihren Einsatz von zugelassenen Pestiziden offenlegen. Was die Auswirkungen von Instrumenten angeht, so deuten die Ergebnisse darauf hin, dass Genossenschaftsmitglieder eher verbotene Pestizide einsetzen, wenn sie keinen Instrumenten erhalten. Die Ergebnisse weisen auch darauf hin, dass Schulungsprogramme die größte Auswirkung auf die Einschränkung des Einsatzes von verbotenen Pestiziden haben. Wobei erwartet man, teilnehmende Landwirte reduzieren den Einsatz von verbotenen Pestiziden um 13,5 Prozent bei Genossenschaftsmitgliedern bzw. 12,4 Prozent bei Nicht-Mitgliedern. Obwohl der Effekt quantitativ gering ist, es wird erwartet, dass Qualitätstests die Wahrscheinlichkeit erhöhen, den Landwirten eingeschränkte Pestizide zu verwenden. Zusätzlich würde ein Zertifizierungsprogramm die Wahrscheinlichkeit der Anwendung empfohlener Pestizide bei Genossenschaftsmitgliedern um 21,4 Prozent und bei Nicht-Mitgliedern um 24,6 Prozent erhöhen, wenn eine Aufzeichnungspflicht besteht, diese Chance noch senken würden. Die Ergebnisse für alle Interventionen zeigen, dass ihre Auswirkungen für Mitglieder und Landwirte außerhalb der Kooperativen gleich sind. Folglich müssen neben Schulungen und Zertifizierungen auch andere Instrumente zur Erreichung eines nachhaltigeren Einsatzes von Pestiziden evaluiert und verbessert werden.

Schlüsselwörter: Renditerisikopräferenz; Verwendung von Pestiziden; Verlustaversion; Risikoaversion; Wahrscheinlichkeitsgewichtung; mentale Budgetierung; Genossenschaften; Ansporn; Gemüsebauer; China

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## List of abbreviations

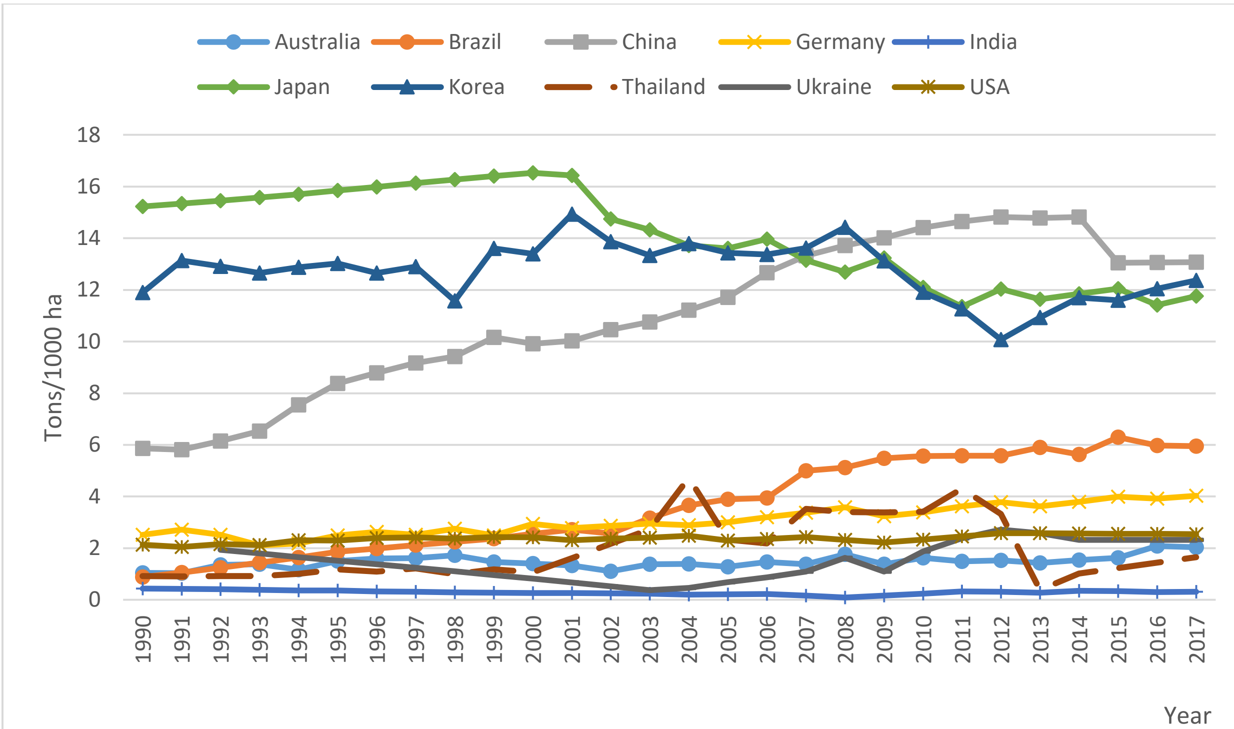
| | |
|---|---|
| ATT | The Average Treatment Effect on the Treated |
| CCTV | China Central Television |
| EUT | Expected Utility Theory |
| FAO | Food and Agriculture Organization of the United Nations |
| IAMO | Leibniz Institute of Agricultural Development in Transition Economies |
| MOA | Ministry of Agriculture and Rural Affairs of the People's Republic of China |
| OLS | Ordinary Least Square |
| PSM | Propensity Score Matching |
| RMB | Renminbi, Chinese Currency, Yuan |
| SAU | Sichuan Agricultural University |
| SD | Standard Deviation |
| SE | Standard Error |

# 1 Introduction

## 1.1 Problem statement and motivation

Food safety has become a major concern in China due to increasing agricultural productivity and living standards. This concern has drawn some attention to the issue of pesticide use, especially pesticide residue, which is one of the important indexes of food safety assessment. Consuming foods containing excessive pesticide residue levels is associated with several foodborne diseases. It is commonly recognized that excessive pesticide use is strongly correlated with pesticide residue and affects the quality of agricultural products. In 2017, a total of 1.773 million tons of pesticide were applied in China, which accounts for approximately 40% of the total global amount (according to data of the Food and Agriculture Organisation of the United Nations (FAO). Figure 1.1 shows the average levels of pesticide use in agricultural production for ten major countries. China's average amount of pesticide use increased strongly between 1990 and 2010 and is, currently, higher than in the other countries.

Figure 1.1: Intensity of pesticide use in ten major countries




*Source: Data from FAOSTAT and calculated by the author.*

Pesticides are primarily formulated to abate pest- and weed-related hazards and ensure productive crop yields (Lichtenberg and Zilberman, 1986). Given that hazards due to invasive pests, fungus, and other weeds are not fixed, the risk of yield loss is very common in agricultural production. According to recent studies, the use of pesticides, including usage, frequency, and types of pesticides, is determined by a range of factors such as personal, household, and farming characteristics (Feola and Binder, 2010, Ma et al., 2018, Zhou and Jin, 2009, Wang et al., 2017, Huang et al., 2000, Khan et al., 2015, Fan et al., 2015, Dasgupta et al., 2001, Schreinemachers et al., 2016), as well as economic factors (Fan et al., 2015). In addition, farmer's knowledge about pesticides and the potential risks to health are shown to have an impact on the use of pesticides empirically (Wang et al., 2015, Jin et al., 2015, Stadlinger et al., 2011, Hashemi and Damalas, 2010).

Moreover, the effects of risk preferences are addressed in some studies (Khan et al., 2015, Liu and Huang, 2013, Hou et al., 2020). However, previous studies still lack an understanding of the effect of risk preferences on vegetable farmers' pesticide use, especially considering that expected utility theory (EUT), as a synonym for standard approach, cannot reflect the effect of loss aversion as the negative utility of loss is larger than the positive utility of gain with the same value and the bias of probability weighting where small probabilities are overestimated and large probabilities are underestimated generally. It is said that the limitations of expected utility theory are one of the main reasons for deviation in explanations of behavior in the face of risk (Shaw and Woodward, 2008, Bartczak et al., 2015, Liebenehm and Waibel, 2014). Behavioral theories, such as prospect theory and its applications in other research aspects in addition to agriculture, on risk preferences have dramatically developed. Prospect theory, introduced by Kahneman and Tversky (1979), presents a non-linear method to measure an individual's level of risk preferences including loss aversion and probability weighting. Whilst, as the measurement for the degree of risk aversion and loss aversion, as well as the non-linear weighting of probabilities, has developed recently, it is possible to calculate such variables via an experiment in a more accurate way (Tanaka et al., 2010).

The strategies to reduce, rectify, or improve the use of pesticides are multifaceted (Zhao et al., 2018). Mandatory rules, such as Pesticide Management Regulations, form the baseline of pesticide use by introducing the application scopes of different types of pesticides, amount of pesticides applied, production and sale of pesticides, and supervision of pesticide use, etc.. Meanwhile, there are some other strategies, such as certifications and subsidies, implemented by the government or private sectors in order to meet the demand for vegetables with higher quality (Fan et al., 2009, MOA, 2013). These strategies aim at motivating farmers to switch from traditional pesticides towards more environmentally-friendly ones or even non-chemical pest control measures generally through monetary incentives. The effectiveness of these strategies highly depends on the types and extent of monetary incentives. In order to make sure the compliance with mandatory or private rules of pesticide use, ex-ante training, input controls, and ex-post tests are found during daily management from both government and private sectors (Ma and Abdulai, 2019, Zhou and Jin, 2009, Zhou et al., 2015). However, the implementation and density of such instruments differ between different governance structures in China.

Pest control is a pivotal activity in maintaining the quality of agricultural production as well. However, the misuse and overuse of pesticides have caused several food incidents in China, including that of "poisonous ginger[1]" in 2013 (CCTV, 2013). Monetary incentives, such as a price premium or a subsidy, are the main measures for synchronizing pesticide application with expectations on behalf of food safety requirements (Miyata et al., 2009). Yet, previous literature, where money is assumed to be perfectly fungible, provides conflicting evidence of the effectiveness of monetary incentives (Wilson and Tisdell, 2001, Pietola and Lansink, 2001b, Huang et al., 2011, Skevas et al., 2012). Individual decision-making, on the other hand, has displayed evidence of differences in incomes use depending on the sources (Thaler, 1985, Levav and McGraw, 2009, Antonides and Ranyard, 2018). Different incomes will be budgeted into different expense categories. In neoclassic economic theory, money is supposed to be fungible (Clot et al., 2015), which means money is substitutable for each category in terms of incomes or expenditures. However, Thaler (1985) demonstrates that the assumption of fungibility is not supported through experiments and introduced the concept of mental accounting. In Thaler's theory, money is not fungible between different categories but fungible within a particular category. And mental budgeting, as a component of mental accounting, describes the separation and allocation of money for different categories and purposes (Thaler, 1999). Thus, the varying and only partial success of current incentives may follow the result of mental budgeting, where farmers view incomes from different incentives separate to the mental account of pesticide use.

In vegetable production, the quality and safety of the products are largely related to the choice of pesticides. Even though there have been regulations that restrict the use of some pesticides (especially high-toxicity pesticides) in vegetable production and encourage to use pesticides with lower toxicity and higher efficiency, such high-toxicity pesticides are still chosen by some farmers in developing countries (Wang et

[1] It was reported by CCTV (China Central Television) on May 10, 2013 that a banned pesticide, namely aldicarb, was used for producing ginger in Weifang, Shangdong.

al., 2015, Jardim and Caldas, 2012). So far, regulations in China have specified a large range of pesticides, mostly the high-toxicity ones, which cannot legally be used for vegetable production anymore. Such restricted pesticides include DDT, methamidophos, parathion, and chlordimeform, etc. (Wang et al., 2015). Restrictions are complemented by a pilot subsidy scheme for low-toxicity pesticides China's government started in 2013 in a few counties across ten provinces (MOA, 2013). Such a subsidy scheme aims at encouraging farmers to voluntarily switch to use more environmentally-friendly pesticides on, for instance, vegetable production through a decrease of cost of pest control measures.

However, food safety related instruments for regulating the use of pesticides differ among different governance structures. The effect of governance structures on the use of pesticides has been analyzed empirically (Ma and Abdulai, 2019, Zhou and Jin, 2009) and experimentally (Bell et al., 2016) so far. Membership in a cooperative is shown to result in more food safety related instruments, such as training program, test, and certification program, etc., on the use of pesticides (Ma and Abdulai, 2019, Zhou and Jin, 2009, Zhou et al., 2015). Besides the likelihood of stricter pesticide use requirements in cooperatives and better facilities to test and trace products, members of cooperatives might have better access to training or supplies of less toxic pesticides which should incentivize more sustainable use of pesticides. However, all these studies treat pesticides as a homogeneous input. Thus, there is still a lack of understanding of the effect of cooperatives on the choice of specific pesticides, especially restricted and recommended ones.

Additionally, there is a lack of evidence whether instruments and incentives are working more effectively in cooperatives compared to other governance structures. Small scale farming is one of the main characteristics of most developing countries, China's agricultural sector does not form any exception in that respect. Given that a supervision system which can fully monitor every step of farmers during production would be extremely costly and hard to manage (Hobbs and Young, 2000, Starbird, 2005), different governance structures, in addition to spot markets and government's food safety regulation, are regarded as an alternative approach for ensuring the compliance or even better application of pesticide use rules. The use of incentives and control measures greatly differs among these governance structures (Williamson, 1991).

Within agriculture, cooperatives can be viewed as a typical hybrid governance structure in addition to market governance and hierarchic governance, as individual production decisions coexist with partial higher-level coordination of decision making (Chaddad, 2012, Peterson et al., 2001). Joining a producer cooperative is usually regarded as one of the main routes for the integration of small individual farms and upscaling of agricultural production in China (Zhou et al., 2015). As of September 2017, there are more than 1.933 million cooperatives in China and more than half of them provide integrated services in terms of production, processing, and sale[2]. Current studies regarding the performance of cooperatives as a governance form mainly focus, for instance, on quantifying differences in marketing results (Ruben and Heras, 2012), the application of quality control practices (Zhou et al., 2015, Zhou et al., 2016, Jin and Zhou, 2011), or decision-making processes (Chaddad and Iliopoulos, 2013), etc.. Current studies, in addition, reveal that the use of pesticides may follow the guidance of cooperatives (Zhou et al., 2018). Yet, researchers have analyzed the impact of membership in cooperatives on farmer's pesticide choices to a limited extend only.

### 1.2 Research objectives and questions

This study includes three aspects in order to contribute to a better understanding of the above problems in deep. The first aim is to explore whether and how risk preferences could have an impact on the use of pesticides by separating risk preferences over the domains of gains and losses under a framework of prospect theory. Two measures are applied to reflect the pesticide use behavior, the amount of pesticides and the cost of pesticides, in order to ensure robust results. Additionally, uncovering the basic characteristics of pesticide use in the primary stage of vegetable production is needed by decision-makers to improve food safety management systems. To address these issues, the types of risk faced by farmers

[2] Source from Chinese government website, http://www.gov.cn/xinwen/2017-09/04/content_5222588.htm.

during the entire growing season are subdivided to focus on yield risk in the current study. Thus, an experiment involving yield risk is designed in this study focusing on understanding how and to what extent risk aversion, loss aversion, and weighted probability of potential hazards would affect farmers' pesticide use decisions. The detail of the experiment refers to Bartczak et al. (2015) and Liu and Huang (2013).

Secondly, this thesis aims at understanding the different effects of different monetary incentives on the use of pesticides. Different monetary incentives struggling to encourage the use of low-toxicity pesticides are mainly based on changing profit or income. The effect of incentives would differ as a result of mental budgeting where different sources of income may perform differently. However, research gaps in this area still remain to date. Thus, how different monetary incentives affect the use of low-toxicity pesticides still needs further study. Production-related income raised on non-differentiating markets should be used for better pest control practices and other expenses only if money is fungible. Conversely, incomes from incentives covering a set of behaviors more than pest control seem to have less effect on encouraging the use of low-toxicity pesticides compared to incomes from specific incentives. Against this background, this study aims at analyzing whether and how mental budgeting can explain differences in farmer's reactions to different incentives to use low-toxicity pesticides. Given that, to the author's knowledge, there is no study on the effect of mental budgeting on input use in agricultural production so far, this new approach helps to understand whether different monetary incentives differ in their effect on encouraging the use of low-toxicity pesticides and, if so, to what extent. More specifically, this study first analyzes whether farmers assign agricultural inputs to different categories (typicality). Second, a mental budgeting scale with respect to agricultural inputs is constructed using principal component analysis. Finally, the effect of mental budgeting on farmers' stated willingness to switch to low-toxicity pesticides conditional upon different income sources is analyzed by estimating a Probit model.

Thirdly, given that there is limited understanding of the effect of governance structures on the choices of pesticides, especially considering that different governance structures differ in food safety related instruments, this study aims to understand the effect of cooperatives on the choice of using restricted pesticides and recommended pesticides for vegetable farmers via two different channels. First, the effect of membership in a cooperative on the revealed behavior is tested. As the decision of pesticide use and the voluntary decision to join a cooperative could be driven by the same farmer's characteristics and, thus, is a non-negligible source of endogeneity, A Propensity Score Matching (PSM) is used to estimate the average treatment effect on the treated (ATT). Second, the indirect effect of particular instruments is analyzed in order to test whether members of cooperatives react differently to them. The choices of two types of pesticides, restricted and recommended pesticides, are analyzed using a Logit model.

This research focuses on vegetable farmers in Sichuan, China. Vegetable farmers are chosen because vegetables belong to the most important crops and are widely cultivated all over the world. Most vegetable production requires multiple applications of pesticides, such as herbicides, fungicides, and insecticides, before the plants mature. Pesticide residue on vegetables, however, is relevant to human health due to commonly fresh consumption. Sichuan Province is selected as the sample area due to its importance to China's vegetable production, especially in the south-western region of China. According to the statistics published by China's Ministry of Agriculture and Rural Affairs, the total vegetable yield in Sichuan Province was 42.4 million tons in 2015, and Sichuan is the fifth-highest ranking province in China in terms of vegetable production. Currently, there are five major regions involved in vegetable production in Sichuan province based on their different geographic characteristics, as well as other conditions for vegetable industry development, such as transportation and the economy. Accordingly, the empirical background for this study is formed by a survey among 393 vegetable farmers in Sichuan Province, China, in October and November 2018.

## 1.3 Structure of the thesis

The remainder of the study is organized as follows. Section 2 explores the key concepts used in the thesis, as well as the existing studies related to pesticide use and risk preferences, as well as studies about mental accounting, mental budgeting, and monetary incentives for pest control practices. In addition, cooperatives in Sichuan, China and the empirical evidence of farmers' pesticide use is reviewed in Section 2. The theoretical framework, methodology, and experimental design this study uses are explained in Section 3, while Section 4 describes the data collection methods and data description. Results are presented and discussed in Section 5, and followed by a conclusion part with some policy suggestions and methodological implications.

# 2 Introduction of concepts and literature review

## 2.1 Pesticides as a risk management tool

Given that farmers are self-employed, especially small farms that are widely existing in developing countries, and that there are limited alternative channels for information acquisition, pesticide use is mostly based on self-report information (Hoppin et al., 2002). Although this kind of decision-making process is a convenient approach, it may cause more errors or deviation of utility as a result of insensitivity to the probability of changes in yield, especially considering potential yield loss and other risks of agricultural production. Risk preferences are found to be one of the main aspects that could have an impact on farmers' pesticide use (Hou et al., 2020). Apart from other determinants, farmers have a subjective trade-off between pesticide use and potential damage to their crop or even farmer's own health before deciding whether or how much pesticides need to be used by evaluating its utility. Potential pest hazards, consequently, has been revealed as a main aspect of risk occurred regarding pesticide application (Feder, 1979, Liu and Huang, 2013, Wilson and Tisdell, 2001). However, many of the decisions regarding pesticide use are, generally, not dealt with a complex perfectly rational process, but rely more on heuristics where previous experiences or similar cases are more important. For example, farmers are found to cultivate partly based on their own experiences (Korsching and Malia, 1991, Jin et al., 2017, Ortega and Ward, 2016). Thus, cultivation decisions based on bias recognized risk may happen. In the case of pesticide use, the existing evidence has shown that farmers would overestimate damage caused by pests and apply unnecessary insecticides (Heong et al., 1998). However, farmers' insecticide use would decrease and their spraying methods are improved following more professional knowledge which changes farmers' perception of potential yield loss with insecticide use (Heong et al., 1998, Escalada et al., 1999). Farmers' risk perception of pest damage could be a major reason for the overuse and misuse of pesticides (Norgaard, 1976), and farmers will make the optimal choice of pesticide use after resolving information asymmetry or, at least, reduce the risk of pest hazards (Feder, 1979).

Some researchers have attempted to uncover the association between risk aversion and pesticide use (Serra et al., 2008, Acs et al., 2009, Huang et al., 2000, Gong et al., 2016). These studies' findings, based on expected utility theory, indicate that risk aversion is related to the use of pesticides in terms of the choice of healthier pest control measures and higher the amount of pesticide use. More specifically, Serra et al. (2008) compare risk attitudes of conventional and organic farmers based on flexible utility function by Saha (1997) showing that organic farmers are more willing to tolerate more risk than conventional ones as a result of a higher wealth of organic farmers. Such a difference in risk preferences may be a reason for the different choice of pest control measures. Serra et al. (2008), however, do not separate the type of risk preferences according to sources of risk, such as health and marketing risks, which are included in the analysis in addition to yield risk. Based on expected utility theory, Acs et al. (2009) show that the degree of risk aversion has a strong effect on the optimal decision of a farmer to switch from conventional farming to organic farming. It is optimal for risk neutral farmers to entirely switch to organic production, while it is not suitable for risk averse farmers. Huang et al. (2000) find that the perception of the potential risk of yield loss can affect pesticide application quantitatively, reflected in 2 to 3 times fewer applications for each rice cropping season for farmers who perceive a 10% decrease of potential yield risk. Based on an experiment regarding risk preference, Gong et al. (2016) find that farmers in Yunnan Province, China with higher risk aversion would use more pesticides. This result holds for subsistence as well as for semi-subsistence farmers and indicates that budgetary constraints are not binding. Consequently, fiscal measures to reduce pesticide use might not result in a reduction of pesticide use.

Prospect theory is a non-linear method to measure an individual's level of risk preferences including loss aversion and biases in terms of probability weighting which represent the main differences of prospect theory compared to expected utility theory. The above studies, however, do not take loss aversion and biases in terms of probability weighting of potential yield loss, which are also main components of risk preferences in addition to risk aversion, into account. It is shown that farmers' behavior highly relies on the reference point and loss aversion from the comparison of actual outcome and reference point, as well as weighted probability of potential outcomes (Bocquého et al., 2013). Bocquého et al. (2013) conduct a monetary incentive experiment and found that prospect theory is more suitable for explaining French farmers' behavior. In this lottery experiment, the reference point is based on the status quo or current assets, and the empirical evidence shows that farmers care more about status quo changes than absolute benefits or losses. In addition, the negative utility of loss is greater than the positive utility of gain with the same absolute values influencing final utility (Kahneman and Tversky, 1979), which means that, for the same degree of risk aversion, people still experience disutility when benefit and loss are substituted equally.

Some studies have tried to calculate the degree of loss aversion. Bocquého et al. (2013) show that farmers' average loss aversion is 3.76. According to a monetary experiment, Liu and Huang (2013) show that cotton farmers have an average loss aversion of 3.47, while a more recent study from Hou et al. (2020) shows a degree of loss aversion at 3.12. These values indicate that the negative effect of loss is more than three times the positive effect of gain.

Probability weighting is another important part that needs to be considered when studying risk related problems. It is said that people usually overestimate small probabilities and underestimate large probabilities in decision-making (Tversky and Kahneman, 1992), and farmers exhibit the same pattern of behavior. For instance, the impact of severe damage to crops would be a high yield loss with a low probability. However, although there is just a minor risk on peril, farmers purchase insurance more than predicted by expected utility theory because of probability over-estimation (Enjolras and Sentis, 2011, Bocquého et al., 2013). In the case of pesticide use, it may suppose farmers have an individual reference point regarding the outcomes of pesticide use, which could further affect their pesticide use. In addition, farmers may apply more pesticides to avoid such a negative effect when they anticipate yield loss.

However, only a few studies have tried to understand the effect of loss aversion and bias weighted probability on the use of pesticides so far. Liu and Huang (2013) conduct a monetary lottery experiment following Tanaka et al. (2010) to calculate the degree of risk aversion, loss aversion, and the parameter of probability weighting for cotton farmers. In their study, they assume that the actual yield is always greater than the farmers' reference point. Therefore, only risk aversion represents the impact of yield loss. More risk-averse farmers would use a higher amount of pesticides. More recently, Hou et al. (2020) employ a similar monetary experiment for rice farmers in Jiangxi Province, China. However, risk aversion does not show a stable impact empirically in their study when relying on a 90% confidence interval.

Loss aversion is regarded as a potential negative impact on health from applying pesticides and potential financial losses incurred by purchasing pesticides for both studies by Liu and Huang (2013) and Hou et al. (2020). Liu and Huang (2013)'s results show that there is a negative impact of loss aversion on the use of pesticides quantitatively. Besides, Hou et al. (2020) find that farmers with a higher degree of loss aversion are more likely to have below-average cost on pesticides and a lower spray frequency.

With regard to the effect of probability weighting. In both studies by Liu and Huang (2013) and Hou et al. (2020), the parameter of probability weighting does not show an impact on influencing pesticide use. This may because the authors only estimate the degree of the bias of weighted probability compared to the actual one, but do not take the probability of potential outcomes into account as well.

All of these studies use a monetary lottery experiment to investigate the association between risk preferences and pesticide use. However, risk preferences might be domain-specific (Weber et al., 2002). Given individual reference points of different risks and the effect of endowment, there is a question of whether a monetary experiment accurately reflects the effect of yield risk farmers may face during pesticide use. In order to study risk preferences in a specific area, Bartczak et al. (2015) conduct a scenario for understanding risk preferences of environmental issues under the framework of prospect theory. Respondents in the experiment are presented environmental effects, specifically reducing the risk of forest wildfires, instead of financial rewards. They are told that two other programs to further reduce the risk of forest fires are available in addition to the current fire protection management, but the success rate differs between the two options.

## 2.2 Mental accounting, mental budgeting, and decision on agricultural production

### *2.2.1 Mental accounting theory*

Mental accounting is the set of subjective cognitive operations for organization, evaluation, and keeping track of economic outcomes (Thaler, 1999). Mental budgeting is one of the components of mental accounting in addition to categorization, income labeling, and hedonic editing (Zhang and Sussman, 2018, Antonides and Ranyard, 2018, Thaler, 1999). Mental budgeting describes the separation and allocation of money across different expenditure purposes (Zhang and Sussman, 2018). The existence of mental budgeting aims at simplifying decision-making processes in two perspectives. First, the budgeting process can facilitate identifying rational trade-offs between competing uses of funds. Second, the system can act as a self-control device which is a way for tracking spending (Thaler, 1999).

Unlike the assumption of rational choice theory that money is fungible across all possible choice sets, reduced fungibility of money across categories of goods is the core implication of the mental accounting theory. Here it is assumed that money is more fungible within a specific mental budget than between different mental budgets. Empirical evidence has been shown for examples such as food consumption (Schady and Rosero, 2008); expenditures of windfall gains (Levav and McGraw, 2009); consumers' reaction to income and price presentation tactics (Homburg et al., 2010); and tax payments of self-employed business owners (Olsen et al., 2019). However, the existence and expression of mental budgeting could differ across individuals.

Categorization, furthermore, describes the behavior of classifying expenses depending on different kinds of demands (Heath and Soll, 1996, Zhang and Sussman, 2018), and can be overlapping for different categories (Heath and Soll, 1996). Categorization is one of the components of the theory of mental accounting and serves as a pre-condition for reduced fungibility of money. Inputs categorized into one category are more likely to be set in one budget, and then expenses of these inputs would be fungible.

Under the term income labeling, it is assumed that individuals label monetary incomes according to different budgets for categories that can hardly be substituted (Thaler, 1999, Krishnamurthy and Prokopec, 2009). Income labeling requires expenses to be categorized. Current literature shows that total expenditures of an individual consumer are commonly sorted into several budgetary categories, such as food, entertainment, and housing. In addition, income is labeled through its sources and, in the current research, can be divided into windfalls/allowances or non-windfalls/allowance for instance (Thaler, 1999, Krishnamurthy and Prokopec, 2009). Windfalls and allowances are more likely to be used for irregular expenses. Income labeling also includes current income and future income, with current income being much more likely to be spent than future income (Antonides et al., 2011).

With regard to hedonic editing, it explains how people evaluate gains and losses for a specific budget. Different combinations of gains and losses differ in the resulting value of the actor (Thaler, 1985). Thaler (1985) shows that gains are preferred to be given separately while integrated losses are more accessible for the same amount of gains and losses. For example, two lotteries worth $50 and $100 were more preferred by the interviewees than just one lottery worth $150. On the contrary, the majority of interviewees believed that two separate amounts of taxes owed of $50 and $100 would make people more upset than to just receive a letter asking for $150 (Thaler, 1985).

Thus, under the assumption that a farmer behaves according to mental accounting theory, money is less likely to be fungible among different budget categories. As monetary incentives in agriculture aim at increasing the income for changing production behavior, how farmers recognize, evaluate, and allocate those incomes largely determines the effect of incentives. The next part reviews the most influential studies to date regarding mental accounting, mental budgeting, and agricultural behavior. Besides, given that mental budgeting is a process for segregating and tracking assigned money, the following analysis mainly focuses on the effects of mental budgeting. However, categorization and income labeling are still premises for the analysis of mental budgeting.

### 2.2.2 *Mental accounting theory and decision on agricultural production*

Available studies to date based on neoclassical economic theories show a mixed effect of income on changing pest control practices. Most studies only try to identify the effect of total or agricultural income (Khan et al., 2015, Dasgupta et al., 2001), ignoring the specific benefit of pest control measures. There is no clear evidence showing that an increase in total or agricultural income encourages better pest control practices such as using low-toxicity pesticides. Some other studies also show empirically that income not related to agriculture, such as off-farm income, may increase pesticide expenditures (Ma et al., 2018).

The application of mental accounting theory for understanding agricultural production decision mechanisms is relatively sparse compared to analyses of consumers' behavior. Current studies on agricultural production decisions contain the adoption of technology and the payment of agricultural inputs (Freudenreich and Mußhoff, 2018, Zhang et al., 2016, Huang et al., 2020, Ocean and Howley, 2019).

More specifically, Freudenreich and Mußhoff (2018) identify the effect of different insurance and subsidy schemes on the adoption of technology among maize farmers. An experiment was set up for 277 farmers where one of four scenarios is presented, including either full insurance, partial insurance with 25% deductible, partial insurance for drought only, or weather index insurance. The full insurance is tested to have a higher effect on stimulating the adoption of a higher-yielding seed variety than other insurance schemes. The authors argue that this is because farmers may place the cost of the premium and the deductible in separate mental accounts.

In another study, Zhang et al. (2016) look at the extent to which Chinese farmers categorize agricultural water fees, based on survey data from 577 farmers in Sichuan, China. Farmers break down expenditures for agricultural water fees, the costs of seeds, pesticides, or fertilizers, and former agricultural taxes and fees (abolished in 2004) into the two categories: agricultural production costs and political charges. Results from descriptive statistics show that farmers categorize water fees most often as both, a cost of production and political charge, which are 90.99% and 95.32%, respectively. Given that the authors allow cross-typicality for these categories, farmers may regard water fees as a cost of production and a political charge at the same time. For the costs of seeds, pesticides, or fertilizers, farmers show intuitively expected response behavior. There are 88.04% of farmers who report the costs of seeds, pesticides, or fertilizers are not political charges.

Huang et al. (2020) use hypothetical scenarios of food reserve and consumption and find that farmers follow mental accounting in deciding how much to consume from their own-produced food. More specifically, 33.49% and 34.20% of farmers apply mental accounting for rice and potatoes, respectively, when facing surpluses of yields of these two products. In a situation of yield shortage of rice and potatoes, 45.75% and 48.81% of total investigated farmers follow mental accounting for rice and potatoes, respectively. Ocean and Howley (2019) conduct an experiment among UK farmers trying to understand the heterogeneous effects of different subsidy schemes on the expenses on environmental management. The results show that there is a difference in the allocation of incomes from different subsidies for environmental management practices when offered an environmental protection scheme or two other subsidy schemes. When offered two less restricted payment schemes, 26.73% and 26.96% of the sum money are allocated for environmental management, respectively, while 32.7% of the subsidy would be assigned for this purpose when offered an environmental protection scheme.

### 2.3 Price premium and subsidy as incentives for pest control

Based on the hypothesis that farmers would maximize their profit, Feder (1979) indicates that increasing the effectiveness of pesticide use can be achieved by obtaining information or by using improved chemical inputs. Improved technology covering genetically modified hybrids, biological control, and optimized application techniques for chemicals can be ways for improving risk control (Meissle et al., 2010). However, farmers may not voluntarily change their pesticides use strategies unless alternative instruments are readily available for adequate pest management (Lamers et al., 2013). Price premiums and subsidies are at the core of the increase in income. In order to improve pest control practices, two main actors are mainly considered as those establishing incentives: government and organizations that collaborate with farmers (Saba and

Messina, 2003, Jin and Zhou, 2011, Zhou et al., 2016, Williamson et al., 2008, Huang et al., 2003, Wilson and Tisdell, 2001, Skevas et al., 2012).

### *2.3.1 Price premium and pest control*

A price premium is offered as one of the main measures by several ways, such as contract farming, cooperatives, and certification schemes, to encourage farmers to use better pest control practices (Bijman, 2008, Thiers, 2005). Joining contract farming or cooperatives, as well as certification schemes, usually means farmers face a price premium and extra constraints because of the pesticide use requirements (Bijman, 2008, Thiers, 2005, Häring et al., 2001). Quality control and standards are often found in provisions, along with cultivation practices and price determination mechanisms (Bijman, 2008, Lamers et al., 2013).

A price premium is reflected through higher selling prices but with a diametrical impact on pesticide use. Whereas some studies show that a price premium decreases the amount of pesticide use or change the way of pest control (Yang et al., 2019, Bolwig et al., 2009), other authors provide evidence that a price premium for certified food could even increase the use of pesticides (Nie et al., 2018), especially considering the existence of information asymmetry in the market (Wilson and Tisdell, 2001). A price premium has no specific component for encouraging better use of pesticides, but a mixed increase in income of all efforts such as labor and other inputs. It is still unclear how this mixed-income might affect the willingness of joining such programs and enhance pesticide use behavior. Thus, if a clear announcement is made about any bonus income, the effect of a price premium on the willingness to use low-toxicity pesticides may increase. For instance, in an experiment for contract design, Saenger et al. (2013) find that an extra bonus following a baseline payment has the largest influence on farmers to produce higher quality milk in Vietnam.

### *2.3.2 Subsidy and pest control*

A subsidy scheme is another common incentive to encourage farmers to adopt designated pest control practices. The provision of a subsidy scheme conditional upon the adoption of pre-defined pesticides is a widely used way that directly encourages farmers to use different selected pesticides, often less toxic ones (Skevas et al., 2012). However, existing evidence shows that subsidies on low-toxicity pesticides do not have a reducing impact on the use of high-toxicity ones (Skevas et al., 2012). Even though a subsidy scheme can affect the use of pesticides, its influence may be different from a price premium. Grovermann et al. (2017) simulate the effects of different incentives to reduce pesticide use for Thai farmers. The results show that the costs of policies for the government differ between price premium and subsidy for reaching a similar impact. In order to achieve a 6.5% reduction of pesticide use, the policy cost of a price premium is 3900 baht per household under the premise of introducing integrated pest management. A subsidy scheme, however, corresponds to 3000 baht per household and a 6.6% reduction of pesticide use under the same condition.

China's government started a pilot subsidy scheme for low-toxicity pesticides in 2013 in several counties across ten provinces, including Hunan and Sichuan (MOA, 2013). The main purpose of the subsidy scheme is to, on the one hand, mobilize farmers to use more expensive low-toxicity pesticides by compensating for their costs. On the other hand, as the advantages of low-toxicity residues have been recognized, this subsidy can help to change traditional pesticide practices. The subsidy for low-toxicity pesticides can be regarded as an extra income to encourage better pesticide practices. In practice, this subsidy is allocated either to farmers after declaring the types and amount of pesticides, or to pesticide dealers for lower prices of low-toxicity pesticides within the pilot area. In view of mental accounting theory, this subsidy is specific to pesticide use if farmers engage in mental budgeting and regard pesticides as an independent category; thus, it may affect pesticide practices directly. Otherwise, the increased income from the subsidy would be regarded as homogenous and fungible to other kinds of income. Yet, it is still unclear whether and how far this subsidy could change farmer's willingness to use low-toxicity pesticides, especially from a comparative perspective with respect to other incentives.

## 2.4 Cooperatives and their role in farmers' pest management

### *2.4.1 The role of cooperatives in Sichuan, China*

Producer cooperatives play an important role in production in China and may have an impact in terms of, for example, farmers' welfare and technology adoption (Zhang et al., 2019, Ma and Abdulai, 2016). In the analysis at hand, some cooperatives with decentralized decision rights regarding pesticides would represent a kind of hybrid governance. In a cooperative, a set of standards, such as business plans and initial financing, is formulated before according to the decentralized decision process. The control right is allocated to some members according to the pre-established governance policies (Peterson et al., 2001). Cooperatives could be distinguished by their decision rules in China (Liang et al., 2015). “One member, one vote” and “proportional vote” are two voting patterns for cooperatives in China. In the “proportional vote” pattern, core members usually have more power to formulate policies, yet other farmers still have the right to execute transactions or instruments. Instruments such as training programs, controls of inputs, price premiums, quality requirements, mutual supervision, and tests are commonly used in cooperatives for ensuring the appropriate use of pesticides (Zhou et al., 2015, Kirezieva et al., 2016, Jin and Zhou, 2011).

By the end of 2017, there are 89,292 cooperatives registered officially in Sichuan Province where more than 6.9 million households are included. Producer cooperatives in Sichuan Province cover a wide range of agricultural sectors including grain, vegetables, fruits, and livestock. Farmers can receive services from the cooperatives. The services provided by the cooperatives are also diverse. Not only marketing and sales are covered, the services from cooperatives also include the procurement of externally sourced inputs for agricultural production, technical extension, labeling, processing, and logistics (Zhang et al., 2019).

### *2.4.2 Pest management in cooperatives*

Earlier evidence demonstrates that different governance structures as well as the existence and intensity of various instruments result in a different performance with respect to sustainable pesticide use. To date, training of farmers, direct supply of inputs, record keeping, certification, and testing of products are regarded as the main instruments for ensuring food safety. Such instruments are not only found in cooperatives, but also in other governance structures such as integrated agricultural companies and individual farmers (Zhou et al., 2015, Wang et al., 2017). Through an enhancement of pest control knowledge, incentives for better pest control, and offsetting of risk of pesticide misuse, farmers may better follow the regulations and adjust pesticide use in a way expected by public authorities or actors along the supply chain.

In a comparative study, Zhou et al. (2015) analyze the relationship between the amount of food safety control practices and governance structures. According to a survey of roughly 600 vegetable and fruit household farms, cooperatives, and companies in Zhejiang Province, Zhou et al. (2015) show that companies implement a higher degree of food safety control practice compared to cooperatives and household farms. In particular, the documentation of input use and production management measures is more consistently implemented by companies (Zhou et al., 2015). The authors argue that this is probably due to the heterogeneity of decision rights. In addition, given that members in cooperatives have different goals and farmers are involved in decision making, instruments might be less strict compared with companies. For example, evidence shows that cooperatives in Zhejiang Province adopt fewer food safety controls than companies and individual household farms as a result of collective and democratic decision-making mechanisms (Zhou et al., 2015). As shown by the survey data, 28.2% of the surveyed cooperatives do not apply product certification compared to 19.86% of the companies surveyed, and an overall average of 23.84%. Further, 57.7% of the cooperatives do not keep production records compared to an overall average of 49.67%. However, the difference in pesticide testing is less pronounced as 89.56% of the cooperatives implement it compared to an average of 90.5% of all observations. Family farms have the largest proportion of certification (90.79%), while companies have the largest proportion of recording (60.09%) and testing (92.20%) programs. Zhou et al. (2018) further show that farmer's way of applying chemical inputs mainly relies on their own experience or guidance from the government or cooperatives and the social capital of cooperatives such as trust and common goals.

More specifically, cooperatives might support their members to change their pesticide use behavior via better information. Instruments such as training programs could be offered and provided to members. Although other farmers might also receive training regarding pest control, a training program in cooperatives may differ in frequency and contents as pest controls are a mutual interest (Feola and Binder, 2010, Hruska and Corriols, 2002). Such training programs usually introduce suggested pest control measures and the corresponding application methods, the policies of pest controls are, as well, included in the program.

Input control is another instrument in the governance of cooperatives. The supply of inputs is a crucial link for food safety. In order to ensure the safe supplement of agricultural inputs, some cooperatives are involved in offering inputs, such as pesticides, to their members (Abebaw and Haile, 2013). A unique supply channel for inputs cannot only decrease the cost due to the enhanced bargaining power and scale effect, it can also help standardize agricultural production according to the same criterion. It is shown that unique input management is considered by cooperative managers in Zhejiang Province (Zhou et al., 2016).

Quality requirements such as certification programs are also commonly found in a cooperative as a control in order to meet market demands. Certification programs usually come along with a certain price premium. Offering higher producer prices is another incentive to stimulate a lower use or even no use of pesticides. However, the price of vegetables is not necessarily inversely proportional to the amount of pesticides. As shown in the example of Vietnam, the lower the price of vegetables, the less chemical input farmers prefer to use (Van Hoi et al., 2009). This is because many farmers believe that only chemical input can ensure a good appearance of vegetables (Van Hoi et al., 2009). Given a lower price, economic theory predicts that farmers would reduce their use of externally supplied inputs. Information asymmetry is another challenge for certification programs. For instance, based on data from Europe, Albersmeier et al. (2009) state that despite quality requirements for organic food, fraud is still found as a result of information asymmetries along the supply chain.

Quality test of agricultural products is also regarded as a crucial control for regulating the use of pesticides. Tests can be applied by either cooperatives or external agencies that aim at quality testing (Zhou et al., 2016). However, as the tests increase the cost, some cooperatives may not implement such a policy for food safety control.

From the perspective of empirical models for estimating the reasons for pesticide choices, descriptive statistics, factor analysis, Poisson regression model, and Probit model are commonly used (Adejumo et al., 2014, Wang et al., 2015, Zhou and Jin, 2009, Sharifzadeh et al., 2018). As some factors revealed in these studies, such as personal and household characteristics, may also affect farmers' choice of joining a cooperative, selection bias may occur and would have to be taken into account appropriately. In addition, given that limited studies are focusing on understanding the effect of governance structures and the direct and indirect effect of food safety instruments in different governance structures on the choices of pesticides, this study aims at filling this gap.

# 3 Theoretical concepts and methodology

## 3.1 Prospect theory, demand for pesticides, and the corresponding experimental design

### *3.1.1 Prospect theory and demand for pesticides*

On the basis of a value function by Kahneman and Tversky (1979), a farmer's optimal pesticide use could be affected by loss aversion, risk aversion, and weighted probability, which are different from classical expected utility. According to prospect theory, an input with uncertain outcomes is related to the editing and evaluation result in people's minds. Assume that $V_\pi(\cdot)$ is the process of evaluation. Then, the value of uncertain profit is $V_\pi(\pi) = V_\pi(\Delta\pi) = V_\pi(\pi_R - \pi_0)$, where $\pi_R$ is the actual profit and $\pi_0$ indicates the reference point in the farmer's mind. The resulting value will be considered for the decision to use pesticides. It is introduced as a two-part exponential form as follows (Tversky and Kahneman, 1992).

$$V_\pi(\pi) = \begin{cases} \Delta\overline{\pi}^{\sigma_\pi}, \Delta\pi \geq 0 \\ -\lambda_\pi(-\Delta\underline{\pi})^{\sigma_\pi}, \Delta\pi < 0 \end{cases}$$

where $\sigma_\pi$ is the curvature parameter of the value function and $\lambda_\pi$ is the loss aversion parameter. This study follows the assumption that the value function curves of gain and loss are of the same curvature. Normally, $\lambda_\pi$ is larger than 1, showing that the negative effect of a loss in the value is larger than the positive effect of a gain of an equal monetary amount. The curvature parameter $\sigma_\pi$ is smaller than 1, indicating that the slope of the value function $V_\pi(\pi)$ decreases gradually with increasing income, $|\Delta\pi|$. Thus, over the domain of gains, the value function would be strictly concave which implies risk-averse preference of the actor considered.

According to prospect theory, the subsequent prospect of profit, $\pi_{PT}$, contains gains and losses. Let $w(1-q)$ and $w(q)$ designate the weighted probability of gains and losses, the function of maximized profit is:

$$\pi_{PT} = Max\{[w(1-q)\Delta\overline{\pi}^{\sigma}] + [w(q)(-\lambda)(-\Delta\underline{\pi})^{\sigma}]\}, \text{subject to } \begin{cases} \pi = Max(pY - p_i X_i - p_p X_p^{PT}) \\ Y = Y(X_i, X_p, Z) \end{cases}$$

where $\pi$ is the profit related to yield $Y$, a series of inputs, $X_i$, and damage abatement by using pesticide, $\mathrm{X}_p$. More information about the production damage abatement function can be found in Lichtenberg and Zilberman (1986). The yield $Y$ is the outcome of a vector of inputs following Cobb-Douglas production function. $Z$ is a vector of variables indicating personal, household, and farming characteristics. The probability weighting function will be $w(q) = 1/\exp[-\ln(q)]^{\delta}$ where $\delta$ shows the shape of the probability weighting function (Prelec, 1998). A parameter $\delta > 1$ indicates that a farmer will underestimate a small probability and overestimate a large probability, while there is no distortion of the probability weighting function if $\delta = 1$. In addition, $\delta < 1$ indicates a farmer overestimate a small probability and underestimate a large probability. Consequently, the prospect of profit can be expressed as a reduced-form as:

$$\pi_{PT} = \pi_{PT}(\lambda_Y, \sigma_Y, \delta, q_Y, p, p_i, p_p, Z)$$

As long as $\partial Y^{PT}/\partial X_p > 0$, a farmer would keep increasing the amount of pesticide use. Assuming that the use of pesticides is independent of other inputs, the demand function for pesticides in a reduced form would be:

$$X_p = X_p(\lambda_Y, \sigma_Y, \delta, q_Y, p, p_p, Z)$$

In short, the demand function for pesticides shows that the amount of pesticide use is determined by risk preference parameters (risk aversion, loss aversion, and weighted probability predicted by the parameter of probability weighting and the probability of yield changes). As the use of pesticides is to abate hazards, the more risk-averse a farmer and the larger her/his loss aversion, the higher the perception of yield loss. More amount of pesticide use is expected to be applied by the respective farmer. Similarly, the higher a farmer weighs the probability of potential hazards, the higher the perceived potential yield loss. Thus, it is predicted that a higher weighted probability of a potential hazard is related to more pesticide use. Personal, household, farming characteristics, and prices of vegetables and pesticides are, as well, factors that could have an impact on the use of pesticides quantitatively.

Thus, an ordinary least square (OLS) measure is applied to estimate the coefficients following Liu and Huang (2013) and Hou et al. (2020). The specific equation is:

$$X_p = \beta_0 + \beta_{\sigma_Y}\sigma_Y + \beta_{\lambda_Y}\lambda_Y + \beta_{w(q_Y)}w(q_Y) + \beta_p p + \beta_{p_p} p_p + \beta_Z Z + \mu$$

where $X_p$ represents the intensity of pesticide use. In order to estimate such variable, two measures are applied which are, on the one hand, the average amount of pesticides, and the average cost of pesticides on the other hand. This is because the higher cost of pesticides is in line with the increased amount of pesticide use and could be a substitute for the amount of pesticides to a certain degree under the assumption that the average price of pesticides remains the same (Hou et al., 2020, Ma et al., 2018). Constant is represented by $\beta_0$, and $\mu$ is random error. Risk aversion, loss aversion, and weighted probability with regard to yield loss are indicated by $\sigma_Y$, $\lambda_Y$, and $w(q_Y)$, respectively. Represent selling price and average price of pesticides are represented by $p$ and $p_p$. The vector $Z$ represents personal, household, and farming characteristics including age, family size, the distance to the nearest fair, planted area, educational level, geographical characteristics, and hygienic habits after pesticide use (Huang et al., 2000, Obopile et al., 2008, Wu and Hou, 2012, Fan et al., 2015). $\beta_{\sigma_Y}$, $\beta_{\lambda_Y}$, $\beta_{w(q_Y)}$, $\beta_p$, $\beta_{p_p}$ and $\beta_Z$ are the corresponding coefficients to be estimated.

### *3.1.2 Experimental design of risk preferences*

In order to estimate risk preference parameters, this study heavily relies on a Holt-Laury-type lottery method introduced by Tanaka et al. (2010). The experiment is divided into three sets of choices. The first two parts aim at obtaining quantitative estimates of the degree of risk aversion and the parameter of probability weighting. The third part aims to calculate the degree of loss aversion. Table 3.1 presents the combinations of choices offered to respondents in the experiment.

Table 3.1: Series of experiments of risk preferences

| Option A | | | | Option B | | | |
|---|---|---|---|---|---|---|---|
| Series 1 | | | | | | | |
| Increased income ($x_{S1,A}$) | Probability | Increased income ($y_{S1,A}$) | Probability | Increased income ($x_{S1,B}$) | Probability | Increased income ($y_{S1,B}$) | Probability |
| 80 | 30% | 20 | 70% | 136 | 10% | 10 | 90% |
| 80 | 30% | 20 | 70% | 150 | 10% | 10 | 90% |
| 80 | 30% | 20 | 70% | 166 | 10% | 10 | 90% |
| 80 | 30% | 20 | 70% | 186 | 10% | 10 | 90% |
| 80 | 30% | 20 | 70% | 212 | 10% | 10 | 90% |
| 80 | 30% | 20 | 70% | 250 | 10% | 10 | 90% |
| 80 | 30% | 20 | 70% | 300 | 10% | 10 | 90% |
| 80 | 30% | 20 | 70% | 370 | 10% | 10 | 90% |
| 80 | 30% | 20 | 70% | 440 | 10% | 10 | 90% |
| 80 | 30% | 20 | 70% | 600 | 10% | 10 | 90% |
| 80 | 30% | 20 | 70% | 800 | 10% | 10 | 90% |
| 80 | 30% | 20 | 70% | 1200 | 10% | 10 | 90% |
| 80 | 30% | 20 | 70% | 2000 | 10% | 10 | 90% |
| 80 | 30% | 20 | 70% | 3400 | 10% | 10 | 90% |
| Series 2 | | | | | | | |
| Increased income ($x_{S2,A}$) | Probability | Increased income ($y_{S1,A}$) | Probability | Increased income ($x_{S2,B}$) | Probability | Increased income ($y_{S2,B}$) | Probability |
| 80 | 90% | 60 | 10% | 108 | 70% | 10 | 30% |
| 80 | 90% | 60 | 10% | 112 | 70% | 10 | 30% |
| 80 | 90% | 60 | 10% | 116 | 70% | 10 | 30% |
| 80 | 90% | 60 | 10% | 120 | 70% | 10 | 30% |
| 80 | 90% | 60 | 10% | 124 | 70% | 10 | 30% |
| 80 | 90% | 60 | 10% | 130 | 70% | 10 | 30% |
| 80 | 90% | 60 | 10% | 136 | 70% | 10 | 30% |
| 80 | 90% | 60 | 10% | 144 | 70% | 10 | 30% |
| 80 | 90% | 60 | 10% | 154 | 70% | 10 | 30% |
| 80 | 90% | 60 | 10% | 166 | 70% | 10 | 30% |
| 80 | 90% | 60 | 10% | 180 | 70% | 10 | 30% |
| 80 | 90% | 60 | 10% | 200 | 70% | 10 | 30% |
| 80 | 90% | 60 | 10% | 220 | 70% | 10 | 30% |
| 80 | 90% | 60 | 10% | 260 | 70% | 10 | 30% |
| Series 3 | | | | | | | |
| Income change ($x_{S3,A}$) | Probability | Income change ($y_{S3,A}$) | Probability | Income change ($x_{S3,B}$) | Probability | Income change ($y_{S3,B}$) | Probability |
| 50 | 50% | -8 | 50% | 60 | 50% | -42 | 50% |
| 8 | 50% | -8 | 50% | 60 | 50% | -42 | 50% |
| 2 | 50% | -8 | 50% | 60 | 50% | -42 | 50% |
| 2 | 50% | -8 | 50% | 60 | 50% | -32 | 50% |
| 2 | 50% | -16 | 50% | 60 | 50% | -32 | 50% |
| 2 | 50% | -16 | 50% | 60 | 50% | -28 | 50% |
| 2 | 50% | -16 | 50% | 60 | 50% | -22 | 50% |

*Note: Income is measured in Chinese yuan, RMB.*

The switching values of different income increments and related probabilities in series 1 and 2 are determining in calculating the risk aversion ($\sigma$) and the parameter of probability weighting ($\delta$) in detail. The later the switching point for both series 1 and 2, the higher the degree of risk aversion. If a farmer switches, for example, at the 1st question in series 1 and the 7th question in series 2, it implies that this farmer reveals risk-neutral behavior. With regard to the parameter of probability weighting, a later switching point in series 1 is related to a higher value of the probability weighting parameter. In contrast, the later the switching point in series 2, the lower the value of the probability weighting parameter. There would be no bias of the weighted probability if, for example, a farmer switches at the 7th question in series 1 and the 1st question in series 2. The complete correspondences are shown in Table A. 1 and Table A. 2 in the Appendix. The values of both risk preference parameters should satisfy the following condition (Bartczak et al., 2015, Tanaka et al., 2010):

$$(\sigma,\delta) \in \begin{cases} {y_{S1,A,N-1}}^{\sigma} + \exp\left[-(-ln0.3)^{\delta}\right]\left({x_{S1,A,N-1}}^{\sigma} - {y_{S1,A,N-1}}^{\sigma}\right) < \\ {y_{S1,B,N-1}}^{\sigma} + \exp\left[-(-ln0.1)^{\delta}\right]\left({x_{S1,B,N-1}}^{\sigma} - {y_{S1,B,N-1}}^{\sigma}\right); \\ {y_{S1,A,N}}^{\sigma} + \exp\left[-(-ln0.3)^{\delta}\right]\left({x_{S1,A,N}}^{\sigma} - {y_{S1,A,N}}^{\sigma}\right) > \\ {y_{S1,B,N}}^{\sigma} + \exp\left[-(-ln0.1)^{\delta}\right]\left({x_{S1,B,N}}^{\sigma} - {y_{S1,B,N}}^{\sigma}\right); \\ {y_{S2,A,N-1}}^{\sigma} + \exp\left[-(-ln0.9)^{\delta}\right]\left({x_{S2,A,N-1}}^{\sigma} - {y_{S2,A,N-1}}^{\sigma}\right) < \\ {y_{S2,B,N-1}}^{\sigma} + \exp\left[-(-ln0.7)^{\delta}\right]\left({x_{S2,B,N-1}}^{\sigma} - {y_{S2,B,N-1}}^{\sigma}\right); \\ {y_{S2,A,N}}^{\sigma} + \exp\left[-(-ln0.9)^{\delta}\right]\left({x_{S2,A,N}}^{\sigma} - {y_{S2,A,N}}^{\sigma}\right) > \\ {y_{S2,B,N}}^{\sigma} + \exp\left[-(-ln0.7)^{\delta}\right]\left({x_{S2,B,N}}^{\sigma} - {y_{S2,B,N}}^{\sigma}\right). \end{cases}$$

where $x$ and $y$ are outcomes. *S1* and *S2* mean the outcomes in series 1 and 2, respectively. A and B indicate outcomes in options A and B respectively. *N-1* and *N* are rows of series 1 and 2. Following Tanaka et al. (2010)'s paper, the midpoints of the scope with regard to $\sigma$ and $\delta$ are applied.

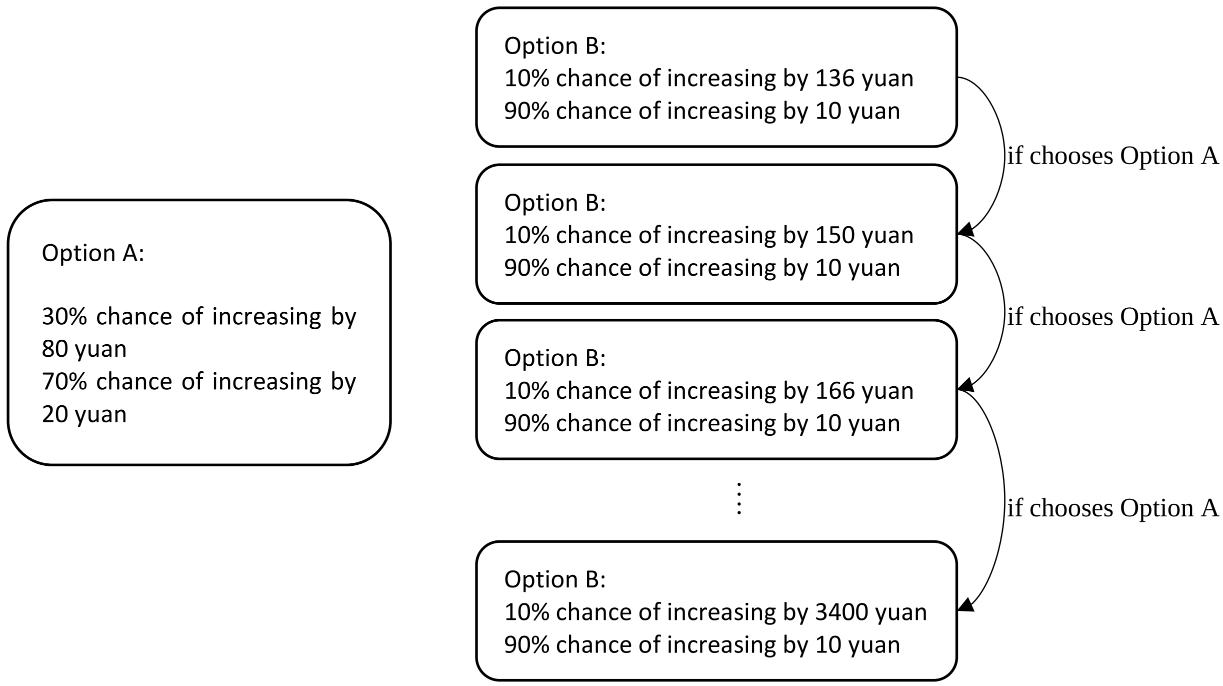
The scope of the parameter of loss aversion can be calculated through a farmer's choice in series 3 and the given risk aversion $\sigma$. For the same degree of risk aversion, the degree of loss aversion increases as a farmer would switch at a later question in this series. Given that the probabilities of each income change in series 3 are the same, weighted probability can be omitted in this case. Thus, the scope of the parameter of loss aversion ($\lambda$) should satisfy the following equation:

$$\lambda \in \begin{cases} x_{S3,A,N-1}{}^{\sigma} + (-\lambda_L) * y_{S3,A,N-1}{}^{\sigma} < x_{S3,B,N-1}{}^{\sigma} + (-\lambda_L) * y_{S3,B,N-1}{}^{\sigma}; \\ x_{S3,A,N}{}^{\sigma} + (-\lambda_H) * y_{S3,A,N}{}^{\sigma} > x_{S3,B,N}{}^{\sigma} + (-\lambda_H) * y_{S3,B,N}{}^{\sigma}. \end{cases}$$

Similarly, *S3* refers to the outcomes in series 3. A and B indicate outcomes in options A and B, respectively. N-1 and N are rows of series 3. $\lambda_L$ and $\lambda_H$ are the low boundary and high boundary of the parameter of loss aversion. In case a farmer continues choosing Option A in Series 3, a low boundary could only be identified as the scope of the parameter of loss aversion is from the low boundary to infinity. Otherwise, the midpoints between $\lambda_L$ and $\lambda_H$ are used following Tanaka et al. (2010)'s paper.

To avoid the influence of other farmers on decision-making in the survey, the whole experiment was conducted in a one-to-one interview at the end of the farm survey questionnaire. To anchor an endowment of vegetable yield in the farmer's mind, farmers were first asked to recall their vegetable yields in recent years and imagine that the income in the experiment comes from selling vegetables. Farmers were told that two other pesticides to further change the risk of pest hazard are available in addition to the current commonly used ones, but the success rate differs between the two options. Thus, the increased income is related to vegetable yields, and the income change should come from changed yields caused by pesticides. At the beginning of the experiment, farmers were also told the choices of the experiment would determine the types of post-experiment presents they would get after finishing the survey. The three series were presented to farmers in turn. For each experiment, two small cards were presented to farmers where option A and option B are written, respectively. Farmers were asked to choose one option. The experiment began with the first row of options for each series. For all series, if the farmers continue choosing option A, the increased income of option A and option B on the cards would be changed to the next question, and the farmers are asked to choose again. If a farmer switches from option A to option B, the experiment moves to the next series. An example of the choice experiment of series 1 is shown in Figure 3.1.

Figure 3.1: Example of cards of series 1 shown to each farmer




Then, an opaque box with ten small Ping-Pong balls inside was presented to farmers for simulating the results of the experiments. The balls were written with numbers from 1 to 10 for indicating the probability (for instance, in series 1, a farmer who chooses option A and picks a ball numbered 1 to 3, i.e. 30%, would get a gain of $x_{S1,A}$ while a number of 4 to 10, i.e. 70%, is related to a gain of $y_{S1,A}$). Farmers were asked to pick the ball three times, once for each series. All participants got presents of different values according to their options in the experiments and the simulating the results. More specifically, in order to avoid that a farmer may ignore a small amount of monetary incentives, the experiment switched to use goods instead of money and prepared four different types of presents, namely soap, towel, gloves, and toothbrush, which value 5, 3, 2, and 1 points, respectively. Farmers received five points for exchanging presents after the interview before the experiment, they would, however, received more points or fewer points according to their answers in the experiments. Each income change of RMB 10 yuan in the experiment equals one point.

In order to illustrate the procedure, let's assume that a farmer switches at the 4$^{th}$ and 3$^{rd}$ choices of series 1 and 3, respectively, but do not switch for series 2. The farmer, then, picks a ball numbered 1, 10, and 6 for series 1 to 3, respectively. This farmer would get 22.4 points (18.6, 8, and -4.2 for series 1 to 3, respectively). Thus, the total sum of points for this farmer would be 27.4 which can be used to exchange, for instance, for five soaps and one pair of gloves.

## 3.2 Mental budgeting and the corresponding measurements

### *3.2.1 The concept of mental budgeting and its role in incentivizing actors*

Before understanding whether a farmer engages in mental budgeting, it is necessary to classify the expenses of agricultural inputs as categorization is the main component of mental accounting theory. Thus, the first step is to identify the categories of these expenses. This study follows a method introduced by Heath and Soll (1996), where typicality identification is used for understanding categorization. Three categories of agricultural inputs are considered here, which are seeds, fertilizer, and pest control measures. These categories have been used by many existing studies (Shankar et al., 2019, Huan et al., 2005). These three agricultural inputs are set because they form the main variable costs for agricultural production. Other costs such as infrastructure costs are assumed to be fixed within one season. In following the principles of categorization (Henderson and Peterson, 1992), it is assumed that seeds, fertilizers, and pest control measures represent easily distinguishable goods[3] that may be categorized with minimal thought and effort due to prior experience. If farmers categorize a specific agricultural input into a certain category, the respective expenses for this category will be subsumed, otherwise, the corresponding expenses for such inputs would be fungible.

More specifically, this study provides farmers with ten specific agricultural inputs and assigns them by breaking them down into three categories. The ten inputs include vegetable seeds, vegetable seedlings, potash fertilizer, nitrogenous fertilizer, phosphate fertilizer, organic fertilizer, insect-proof lamps/nets, high-toxicity pesticides, low-toxicity pesticides, and sexual attractants. Respondents are asked to assign values to each input item for each category, which indicates which inputs belong to which category. Similar to

[3] Cross typicality exists in some inputs. For example, BT cotton may have both typicality of seeds and pest control measures. The majority of inputs, however, are still with just one typicality.

Heath and Soll (1996)'s research, this study uses a Likert Scale Points for testing typicality. This study applied a five-point scale, from 1 (very typical) to 5 (very untypical); when farmers felt the item did not belong to a category, they had an option of filling in an 'X', which reflected null for the typical rating. All investigated farmers were asked to answer the typicality for all selected agricultural inputs in the questionnaire.

The setting of mental budgets and expenses of agricultural inputs highly depend on the results of categorization. Money is more fungible within a specific mental budget than between different mental budgets. Thus, as a precondition for mental budgeting, farmers need to assign inputs to different categories in a consistent way. For instance, vegetable seeds and seedlings should typically fall under the seeds category. Fertilizer includes potash fertilizer, nitrogenous fertilizer, phosphate fertilizer, and organic fertilizer. Insect-proof lamps/nest, high-toxicity pesticides, low-toxicity pesticides, and sexual attractants are a part of pest control measures. The expenses, for example, of insect-proof lamps/nets, high-toxicity pesticides, low-toxicity pesticides, and sexual attractants are an expense for pest control measures if farmers believe these items are typical in the category of pest control measures. Otherwise, if these items show partial typicality or non-typicality as pest control measures, they cannot be treated as falling under the category of pest control measures.

### *3.2.2 Mental budget scale*

In order to accept a mental budgeting behavior by a farmer, the respondent should have a budget plan for the expenses within the categories above, and overspending within a category should be hard to accept. In addition, if farmers spend more money on a specific input, the expenses for other inputs in the same category should decrease but affecting inputs in other categories only minimal or not at all (see empirical evidence of the strictness of separation for consumption from Heath and Soll (1996)). Otherwise, if farmers do not engage in mental budgeting, it is less likely for them to show a budget plan for each category and money should be fungible between the different agricultural inputs. Whether people engage in mental budgeting is determined by the expenses within and across different budgets. Structural questions and purchase behaviors are commonly used for understanding the threshold of mental budgeting (Antonides et al., 2011, Homburg et al., 2010, Hoque, 2017, Habibah et al., 2018, Heath, 1995, Huang et al., 2000, Hirshman et al., 2018, Oh et al., 2016, Yang, 2020). Structural questions are set according to the properties of mental budgeting, and the threshold of mental budgeting results from the answers to such questions. Real and experimental purchase behaviors can also identify the threshold of mental budgeting through whether expenses are more fungible within a specific mental budget than between different mental budgets.

However, previous studies have shown that people will categorize incomes into different mental budgets that can be hardly substitutable (Thaler, 1999), and that money originally allocated in a certain category is more likely to be used within the same category when prices of products or budgets of categories change (Henderson and Peterson, 1992, Antonides et al., 2011). Here, it is assumed that a farmer applying mental budgeting sets a budget for pest control measures including all expenses for pest control measures. Subsequently, any monetary incentive directly linked to pest control practices would result in a change of expenses from this budget but not of other accounts while a non-specific monetary incentive is expected to affect all budgets.

In this thesis, in order to figure out whether farmers engage in mental budgeting for seeds, fertilizer, and pest control measures, a mental budgeting scale was conducted following Antonides et al. (2011) and Homburg et al. (2010). Such a scale bases on the aggregation of farmer's responses to a set of four Likert Scale questions ranging from following budget plans for comparison of expenses across categories. The first question figures out whether farmers have a total budget for agricultural inputs. The second question strives to understand whether budgets are fixed or not. The third question tries to understand whether money is fungible within one budget. The fourth question is to understand whether money is fungible between the budgets of agricultural inputs and other budgets. These four aspects form the core properties in order to accept the existence of mental budgeting for a certain farmer. In comparison to the research by Antonides et al. (2011) and Homburg et al. (2010) which just focuses on financial and consumers' expenditure behavior, this study firstly carried out an analysis of the mental budgeting scale of agricultural inputs to provide more evidence for different categories. The specific questions are as follows:

*Please indicate the extent to which you agree or disagree with the following statements.*

*(answers: 1=totally agree to 5=totally disagree)*

*1. I set up a budget plan or reserve money for different agricultural expenses, such as seeds, fertilizer, pest control measures, etc.*

*2. I never spend more than a fixed amount on seeds, fertilizer, pest control measures, etc.*

*3. If I spend more on one agricultural input, I spend less on other inputs in the same category.*

*4. If I spend more on either seeds, fertilizer, pest control measures, etc., the expenses in other categories remain as before.*

The mental budgeting scale consists of the factor score of farmer's response to the four statements wand ranges from 1 (totally agree) to 5 (totally disagree). Hence, a lower score implies that a farmer is more likely to apply mental budgeting.

### *3.2.3 Farmers' intentions towards pest control measures*

Finally, in order to understand the effect of mental budgeting on farmers' intentions towards the use of low-toxicity pesticides, this study considered incomes from two different sources: agricultural revenue with price premiums for quality and subsidies for low-toxicity pesticides. For each income source with an equal monetary equivalent, each farmer has been asked to reveal his/her willingness to adopt less toxic pesticides on a Likert Scale ranging from 1 (totally disagree) to 5 (totally agree):

> *1: If you were to receive an additional* ***agricultural revenue with a price premium for quality*** *by ￥200*[4]*, please indicate the extent to which you would agree with the statement that I prefer to switch to low-toxicity pesticides.*
>
> *2: If you were to receive a* ***subsidy for low-toxicity pesticides*** *by ￥200, please indicate the extent to which you agree with the statement that I prefer to switch to low-toxicity pesticides. (Answers: 1=totally agree to 5=totally disagree)*

Before asking the willingness, farmers were explained that low-toxicity pesticides are those more environmentally-friendly pesticides and generally more expensive than normal ones. These pesticides are subsidized in some pilot areas. Several examples, such as Pyrethrin, Dimethomorph, and Plutella xylostella granulosa virus, etc., from the "List of main varieties of low-toxic and low-residue pesticides used in crop production, 2016" issued by the Ministry of Agriculture and Rural Affairs were also shown to farmers in order to illustrate the concept of low-toxicity pesticides.

#### *3.2.4 Mental budgeting and the intentions towards pest control measures*

In order to test the effect of mental budgeting on the use of low-toxicity pesticides conditional upon different income sources, it is necessary to compare the effect of different incentives between farmers who engage in mental budgeting and those who do not engage in mental budgeting. If farmers engage in mental budgeting for pest control measures, the change in the corresponding budget should influence the corresponding pest control inputs and expenses. As a result, an increase in such a budget would offset the

[4] According to the National Bureau of Statistics, per capita disposable income of farmers in 2018 was 14,617 yuan. 200 yuan is close to an average weekly income. This study uses weekly rather than daily income because the effect of daily income would be too small to affect planned decision making. Another reason for setting 200 yuan as the amount of incentives is that before having more detailed knowledge of the local situation, the weekly income per capita appeared to be the most reliable information. Furthermore, based on the neoclassical assumption of fungibility of money, this study opted for an incentive which will be unaffected by the existence of mental budgeting behavior. From the collected data, the average cost of pesticides for vegetable farmers in Sichuan Province is 205.882 yuan/mu with a standard deviation of 226.880. The costs are similar between farms of less than 10 mu (206.354 yuan/mu with a standard deviation of 218.561) and those strictly larger than 10 mu (204.605 yuan/mu with a standard deviation of 249.111). Thus, the incentive is rather close to the pesticide costs in vegetable production in the sample.

negative effect of risks from potential yield losses due to changing to use low-toxicity pesticides. In this way, farmers would be more willing to change their behavior in accordance with the increased income from incentives.

In this research, two incentives from different income sources are considered, agricultural revenue with price premiums for higher quality and subsidies for low-toxicity pesticides. A specific subsidy is assumed to be part of a specific mental budget for using low-toxicity pesticides while a quality price premium does not have an obvious announcement on using low-toxicity pesticides but for all agricultural efforts. Given that costs of pest control practices are part of cultivation efforts and would be covered by agricultural revenue, any increase in revenue could be also used for labor and other agricultural inputs. Against this background, it is assumed that a farmer's stated willingness to switch to low-toxicity pesticides facing two different incentives differs conditional upon their engagement in mental budgeting.

More specifically, during the survey, the questions regarding typicality, mental budgeting scale, and farmer's intentions towards pest control measures were asked after obtaining personal, household, and farming information. Farmers were asked to show the typicality of selected agricultural inputs firstly. Four structural questions about mental budgeting scale were, then, presented followed by the intentions towards pest control measures. The detail of each step complies with the descriptions in the subsections previously.

### *3.2.5 Econometric method for estimating the effect of mental budgeting*

In this study, the outcome is a binary choice where the value "1" and "0" represent the farmers with positive intentions towards using low-toxicity pesticides and others. The Probit model is widely used for studying questions where dependent variables are binomial distributions. A binary Probit model is, consequently, suitably chosen rather than traditional linear models such as OLS in this case. Thus, in order to test the effect of mental budgeting on the intentions towards pest control measures, a binary Probit model is applied to estimate the probability of willingness to switch to low-toxicity pesticides as follows:

$$Pr(willingness = 1|X) = \Phi(\beta X) = \Phi(\beta_0 + \beta_1 M + \beta_2 Z)$$

where $\Phi(.)$ Is the standard normal cumulative distribution function, $X$ is a vector of variables including mental budgeting ($M$), and personal and household characteristics (Z). $\beta_1$ and $\beta_2$ are coefficients for $M$ and $Z$, respectively.

### 3.3 Cooperative governance and the choice of pesticides

In order to study the effect of cooperative on the choice of pesticides, it is assumed that a farmer's choices follow random utility theory where the unobservable utility is determined by a set of observable factors (Adesina and Zinnah, 1993, McFadden, 1973) such as personal, household, and farming characteristics. As the personal, household, and farming characteristics may also have an impact on farmer's decision to join a cooperative, the existence of an endogenous relation is likely. Thus, in order to eliminate this potential selection bias, this study relies on the average treatment effect on the treated (ATT) to test for differences between members and non-members of cooperatives. The empirical strategy closely follows the one suggested by Abebaw and Haile (2013).

Assuming that farmer's utility, $U$, from joining a cooperative is related to observable characteristics as follows:

$$U = U(Z_i) + \varepsilon_i$$

Where the vector $Z_i$ includes personal, household, and farming characteristics. $\varepsilon_i$ is the error term. Personal characteristics in this research include age and educational level, while household characteristics include a dummy whether household members have an off-farm job(s), the number of household members, and the distance from home to the nearest fair. Farming characteristics contain the average cost of pesticides, selling prices of products, and size of the planted area for vegetables. All of these characteristics may have an impact on the allocation of household capital and labor resources for agricultural production (Ma et al., 2018, Euler et al., 2016).

Assuming that $C_i$ represents the choice of joining a cooperative. A farmer is expected to opt for joining a cooperative when the utility $U_c$ is larger than the random utility of not joining a cooperative, $U_{nc}$. As the utility is unobservable, this study shifts to focus on the choice of being cooperative members by a latent variable as follows:

$$\begin{cases} C_i = 1 \; if \; U_c > U_{nc} \\ C_i = 0 \; if \; U_c \leq U_{nc} \end{cases}$$

The probability of joining a cooperative can be expressed as:

$$Pr(C_i = 1|Z_i) = Pr(U_c > U_{nc})$$

In this case, ATT is, on the one hand, the average impact of joining a cooperative on the use of restricted pesticides, which can be estimated as follows[5]:

$$ATT = E(D_b(1) - D_b(0)|C_i = 1) = E(D_b(1)|C_i = 1) - E(D_b(0)|C_i = 1)$$

where $D_b(1)$ and $D_b(0)$ are dummy outcomes represent whether farmers use restricted pesticides. $E$ represents the conditional expected value.

Explaining the use of recommended pesticides is quite similar. The average impact of joining a cooperative on the use of recommended pesticides can be estimated as follows:

$$ATT = E(D_r(1) - D_r(0)|C_i = 1) = E(D_r(1)|C_i = 1) - E(D_r(0)|C_i = 1)$$

where $D_r(1)$ and $D_r(0)$ are dummy outcomes representing whether a farmer uses any of the recommended pesticides.

### 3.4 Pesticide choices and food safety instruments inside and outside cooperatives

Given that there are a large number of food safety related instruments influencing the use of pesticides and it will be hard to study them comprehensively, this thesis focuses on a subset of commonly used ones that are widely applied in the survey region and compare whether and how far the effect of such instruments on

[5] There might be sanctions that could have an impact on the choice of pesticides. However, sanctions may happen in secondary markets where sellers are not vegetable farmers. As current traceability systems cannot trace every batch of vegetables, vegetable farmers who use restricted pesticides may not be discovered. Thus, this study focuses on other more influential instruments in this research.

the use of restricted pesticides and recommended pesticides differ between cooperative and other governance structures. In the thesis, commonly mentioned food safety instruments, training of farmers, direct supply of inputs, record keeping, certification, and testing of products, are studied. In addition to the effect of cooperatives, a multi-level model is used, by following Wooldridge (2016), to examine the association between the choice of pesticides and food safety related instruments in cooperatives where cooperative is regarded as the group level. Group level is supposed to be related to specific instruments that could have an impact on farmer's decision of using restricted pesticides or recommended pesticides. Let farmer's choice of one of the two types of pesticides be the dependent variable, level 1 will be estimated:

$$C_i = \begin{cases} C_b = \beta_{0j} + \beta_{1j}X_{ij} + \beta_{ij}Z_{ij} + e_{ij} \\ C_r = \beta_{0j} + \beta_{1j}X_{ij} + \beta_{ij}Z_{ij} + e_{ij} \end{cases}$$

where $C_i$ includes the choice of restricted pesticides, $C_b$, and the choice of recommended pesticides, $C_r$. $\beta_{0j}$ is the intercept, $\beta_{1j}$ and $\beta_{ij}$ are the coefficients of instruments, $X_{ij}$, and personal, household, and farming characteristics, $Z_{ij}$, respectively. $e_{ij}$ reflects a random error. Given that the intensity of instruments, such as the amount and the frequency of implementation of food safety instruments, differs among different governance structures, $\beta_{0j}$ and $\beta_{1j}$, then, are affected by the governance structure. Assuming $W_{1j}$ is cooperative governance, the equations of level 2 are:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}W_{1j} + \mu_{0j}$$

$$\beta_{1j} = \gamma_{10} + \gamma_{11}W_{1j} + \mu_{1j}$$

where $\gamma_{00}$ is the intercept which also means the likelihood to use the respective type of pesticide of all farmers. $\gamma_{01}$ is the coefficient of $W_{1j}$ and the effect of cooperative on the likelihood to use the respective type of pesticide of members who do not receive any instrument. $\gamma_{10}$ is the intercept of $\beta_{1j}$ reflecting the effect of instruments on the choice of restricted and recommended pesticides for non-cooperative-members. $\gamma_{11}$ is the coefficient of $W_{1j}$ with regard to $\beta_{1j}$ and reflects the extra effect of instruments on the choice of pesticides for cooperative members. $\mu_{0j}$ and $\mu_{1j}$ are random errors. Thus, the integral equation can be written as:

$$C_i = U_{pe}\left(W_{1j}, X_{ij}, W_{1j}X_{ij}, Z_{ij}\right) = \gamma_{00} + \gamma_{01}W_{1j} + \gamma_{10}X_{ij} + \gamma_{11}W_{1j}X_{ij} + \beta_{ij}Z_{ij} + \left(\mu_{0j} + \mu_{1j}X_{ij} + e_{ij}\right)$$

Accordingly, whether farmers use restricted pesticides, $C_b$, and whether farmers use recommended pesticides, $C_r$, are studied by using the above equation in the following study. The effects of selected independent variables on both choice options are estimated in a Logit regression.

# 4 Data collection and description

## 4.1 Sample area and sample size

The survey was conducted by the author with support from Leibniz Institute of Agricultural Development in Transition Economies (IAMO) in October and November of 2018, in association with Sichuan Agricultural University. Samples were selected through stratified sampling. A total of 17 districts or counties in 10 cities and prefectures in Sichuan Provence were selected. In each district or county, three townships were selected. University students were chosen as assistants. They were trained before the survey and were allocated into six groups. Each group had a leader and was in charge of two to four districts or counties depending on distances between villages. In particular, this study focused on those households who plant vegetables commercially instead of 'backyard' farmers, who grow vegetables primarily for non-commercial consumption. Approximately 20–30 vegetable farmers were interviewed in each district or county. Farmers in each district and county were randomly chosen. The head of the household or a family member who supervises the household's farming activities were interviewed individually. In sum, 393 valid questionnaires were collected.

The questionnaire consists of different sections covering personal and household characteristics such as age, sex, educational level, and income, etc.. The section farming characteristics aims at collecting information on farm size, the area planted with vegetables, use of production inputs. This study has also gotten information about vegetable production in detail including types of pesticides, amount of pesticides, yield, size of planted area[6], prices of inputs, selling prices, and marketing channels, etc.. In addition, this study has investigated the organizational characteristics and food safety related information during the survey.

[6] Size of planted area indicates the farmland that is used to grow vegetables over the whole year. Due to multiple harvests of different vegetables in one year, the planted area could be larger than farm size. In addition, some farmers do not just cultivate vegetables, but also other crops.

More specifically, in order to collect information on the choices of pesticides, including insecticides, fungicides, and herbicides, farmers were asked to show the package of pesticides they use for vegetable production. Due to the consistent choices of pesticides to some extent, some farmers still keep the same pesticides they used. For those farmers who do not keep the package, the names of pesticides were investigated. However, there were still a small number of farmers who neither keep the package nor remember the pesticide name. For these farmers, pictures of commonly used pesticides from their counterparts around were shown and picked as farmers within a certain range of area are likely to buy the same pesticides in the same place.

Each interview ended with questions to test categorization and the flexibility of spending behavior followed by measurement of elicit variables which are necessary to quantify risk preference parameters. The details of those questions are presented in the following.

### 4.2 Personal, household, farming, and regional characteristics

Table 4.1 summarises the personal characteristics of samples in this thesis. The average age of the samples is 52.85 years old. 68% of the investigated farmers are male. The mean of the degree of the educational level is 2.62, which means the average level of education is beyond primary school. It is worth noting that only 15 farmers (3.8%) hold a degree of bachelor or above, while 46 farmers (11.7%) do not have experience with any formal education.

Table 4.1: Summary statistics of the personal characteristics

| ***Personal characteristics*** | Mean | SD |
|---|---|---|
| Age (years) | 52.85 | 10.51 |
| Gender (“1” for male) | 0.68 | 0.47 |
| Educational level (‘1’ = no formal education, ‘2’ = primary school, ‘3’ = secondary school, ‘4’ = high school or technical secondary school, ‘5’ = undergraduate or junior college, ‘6’ = graduate school) | 2.62 | 0.96 |
| Number of observations | | 393 |

*Source: Own calculation using IAMO-SAU vegetable farmer survey.*

Table 4.2 summarises the household characteristics of samples in this thesis. The average family size of the samples is 4.318 with an average of 2.794 labors. At least one member in about 56.5% of the households included in the samples had an off-farm job. The total income per year of the samples is 85505.12 yuan, including an average agricultural income of 58441.86 yuan and an average off-farm income of 23877.25 yuan.

Table 4.2: Summary statistics of the household characteristics

| ***Household characteristics*** | Mean | SD |
|---|---|---|
| Family size (number of family members) | 4.318 | 1.691 |
| Labors (number of labors) | 2.794 | 1.091 |
| Distance to the nearest fair (km) | 4.414 | 4.976 |
| Off-farm job (“1” for yes) | 0.56 | 0.50 |
| Total income (yuan) | 85505.12 | 132104.8 |
| Agricultural income (yuan) | 58441.86 | 122586.4 |
| Off-farm income (yuan) | 23877.25 | 43444.44 |
| Number of observations | | 393 |

*Source: Own calculation using IAMO-SAU vegetable farmer survey.*

Table 4.3 summarises the farming characteristics of samples in this thesis. Each responder holds, on average, 36.09 mu[7] farmland, and the median farm size is five mu, including rented farmland. More specifically, 52 responders hold farmland between 50 to 1200 mu, which accounts for 13.2% of total samples. Not all of the surveyed farmers' farmland is planted with vegetables, but vegetable production represents a major part of the households' cultivation. 29.3% of the total samples are cooperative members. In the survey, the average price of pesticides is 13.841 yuan per type, while the average selling price for vegetables is 2.301 yuan per kilogram. The average amount of pesticide use is 603.78 grams per mu, according to an average cost of 205.882 yuan. The average cost of vegetable farming is 1388.751 yuan per mu, including costs on seeds, fertilizers, pest control, mulch film, agri-machinery, and labor hiring. The average cost of pesticides accounts for 14.82% of the total cost.

[7] Mu is a typical area unit in China. 15 mu equals 1 hectare.

Table 4.3: Summary statistics of the farming characteristics

| ***Farming characteristics*** | Mean | SD |
|---|---|---|
| Farm size (mu) | 36.09 | 105.9 |
| Planted area for vegetables (mu) [8] | 33.66 | 95.41 |
| Member of a cooperative ('1' = if farmer joins a cooperative) | 0.293 | 0.456 |
| Change clothes ('1' = always change clothes after applying pesticides, '2'=sometimes change clothes after applying pesticides, '3'=do not change clothes after applying pesticides) | 1.356 | 0.760 |
| Wash hands ('1' = always wash hands after applying pesticides, '2' = sometimes wash hands after applying pesticides, '3' = do not wash hands after applying pesticides) | 1.066 | 0.278 |
| Average price of pesticides (yuan/type) | 13.841 | 12.403 |
| Average selling price (yuan/1000g) | 2.301 | 1.775 |
| Average amount of pesticide use (g/mu) [9] | 603.78 | 1474.21 |
| Average cost of pesticides (yuan/mu) | 205.882 | 226.880 |
| Average cost of vegetable production (yuan/mu) | 1388.751 | 1150.945 |
| Number of observations | | 393 |

*Source: Own calculation using IAMO-SAU vegetable farmer survey.*

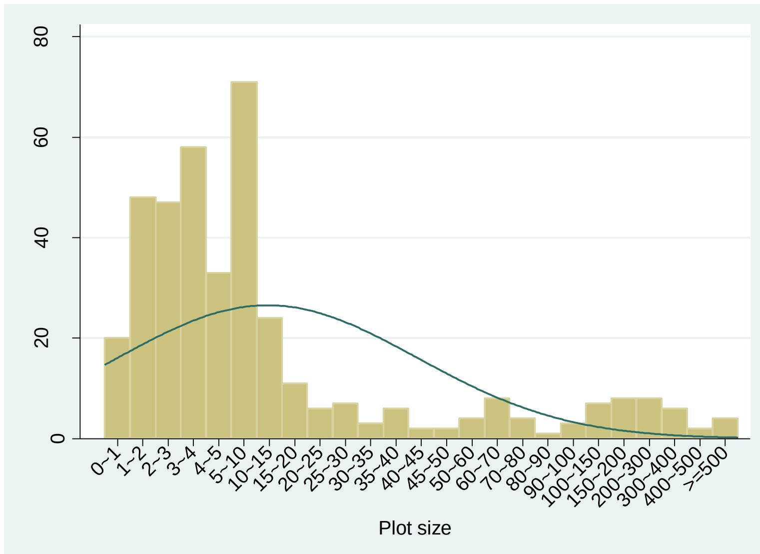
Figure 4.1 shows the distribution of areas planted with vegetables. It is important to highlight that farmers in Sichuan can cultivate vegetables multiple times per year on the same land. Thus, in Figure 4.1, the planted area does not necessarily correspond to the physical size of a plot. Most of the vegetable farmers we interviewed hold a planted area less than 20 mu in size per household. There are also some large farms

[8] Because there are multiple harvests per year, a planted area could be larger than the farm's size. For example, vegetable farmers may plant several kinds of vegetables in the same planted area at different times within the same year. In addition, some farmers cultivate other crops in addition to vegetables. Thus, the sum area of each investigated vegetable-planted area is used to reflect the real-vegetable planted area.

[9] This study assumes that 1g=1ml to combine the units of liquid and solid pesticides.

where the planted area is more than 100 mu. In the survey, not all farmland is planted with only vegetables, but vegetable production represents a major part of the households' cultivation.

Figure 4.1: Distribution of planted areas




*Source: Own representation using IAMO-SAU vegetable farmer survey.*

Table 4.4 summarises the regional characteristics of samples in this thesis. 29% of the samples are from the plain area. Samples from the hilly area and the mountain area account for 53.7% and 17.3%, respectively.

Table 4.4: Summary statistics of the regional characteristics

| ***Regional characteristics*** | Mean | SD |
|---|---|---|
| Plain area ('1' = household is living in the plain area) | 0.290 | 0.454 |
| Hilly area ('1' = household is living in the hilly area) | 0.537 | 0.499 |
| Mountain area ('1' = household is living in the mountain area) | 0.173 | 0.379 |
| Number of observations | | 393 |

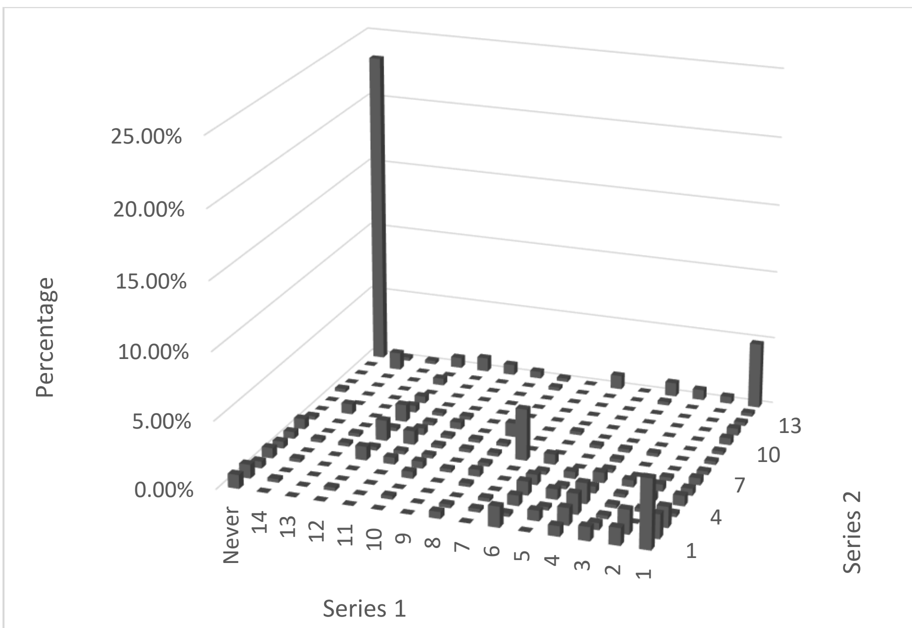
*Source: Own calculation using IAMO-SAU vegetable farmer survey.*

## 4.3 Parameters for the experiment of prospect theory

### *4.3.1 Experiment of series 1and 2, risk aversion, and probability weighting*

Risk aversion and probability weighting parameter are measured through series 1 and 2 of the experiment. Figure 4.2 shows the distribution of the switching points in series 1 and 2 of the experiment. 91 of the total sample of vegetable farmers in the survey, 23.16%, which is the largest proportion, do not switch from option A to option B in either series. A number of vegetable farmers switch in the first few options of series 1 and series 2. In addition, switching at the 7th option in both series is preferred by 15 (3.82%) vegetable farmers in Sichuan. This situation is similar to switching in the 1st option in series 1 and not switching in series 2, which is chosen by 19 (4.83%) respondents.

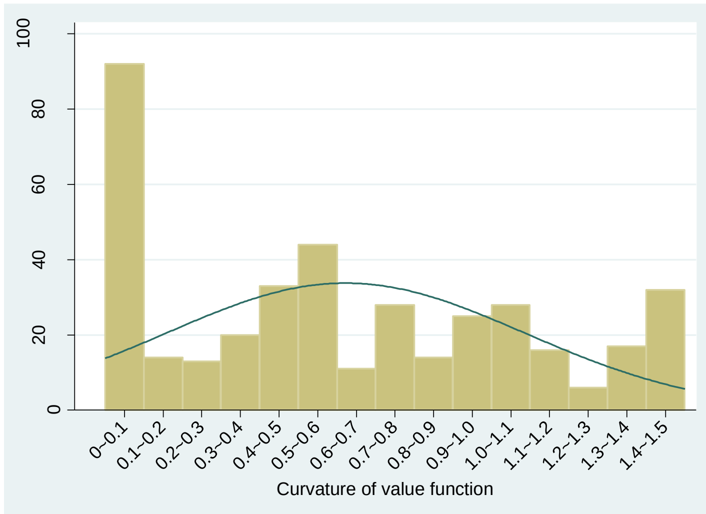
Figure 4.2: Switching points of yield risk preference in series 1 and 2




*Source: Own representation using IAMO-SAU vegetable farmer survey.*

The distribution of the resulting parameter of risk aversion calculated from the answers to series 1 and 2 is shown in Figure 4.3. There are 294 (74.8%) vegetable farmers who have a value that is less than 1. This implies that most farmers are risk-averse. In other words, farmers would be sensitive to changes in vegetable yields. In Figure 4.3, it is also shown that vegetable farmers with a very low degree of risk aversion between 0 and 0.1 represent the largest group, which accounts for 23.4% of all samples.

Figure 4.3: Distribution of risk aversion

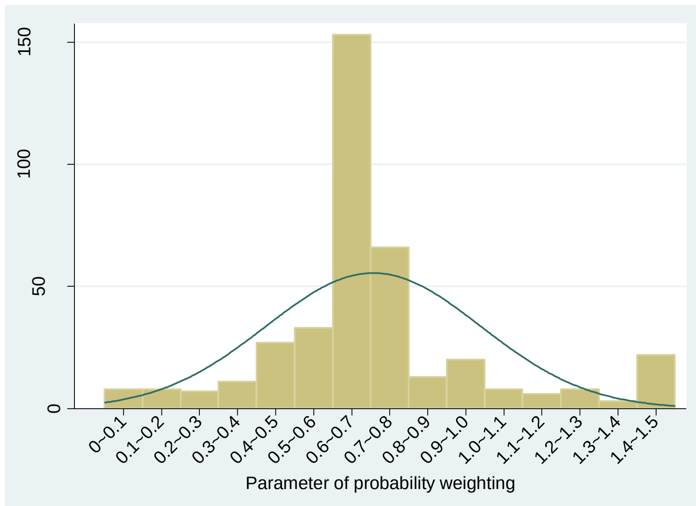



*Source: Own representation using IAMO-SAU vegetable farmer survey.*

Theoretically, for a risk-neutral farmer, a parameter equal to unity is expected. In this case, a total of 294 vegetable farmers (74.8%) show aversion to yield risk, and 13 (3.3%) of them show neutrality to yield risk. The other 86 farmers show risk-appetite behavior, i.e. the curvature parameter of the value function is strictly larger than 1, which accounts for 21.9%. Figure 4.4 also documents that risk-averse farmers are not homogeneous as there are 77 respondents (19.6%) clustering around 0.4 to 0.6 in addition to extremely risk-averse farmers (92 respondents accounting for 23.4% of the sample) with a value strictly less than 0.1 (<0.1).

The distribution of the parameter of probability weighting is shown in Figure 4.4. The values of the parameter of probability weighting are also based on the farmers' choices in series 1 and 2 of the experiment. The distribution of the parameter of probability weighting is close to a normal distribution with the majority of farmers clustering in the interval between 0.5 and 0.8. Most of the vegetable farmers have a parameter of probability weighting between 0.6 and 0.7. This means farmers would slightly overestimate the small probabilities and underestimate large ones. It is also worth noting that 19 farmers hold a parameter of probability weighting larger than 1.4, which means these farmers would underestimate the small probabilities and overestimate large ones.

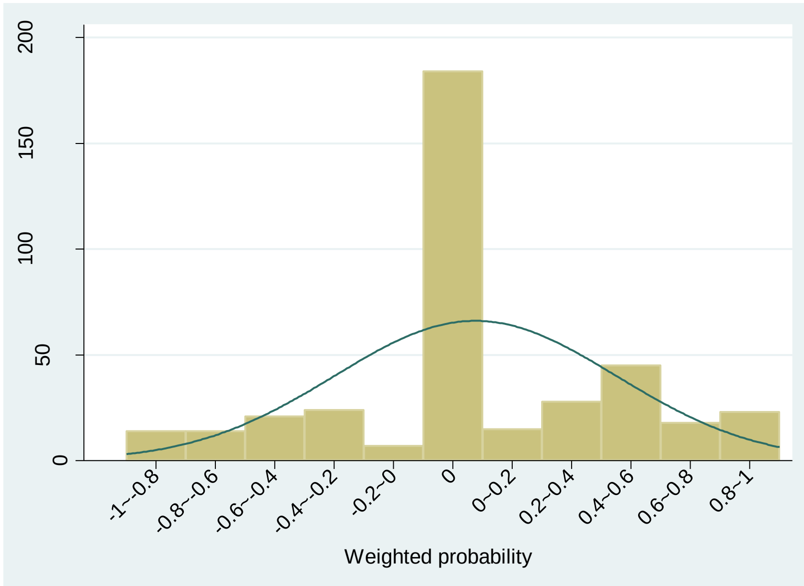
Figure 4.4: Distribution of Parameter of probability weighting




*Source: Own representation using IAMO-SAU vegetable farmer survey.*

Figure 4.5 shows the distribution of weighted probability. As introduced in the description of the theoretical framework, the weighted probability is calculated by the function, $w(q) = 1/\exp[-\ln(q)]^{\delta}$ where $\delta$ is the probability weighting parameter (Prelec, 1998), and $q$ is a farmer's perceived probability of a change in hazards if they continue current pest control measure. 184 vegetable farmers (46.8%) predicted that hazards would not change in the future. However, 129 farmers (32.8%) have a weighted probability larger than zero versus 80 farmers (20.4%) with a negative weighted probability. This means that 32.8% of farmers predicted hazards would increase, and the vegetable yield may face more risks in the future.

Figure 4.5: Distribution of weighted probability

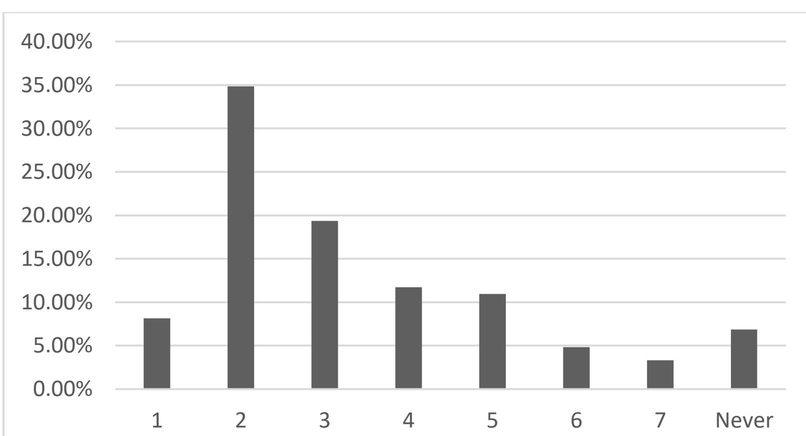



*Source: Own representation using IAMO-SAU vegetable farmer survey.*

### *4.3.2 Experiment of series 3 and loss aversion*

Series 3 of the experiment aims at measuring the degree of loss aversion. Figure 4.6 shows the distribution of the switching points in series 3 of the experiment. Most respondents (34.86%) switched at the second question. However, only 3.31% of the sample of vegetable farmers switch at the 7$^{th}$ question of the series. Of the total sample, 6.87% do not switch from option A to option B in series 3.

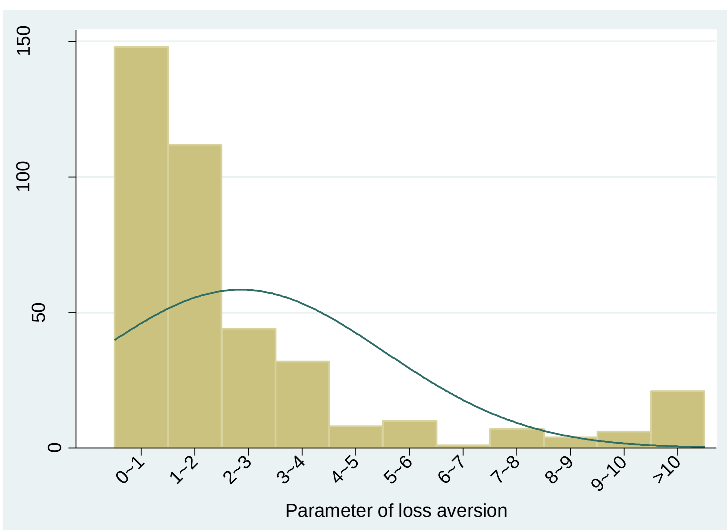
Figure 4.6: Switching points of yield risk preference in series 3




*Source: Own representation using IAMO-SAU vegetable farmer survey.*

Figure 4.7 shows the distribution of the loss aversion which is calculated through all three experimental series. As loss aversion has to be calculated and is related to the degree of risk aversion, it cannot be simply stated which farmers are neutral to losses. However, it is safe to conclude that farmers are loss averse ($\lambda > 1$) when they switch the choice of series 3 at the second question or later. Respondents who never switch hold the largest degree of loss aversion, which would be larger than nine. More specifically, 148 farmers (37.7%) show a loss aversion less than one, while the rest of the farmers (62.3%) hold a loss aversion larger than one. Twenty-one farmers (5.3%) have an extremely large degree of loss aversion larger than ten. In order to ease the interpretation of the distribution, this study follows the classification rules by Bartczak et al. (2015) where respondents with a loss aversion parameter between 0.9 and 1.1 are classified as neutral for loss. Respondents with loss aversion parameters less than 0.9 and larger than 1.1 are classified as appetite and averse for loss, respectively. 235 farmers (59.8%) are found to be loss aversion, while 125 (31.8%) of total samples show loss appetite. Other 8.4% of farmers, however, are neutral to loss.

Figure 4.7: Distribution of Parameter of loss aversion




*Source: Own representation using IAMO-SAU vegetable farmer survey.*

### 4.3.3 Summary of risk preference parameters

Table 4.5 shows the summary of yield risk preference parameters. The mean of risk aversion, loss aversion, and probability weighting are 0.6, 2.38, and 0.68, respectively. And the average probability of hazard change perceived by farmers is 7.16%. Thus, the mean calculated weighted probability is 6.89%. Compared to similar studies, these estimates indicate a higher degree of risk aversion and a similar parameter of probability weighting. The degree of loss aversion in this study, however, is about one unit less than these two studies. More specifically, Bartczak et al. (2015), analyze preferences with respect to financial risk, estimated the parameters of risk aversion, loss aversion, and probability weighting, which are 0.41, 3.01, and 0.77, respectively. Studying Chinese farmers, Liu and Huang (2013) obtained the degrees of risk aversion, loss aversion, and probability weighting are 0.48, 3.47, and 0.69, respectively.

Table 4.5: Summary of yield risk preferences

| ***Yield risk preference variables*** | Mean | SD |
|---|---|---|
| Risk aversion ($\sigma$) | 0.60 | 0.46 |
| Loss aversion ($\lambda$) | 2.38 | 2.60 |
| Parameter of probability weighting ($\delta$) | 0.68 | 0.29 |
| Probability of hazard change (%) | 7.66 | 44.76 |
| Weighted probability (%) | 6.89 | 42.26 |
| Number of observations | | 393 |

*Source: Own calculation using IAMO-SAU vegetable farmer survey.*

## 4.4 Parameters for testing mental budgeting and the intentions towards pest control measures

### 4.4.1 Typicality testing

Table 4.6 shows the results of the typicality rating for the selected agricultural inputs. 393 (100%) and 360 (91.60%) farmers think vegetable seeds and seedlings belong to seeds, respectively; the corresponding ratings are 1.05 and 1.39. Just a few farmers classify these two inputs as fertilizer and pest control measures.

More specifically, five farmers in the samples classify either seed or seedling into pest control measures. These five farmers are not a member of a cooperative. Four of them have farmland of fewer than five mu, while one farmer holds a larger farm with 308 mu. Only one out of the small farms has a certificate for their vegetables.

The number of farmers who group potash fertilizer, nitrogenous fertilizer, phosphate fertilizer, and organic fertilizer into the category fertilizer is 388 (98.73%), 388 (98.73%), 384 (97.71%), and 369 (93.89%), respectively. The corresponding ratings for this are 1.16, 1.17, 1.16, and 1.30 for potash fertilizer, nitrogenous fertilizer, phosphate fertilizer, and organic fertilizer, respectively.

In addition to chemical plant protection measures, the majority of farmers also classified insect proof-lamps/nets and sexual attractants as pest control measures. The exact numbers are 382 (97.20%), 370 (94.15%), 385 (97.96%), and 364 (92.62%) for insect-proof lamps/nets, high-toxicity pesticides, low-toxicity pesticides, and sexual attractants, respectively.

In sum, 299 farmers, i.e. 76.08% of the sample, categorize all agricultural input types according to professional practice. In this case, farmers classify selected inputs as typical in uncommon categories are regarded as unconventional wisdom. For example, farmers regard vegetable seeds are somehow typical for fertilizers will be marked as unconventional wisdom. Besides, as some farmers are not very familiar with some inputs, such as sexual attractants, they might show typicality unconventionally. Although the remaining 24% of farmers use different categories, this does show that a large majority of farmers do categorize agricultural inputs in the same way. In addition, with regard to commonly used inputs (vegetable seeds, potash fertilizer, nitrogenous fertilizer, phosphate fertilizer, high-toxicity pesticides, and low-toxicity pesticides), 354 (90.08%) respondents show completely conventional wisdom. More specifically to the category of pest control measures, 362 (92.11%) show conventional typicality according to professional practice.

Table 4.6: Typicality rating for agricultural inputs

| | Seeds | | | Fertilizers | | | Pest control measures | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean (SD) | Obs. | % | Mean (SD) | Obs. | % | Mean (SD) | Obs. | % |
| Vegetable seeds | 1.05 (0.23) | 393 | 100 | 2.00 (1.41) | 2 | 0.51 | 2.00 (0.82) | 4 | 1.02 |
| Vegetable seedlings | 1.39 (0.85) | 360 | 91.60 | 3.25 (2.06) | 4 | 1.02 | 1.67 (0.58) | 3 | 0.76 |
| Potash fertiliser | 2.00 (1.41) | 2 | 0.51 | 1.16 (0.47) | 388 | 98.73 | 3.00 (1.41) | 8 | 2.04 |
| Nitrogenous fertiliser | 1.00 (-) | 1 | 0.25 | 1.17 (0.44) | 388 | 98.73 | 2.00 (0.89) | 6 | 1.53 |
| Phosphate fertiliser | 1.00 (-) | 1 | 0.25 | 1.16 (0.48) | 384 | 97.71 | 2.00 (0.71) | 5 | 1.27 |
| Organic fertiliser | 1.00 (-) | 1 | 0.25 | 1.30 (0.66) | 369 | 93.89 | 2.64 (1.03) | 11 | 2.80 |
| Insect-proof lamps/nets | 4.00 (-) | 1 | 0.25 | n.a. | n.a. | n.a. | 1.25 (0.57) | 382 | 97.20 |
| High-toxicity pesticides | 5.00 (-) | 1 | 0.25 | 3.00 (2.00) | 3 | 0.76 | 1.31 (0.79) | 370 | 94.15 |
| Low-toxicity pesticides | 5.00 (-) | 1 | 0.25 | 1.67 (1.16) | 3 | 0.76 | 1.23 (0.54) | 385 | 97.96 |
| Sexual attractants | 3.29 (0.76) | 7 | 1.78 | 2.60 (0.84) | 10 | 2.55 | 1.69 (0.95) | 364 | 92.62 |

*Source: Own calculation using IAMO-SAU vegetable farmer survey.*

*Note: 1) Obs. refers to the number of observations for which farmers didn't show a typical rating that was not "null". 2) "n.a." means that none of the farmers thought the item is typical in that category. 3) The sum of the rows could be higher than the sample size (393) because farmers were asked to show the typicality for all categories in order to see if there is cross typicality.*

Although most studies in the field of mental budgeting look at consumer behavior, the results of this study are comparable to previous findings. Heath and Soll (1996), for instance, report that 25 of 26 respondents total displayed typicality for "sports ticket" in one of three categories, "entertainment". Only, one person did not show typicality for this item. In addition, four students reported typicality for "sweatshirt" in "entertainment" instead of "clothes" as the majority did.

### *4.4.2 Construction of mental budgeting scale*

Table 4.7 shows for the mental budgeting scale statements the percentage of farmers who responded with "totally agree" or "agree". Between 35 and 64% of respondents agree with the individual statements. Aggregating responses result in a subsample of 104 farmers (26.46%) which agree with all four statements and would be classified as applying mental budgeting. However, 79 farmers (20.10%) always disagree with the four statements, accounting for 20.10%, while the others remained neutral.

Table 4.7: Percentage of farmers who agree with the mental budgeting scale statements

| | Percentage |
|---|---|
| 1) I set up a budget plan or reserve money for different agricultural expenses. | 62.09 |
| 2) I never spend more than a fixed amount on seeds, fertilizer, pest control measures, etc. | 36.64 |
| 3) If I spend more on one agricultural input, I spend less on other inputs in the same category. | 34.86 |
| 4) If I spend more on either seeds, fertilizer, pest control measures, etc., the expenses in other categories remain as before. | 64.12 |

*Source: Own calculation using IAMO-SAU vegetable farmer survey.*

### *4.4.3 Pest control intentions*

Finally, a farmer's willingness to switch to low-toxicity pesticides is used as the dependent variable in the following econometric analysis. Table 4.8 displays farmers' responses when facing the two hypothetical options, agricultural revenue with a price premium for quality and subsidy, during the interview. Based on the responses on the five-point Likert Scale, this study aggregates farmers who answered "totally agree" and “agree” into one group. They are assigned a value of “1”, while farmers who reported disagreement or a neutral response are assigned a value of “0”. Although it would be possible to analyze the answer categories separately, the main interest of this part is on the degree of agreement in order to distinguish farmers applying mental budgeting from farmers not applying. Comparing the two options, more farmers report a willingness towards adopting low-toxicity pesticides when facing a subsidy compared to a price premium. 194 farmers show a willingness to adopt low-toxicity pesticides under both scenarios of agricultural revenue and subsidy. 81 farmers, however, do not want to switch when extra revenue and subsidy are offered. In addition, the average response to agricultural revenue between farmers with different farm sizes are similar (2.861 and 2.783 for farms with less than 10 mu and strictly larger than 10 mu, respectively), while farms with larger size response in a lower degree (1.953) than smaller farms (2.293) with regard to a subsidy.

Table 4.8: Frequency and percentage of agreement with selected pest control measures

| Pest control measures (“1” for agree, “0” for disagree and neutral) | Agricultural revenue with a price premium for quality | | Subsidy | |
|---|---|---|---|---|
| | Obs. | % | Obs. | % |
| Willingness to switch to low-toxicity pesticides | 205 | 52.16 | 282 | 71.76 |

*Source: Own calculation using IAMO-SAU vegetable farmer survey.*

*Note: Obs. refers to the number of observations of farmers who “totally agree” and “agree” with the pest control statements.*

### 4.5 Cooperatives and food safety related instruments

The final econometric part analyzes whether members in cooperatives show different choices of pesticides compared to other farmers. The direct and indirect effects of different food safety related instruments on cooperative members and non-members are, as well, studies. Table 4.9 shows the definitions of all variables used in the following tests, as well as the mean and standard deviation of these variables. More specifically, 115 farmers are members of one of the cooperatives in the survey region which accounts for 29.26% of all samples. In order to investigate whether a farmer is still using restricted pesticides, this study cross-checks each pesticide a farmer is using with the "Prohibited and Restricted Pesticide List (2019)" issued by the Ministry of Agriculture and Rural Affairs. This list names 46 types of pesticides that are prohibited for all crops and 20 types of pesticides which are restricted to be used for certain crops only. Out of the total sample, 53 farmers are still using at least one restricted pesticide (13.49% of the sample).

Similarly, whether farmers use recommended pesticides is studied as well. These recommended pesticides are mostly of low toxicity and may be subsidized in China in the future. As the subsidy schemes for highly efficient and low-toxic pesticides are still in the pilot stage and differ within provinces, this study selects pesticides, which appear on the "List of main varieties of low-toxic and low-residue pesticides used in crop production, 2016", as recommended pesticides here. As shown in Table 4.9, there are 238 farmers (60.56%) who use at least one recommended pesticide in vegetable production. It is also worth noting that 8.14% of the sample (32 investigated farmers) use both restricted and recommended pesticides. Therefore, the two decisions cannot be modeled as alternative options.

More specifically, Table 4.9 also summarizes the characteristics revealed in the survey by dividing the sample into members and non-members of cooperatives. The t-statistic of the mean difference is also presented in the last column. The significance of t-statistics indicates that members and non-members partly differ in the use of restricted and recommended pesticides without controlling for a possible selection bias and other explanatory variables. The instruments faced by cooperative members and non-members differ partly, too. Members seem to have easier access to services such as training and food safety control measures. Instruments supplied outside of the cooperatives are normally supplied by the government and sometimes by companies. For instance, the way of pesticide adoption and new pest control technology would be introduced and extended in training programs held by the government for farmers. This is also happening in cooperatives with different frequencies.

Table 4.9: Summary statistics of personal, household, and farming characteristics

| Variable | Definition and measurement | Total sample (N=393) | Cooperative member (N=115) | Non-member (N=278) | Difference |
|---|---|---|---|---|---|
| Member of a cooperative | =1 if farmers join a cooperative | 0.293 (0.456) | | | |
| Use of restricted pesticides | =1 if farmers use restricted pesticides | 0.135 (0.342) | 0.183 (0.388) | 0.115 (0.320) | -0.068 (0.038) |
| Use of recommended pesticides | =1 if farmers use recommended pesticides | 0.606 (0.489) | 0.696 (0.462) | 0.568 (0.496) | -0.127 (0.054) |
| Training program | =1 if farmers attend pest control training program | 0.529 (0.500) | 0.852 (0.356) | 0.396 (0.490) | -0.456 (0.050) |
| Supply | =1 if pesticides are supplied by a company, a cooperative, or the government | 0.201 (0.401) | 0.435 (0.498) | 0.104 (0.306) | -0.330 (0.041) |
| Test | =1 if there is a quality test for final products | 0.471 (0.500) | 0.722 (0.450) | 0.367 (0.483) | -0.355 (0.053) |
| Certification | =1 if there is a certification for vegetables | 0.349 (0.477) | 0.443 (0.499) | 0.309 (0.463) | -0.134 (0.053) |
| Record | =1 if farmers record the names of pesticides used | 0.252 (0.435) | 0.417 (0.495) | 0.183 (0.388) | -0.234 (0.047) |
| Age | Age of household head in years | 52.850 (10.510) | 51.687 (9.595) | 53.331 (10.846) | 1.644 (1.164) |
| Planted area | Cumulated planted arable land over the whole year in mu | 33.663 (95.409) | 60.385 (136.850) | 22.609 (68.960) | -37.776 (10.418) |
| Educational level | Achieved education of household head: =1 if not formally educated =2 if finished primary school, =3 if finished secondary school =4 if finished high school or technical secondary school =5 if finished undergraduate or junior college =6 if finished graduate school | 2.623 (0.961) | 2.930 (0.905) | 2.496 (0.957) | -0.434 (0.104) |
| Off-farm job | =1 if any household member has an off-farm job | 0.565 (0.496) | 0.670 (0.472) | 0.522 (0.500) | -0.148 (0.055) |
| Distance to fair | Distance to the nearest fair in km | 4.414 (4.976) | 3.789 (3.554) | 4.673 (5.442) | 0.884 (0.551) |
| Household members | The number of household members | 4.318 (1.691) | 4.557 (1.645) | 4.219 (1.703) | -0.337 (0.187) |
| Selling price | Average selling price of 500g vegetables in yuan | 1.15 (0.888) | 1.204 (1.108) | 1.129 (0.780) | -0.075 (0.098) |
| Cost of pesticides | Average cost of pesticides per planted area in yuan/mu | 205.882 (226.880) | 199.763 (268.476) | 208.414 (207.746) | 8.650 (25.183) |
| Observations | | | | | 393 |

*Source: Own calculation using IAMO-SAU vegetable farmer survey.*

*Note: standard deviations and standard errors are shown in the parentheses*

In the survey of this study, cooperative members and non-members differ partly with respect to selected household and farming characteristics such as the number of household members, the size of planted area, and whether household members have at least one off-farm job. Table 4.9 also shows that characteristics such as age, educational level, distance to the nearest fair, selling price, and cost of pesticides, do not show huge differences between cooperative members and non-members. Given that the cooperative membership is not independent but a result of many determinants such as personal, household, and farming characteristics, selection bias may occur. Thus, an appropriate method is required.

# 5 Results and Discussion

The estimations of this thesis are based on a sample derived from stratified sampling where sample areas in each region of vegetable production and farmers in each sub-sample area have been randomly chosen. Thus, the sample in this study could represent an approximately random sample of commercial vegetable farmers in Sichuan. Following the suggestion by Berry (2016) about the use of p-values, this study just provides some exploratory evidence. In addition, following the suggestions by Hirschauer et al. (2019), this thesis reports coefficients, standard errors, marginal effects in the non-linear models, and confidence intervals in the tables for effect size estimates instead of p-values.

## 5.1 Farmer's yield risk preferences and pesticide use

The results of the association between yield risk preference parameters and the corresponding influence on the amount of pesticides per planted area (g/mu) and the cost of pesticides per planted area (yuan/mu) are presented in Table 5.1. The first three columns of Table 5.1 show the result of the amount of pesticides. The coefficient of risk aversion is 283.304 along with a standard error of 175.353. It is shown that the standard error of risk aversion regarding yield is comparatively large, and risk aversion regarding yield affects the use of pesticides inconclusively when relying on a 90% confidence interval, from -5.843 to 572.450. However, loss aversion and weighted probability are tested to have a positive correlation with the average amount of pesticide use when relying on a 90% confidence interval. The average marginal effects of loss aversion and weighted probability are 63.424 and 3.963, respectively. It means that vegetable farmers who are more loss averse regarding yield risk by one unit tend to apply, on average, 63.424 grams more pesticides per mu. Besides, a higher weighted probability of potential hazards is correlated with a higher amount of pesticide use by 3.963 grams per mu. The estimated results of personal, household, and farming characteristics, however, do not support a rejection of the hypothesis that there is, ceteris paribus, no correlation with the amount of pesticide use. This is similar to the results with respect to the geographical regions.

The last three columns of Table 5.1 show the results with respect to estimates of the determinants of the average cost of pesticides. Contrary to the results of the amount of pesticides, the coefficient of risk aversion is negative. The coefficient is -4.765 with a large standard error of 25.506. The effect of risk aversion on the average cost of pesticides is also inconclusive when relying on a 90% confidence interval, from -46.823 to 37.292. Table 5.1 also shows that loss aversion and weighted probability are estimated to have a positive correlation with the average cost of pesticides when relying on a 90% confidence interval, which is similar to the results of the amount of pesticide use. The coefficient of loss aversion and weighted probability are 8.232 and 0.566, respectively. These results indicate that one higher unit of loss aversion and a ten percent higher weighted probability of potential hazards would increase the cost of pesticides by 8.232 yuan per mu and 5.66 yuan per mu, respectively. From the results of the cost of pesticides, it is also shown that the number of family members has a positive association with the cost of pesticides. In contrast, the coefficient of age and educational level show a negative association indicating that the elderly people and more educated people are more likely to spend less on pesticides averagely. In addition, vegetable farmers in the hilly area would have a lower cost of pesticides by 120.140 yuan per mu compared to their counterparts in the plain area. The coefficient of average price of pesticides is 3.774, while the coefficient of average price of pesticides square is -0.053. It means that in line with a higher price of pesticides, farmers would spend more on pesticides, and the increased cost of pesticides follow a decreasing trend. This may because pesticides are a necessity for vegetable production. The change in prices can hardly affect the use of pesticides quantitatively.

From both perspectives of pesticide use variables, loss aversion and weighted probability show a positive effect. It means that farmers who are more loss averse or have a higher weighted probability of potential hazards are more likely to spend more on pesticides and apply more pesticides. One reason for this observed behavior could be that the potential financial loss incurred by yield loss is perceived as more severe by more loss-averse farmer. As a result, farmers with higher loss aversion would use more pesticides to ensure the expected yield. A higher weighted probability of potential hazards is also related to a higher expectation of potential yield loss. This, similarly, would increase the use of pesticides for ensuring yields and avoid potential financial loss. The effect of risk aversion, however, is uncertain on both the amount and cost of pesticides from the estimation results of this research.

The results of this study differ from the results by Liu and Huang (2013) and Hou et al. (2020) where risk aversion shows a positive association with the amount of pesticide use while the association between loss aversion and the amount of pesticide use is negative. The different settings of the experiment might be one reason. The two papers cited above derived their parameters of interest from an experiment with monetary risk while here farmers' response to yield risk is studied. In the studies by Liu and Huang (2013) and Hou et al. (2020) loss aversion is regarded as loss aversion over health and shows a negative effect on pesticide use. Actions to prevent health damages will necessarily result in a lower amount of pesticide use but the opposite holds for actions to prevent yield loss.

Table 5.1: Regression results of average amount and cost of pesticides

| Variables | Average amount of pesticides | | | Average cost of pesticides | | |
|---|---|---|---|---|---|---|
| | Coefficient | [90% Confidence Interval] | | Coefficient | [90% Confidence Interval] | |
| ***Risk preference parameters*** | | | | | | |
| Risk aversion | 283.304<br>(175.353) | -5.843 | 572.450 | -4.765<br>(25.506) | -46.823 | 37.292 |
| Loss aversion | 63.424<br>(31.072) | 12.189 | 114.659 | 8.232<br>(4.519) | 0.780 | 15.684 |
| Weighted probability | 3.963<br>(1.785) | 1.019 | 6.907 | 0.566<br>(0.260) | 0.138 | 0.995 |
| ***Personal, household, and farming characteristics*** | | | | | | |
| Age | 7.873<br>(8.689) | -6.454 | 22.200 | -3.921<br>(1.264) | -6.005 | -1.837 |
| Family size | 34.935<br>(45.148) | -39.510 | 109.381 | 15.217<br>(6.567) | 4.389 | 26.045 |
| Distance to the nearest fair | -36.399<br>(38.021) | -99.093 | 26.295 | -5.524<br>(5.530) | -14.643 | 3.595 |
| Distance to the nearest fair squared | 2.785<br>(1.485) | 0.335 | 5.234 | 0.214<br>(0.216) | -0.142 | 0.570 |
| Planted area | -1.846<br>(1.795) | -4.806 | 1.113 | -0.208<br>(0.261) | -0.638 | 0.222 |
| Planted area squared | 0.002<br>(0.003) | -0.002 | 0.006 | 0.0003<br>(0.0004) | 0.000 | 0.001 |
| Educational level | 43.644<br>(91.410) | -107.085 | 194.373 | -35.064<br>(13.296) | -56.988 | -13.140 |
| Change clothes | -105.504<br>(121.213) | -305.376 | 94.369 | 1.543<br>(17.631) | -27.529 | 30.615 |
| Wash hands | 25.541<br>(284.489) | -443.565 | 494.646 | 17.553<br>(41.380) | -50.680 | 85.785 |
| ***Prices of input and output*** | | | | | | |
| Average price of pesticides | 17.113<br>(13.362) | -4.919 | 39.145 | 3.774<br>(1.943) | 0.569 | 6.978 |
| Average price of pesticides squared | -0.165<br>(0.181) | -0.463 | 0.133 | -0.053<br>(0.026) | -0.096 | -0.010 |
| Selling price | 133.893<br>(234.852) | -253.363 | 521.149 | -9.845<br>(34.16) | -66.173 | 46.482 |
| Selling price squared | -17.986<br>(38.187) | -80.954 | 44.982 | 1.064<br>(5.554) | -8.095 | 10.223 |
| ***Geographical dummies*** | | | | | | |
| Hilly area | 111.520<br>(185.424) | -194.233 | 417.273 | -120.140<br>(26.970) | -164.612 | -75.667 |
| Mountain area | -37.335<br>(268.309) | -479.759 | 405.089 | -52.000<br>(39.026) | -116.351 | 12.352 |
| Constant | -575.76<br>(770.923) | -1846.963 | 695.444 | 465.525<br>(112.132) | 280.625 | 650.424 |
| Observations | | | | | | 393 |

*Source: Own calculation using IAMO-SAU vegetable farmer survey.*
*Note: Standard errors are presented in parentheses.*

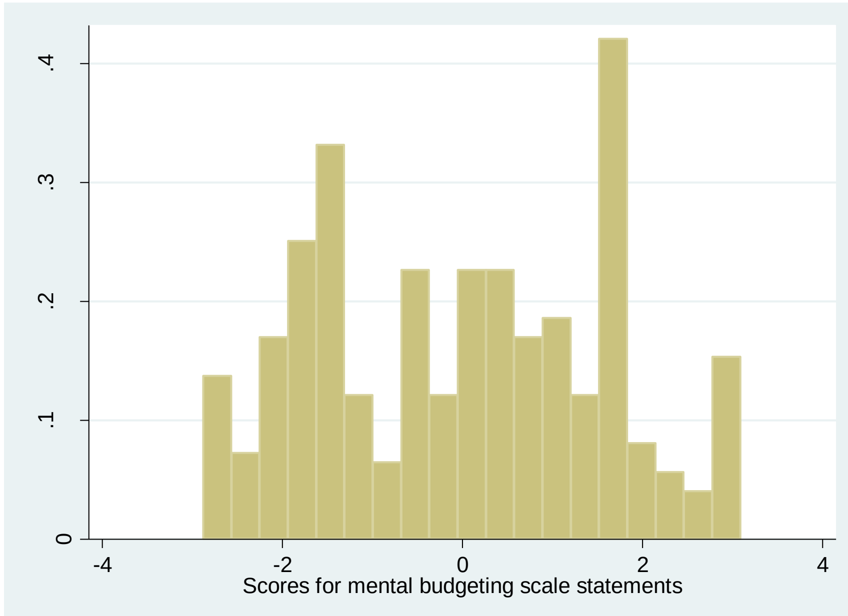
### 5.2 Mental budgeting and pest control intentions

After receiving the answers from the four mental budgeting scale statements introduced in Section 3.2.4, responses have to be aggregated in order to obtain a dimensionality reduction of statements as a useful measure. In order to achieve this, here the approach suggested by Antonides et al. (2011) is used where a Principal Component Analysis is applied to determine the mental budgeting scale. The Cronbach's alpha for these four mental budget statements is 0.8098, explaining 64.12% of the item's variance. In order to reduce the dimension of the mental budgeting scale statements, the following analysis uses the factor score resulting from the Principal Component Analysis, which is labeled as "mental budgeting". The density of the factor scores is shown in Figure 5.1.

This indicator will be used as a main independent variable in order to explain farmers' willingness to switch to low-toxicity pesticides. In interpreting the coefficients below, it is important to note that a lower number indicates that a farmer tends to agree more with the mental budgeting scale statements corresponding to a higher likelihood of engaging in mental budgeting. In addition, given that mental budgeting scale is a continuous variable, its interpretation in the econometric analysis is less straightforward. As an additional explanatory variable, this study constructs a dummy variable ("mental budgeting dummy") which equals one for farmers who engage in mental budgeting. More specifically, vegetable farmers agreeing with all four statements (i.e. answering 1 or 2 for all statements) were assigned a value of "1", while others who show disagreements or were neutral were assigned a value of "0". The use of factor scores is to compare farmers with low and high scores, while the mental budgeting dummy helps to test for differences between farmers completely following and not following mental budgeting.

In addition, there are 187 farmers (47.58%) who received a factor score below zero according to their mental budgeting scale statements. Given that the sum of factor scores is zero, a factor score reflects the distance between the samples and the neutral level.

Figure 5.1: Density of scores for mental budgeting scale statements




*Source: Own representation using IAMO-SAU vegetable farmer survey.*

This study also tested the effect of mental budgeting on farmers' willingness to switch to low-toxicity pesticides conditional upon two different incentives. Given that the dependent variable is a binary variable, a Probit model is used to test the effect of both mental budgeting and the mental budgeting dummy.

Table 5.2 shows the Probit regression results explaining farmers' willingness to switch to low-toxicity pesticides conditional upon the two incentives. In order to test the robustness of the model of this study by dichotomizing mental budgeting, this study additionally applied receiver operating characteristic (ROC) to test the impact of mental budgeting on the willingness to switch. A detailed introduction about ROC can be achieved from Streiner and Cairney (2007). The details of the results of ROC tests are shown in the appendix.

Turning to the correlation of the behavioral variable with farmer's willingness to adopt low-toxicity pesticides displayed in Table 5.2, the coefficient of mental budgeting is -0.346 with a standard error of 0.049 when facing a subsidy. The average marginal effect of receiving the 200 yuan would increase the willingness to switch for farmers holding one-unit lower mental budgeting factor score by almost 10% in the case of the subsidy. Although the coefficient and the average marginal effect of a price premium are opposite to a subsidy, the standard error for a price premium is comparatively high. Thus, the results cannot derive empirical evidence of a strong correlation between the behavioral variable and the willingness to switch to low-toxicity pesticides. This shows that farmers who are more likely to engage in mental budgeting react differently when facing a subsidy or a price premium.

Table 5.2: Probit regression results of mental budgeting for the willingness to switch to low-toxicity pesticides

| Variables | Agricultural revenue with price premiums for quality | | | | | | Subsidy | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coefficient | [90% Confidence Interval] | | Average marginal effect | [90% Confidence Interval] | | Coefficient | [90% Confidence Interval] | | Average marginal effect | [90% Confidence Interval] | |
| Mental budgeting | 0.054 (0.041) | -0.013 | 0.121 | 0.021 (0.015) | -0.005 | 0.046 | -0.346 (0.049) | -0.426 | -0.265 | -0.098 (0.011) | -0.116 | -0.079 |
| Age | -0.017 (0.007) | -0.028 | -0.005 | -0.006 (0.003) | -0.011 | -0.002 | -0.013 (0.008) | -0.026 | 0.000 | -0.004 (0.002) | -0.007 | 0.000 |
| Farm size | -0.0002 (0.0007) | -0.001 | 0.001 | -0.0001 (0.0003) | -0.001 | 0.000 | 0.001 (0.001) | -0.001 | 0.003 | 0.0003 (0.0004) | -0.000 | 0.001 |
| Educational level | -0.064 (0.079) | -0.194 | 0.066 | -0.024 (0.030) | -0.074 | 0.025 | 0.053 (0.088) | -0.092 | 0.198 | 0.015 (0.025) | -0.026 | 0.056 |
| Off-farm job | -0.381 (0.139) | -0.610 | -0.153 | -0.146 (0.052) | -0.231 | -0.061 | -0.136 (0.154) | -0.389 | 0.116 | -0.038 (0.043) | -0.110 | 0.033 |
| Lnincome | 0.138 (0.062) | 0.037 | 0.240 | 0.053 (0.023) | 0.015 | 0.091 | 0.110 (0.057) | 0.016 | 0.203 | 0.031 (0.016) | 0.005 | 0.057 |
| Constant | -0.159 (0.790) | -1.458 | 1.140 | | | | 0.092 (0.818) | -1.253 | 1.437 | | | |
| Obs. | | | | | | | | | | | | 393 |

*Source: Own calculation using IAMO-SAU vegetable farmer survey.*

*Note: Robust standard errors are presented in parentheses. As the coefficients cannot be interpreted as effects of explanatory variables on the probability of the outcome, the average marginal effect is calculated by using 'margins, dydx(*)' command in STATA after Probit regression.*

Table 5.3 shows the results of a mental budgeting dummy instead of a continuous mental budgeting variable. Farmers who agree with the mental budget statements show a similar pattern as in the mental budgeting factor score case in terms of both incentives. The coefficients of the mental budgeting dummy for a price premium is even negative and amounts to -0.371. Thus, farmers following mental budgeting are predicted to show a 14.1% lower probability to adopt low-toxicity pesticides compared to the other farmers. When faced with a subsidy, farmers following mental budgeting are predicted to switch to low-toxicity pesticides with a 32.9% higher likelihood. These results indicate that a specific subsidy would be more effective to encourage farmers who follow mental budgeting than a price premium. However, given that the subsidy is offered by the government while marketing entities are able to adjust prices, prices are also important if the government does not intervene in markets.

In addition, to obtain robust results, this study has tested the results by re-grouping 'mental budgeting dummy 2' where farmers agreed with all four statements or were neutral (i.e. answering 1 or 3 for all statements) were assigned a value of "1", others who show disagreements were assigned a value of "0". The results of 'mental budgeting dummy 2' are similar to the previous specification 'mental budgeting dummy'. Farmers who engage in or are neutral to mental budgeting show an 18.6% lower probability to adopt low-toxicity pesticides when facing an increase in agricultural revenue. Whereas, a 30% higher probability of adopting low-toxicity pesticides under subsidy is predicted for the same group of farmers. The detailed results are shown in Table A. 3 in the appendix. The intentions under two different sources are, as well, re-grouped into two groups where farmers who answered "totally agree", "agree", and "neutral" have been assigned a "1", and other farmers have been assigned a value of "0". The results are similar: compared to the coefficient of agricultural revenue where a comparatively high standard error is shown and inconclusive direction when relying on the90% confidence interval, farmers who engage in mental budgeting are more willing to switch to low-toxicity pesticides when facing a specific subsidy. The detailed regression results are shown in Table A. 4 and Table A. 5 in the Appendix.

Table 5.3: Probit regression results of mental budgeting dummy for the willingness to switch to low-toxicity pesticides

| Variables | Agricultural revenue with price premiums for quality | | | | | | Subsidy | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coefficient | [90% Confidence Interval] | | Average marginal effect | [90% Confidence Interval] | | Coefficient | [90% Confidence Interval] | | Average marginal effect | [90% Confidence Interval] | |
| Mental budgeting dummy | -0.371 | -0.617 | -0.125 | -0.141 | -0.232 | -0.050 | 1.098 | 0.753 | 1.442 | 0.329 | 0.234 | 0.424 |
| | (0.150) | | | (0.055) | | | (0.209) | | | (0.058) | | |
| Age | -0.017 | -0.029 | -0.006 | -0.007 | -0.011 | -0.002 | -0.012 | -0.025 | 0.001 | -0.004 | -0.007 | 0.000 |
| | (0.007) | | | (0.003) | | | (0.008) | | | (0.002) | | |
| Farm size | -0.00002 | -0.001 | 0.001 | -7.75e-6 | -0.000 | 0.000 | 0.001 | -0.001 | 0.003 | 0.0003 | -0.000 | 0.001 |
| | (0.0007) | | | (0.0003) | | | (0.001) | | | (0.0004) | | |
| Educational level | -0.069 | -0.200 | 0.061 | -0.026 | -0.076 | 0.023 | 0.067 | -0.078 | 0.211 | 0.020 | -0.023 | 0.063 |
| | (0.079) | | | (0.030) | | | (0.088) | | | (0.026) | | |
| Off-farm job | -0.392 | -0.622 | -0.162 | -0.149 | -0.233 | -0.064 | -0.119 | -0.366 | 0.128 | -0.036 | -0.109 | 0.038 |
| | (0.140) | | | (0.051) | | | (0.150) | | | (0.045) | | |
| Lnincome | 0.137 | 0.035 | 0.239 | 0.052 | 0.014 | 0.090 | 0.111 | 0.020 | 0.202 | 0.033 | 0.006 | 0.060 |
| | (0.062) | | | (0.023) | | | (0.056) | | | (0.016) | | |
| Constant | 0.010 | -1.296 | 1.316 | | | | -0.301 | -1.624 | 1.023 | | | |
| | (0.794) | | | | | | (0.805) | | | | | |
| Obs. | | | | | | | | | | | | 393 |

*Source: Own calculation using IAMO-SAU vegetable farmer survey.*

*Note: Standard errors are presented in parentheses. As the coefficients cannot be interpreted as effects of explanatory variables on the probability of the outcome, the average marginal effect is calculated by using 'margins, dydx(*)' command in STATA after Probit regression.*

In general, subsidies generate income effects for specific mental budgeting of pest control and the increased budgets that would change the demand structure for pest control measures. A subsidy has higher income effects for farmers who engage in mental budgeting, while a price premium for quality shows even a negative impact. Earlier studies show some evidence for different reactions to prices and specific subsidies, but no similar study for mental budgeting among agricultural producers exists. A study by Pietola and Lansink (2001a) shows that a subsidy for organic farming has a positive elasticity of 0.2 for adopting organic technology, while a decrease of output price by 1% would increase the rate by 0.4% to choose organic technology by farmers. The underlying reason for such different behavior might be mental budgeting.

A price premium for quality does not show a similar impact as a subsidy. There might be several possible reasons for this. First, farmers might perceive a price premium as not enough to compensate for potential losses due to less strict pest control. In addition, agricultural revenue with a price premium for quality assigned to the mental budget of pest control may be too small to encourage farmers to change their intentions towards switching to low-toxicity pesticides. It is worth noting that all these analyses assume the absence of risky outcomes. The situation would become more complicated if farmers would be uncertain whether both incentives can be obtained. However, the results don't allow to conclude that a price premium would not affect. The simulated results from Grovermann et al. (2017) show that in order to achieve a similar percentage reduction of pesticide use, a combination of an integrated pest management scheme and a subsidy scheme would be less expensive than the combination of an integrated pest management scheme and a price premium. Depending on farmer's behavioral characteristics, farmers' responses to incentives might be more or less heterogeneous.

### 5.3 The impact of cooperative governance on pesticide choices

In addition, this study has tested the effect of cooperatives on the choice of restricted pesticides through a propensity score matching (PSM) method. In order to test the average impact of joining a cooperative, this study follows Abebaw and Haile (2013) and Faltermeier and Abdulai (2009)'s way. Three kinds of matching, nearest-neighbor matching, kernel-based matching, and radius matching, are applied in the following tests for ensuring robustness. Table 5.4 shows the results of the estimations of ATT of cooperative on the revealed use of restricted pesticides as well as the choice of recommended pesticides. It is shown in Table 5.4 that if farmers would be members of a cooperative, they are more likely to use recommended pesticides. Whereas, the estimation results do not show that being cooperative members have an impact on the choice of restricted pesticides. According to the results of nearest neighbor matching, kernel matching, and radius matching, the rate of using recommended pesticides would increase by 13%, 12.4%, and 12%, respectively. For all these matching methods with regard to ATT of cooperative on the use of restricted pesticides and recommended, there are 115 treated observations, while 278 observations are untreated. Six treated observations are off support in kernel matching and radius matching.

Table 5.4: Estimation of ATT of cooperative governance

| Matching estimator | ATT of cooperative on the use of restricted pesticides | | | | | ATT of cooperative on the use of recommended pesticides | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Treated | Controls | Difference | [90% Confidence Interval] | | Treated | Controls | Difference | [90% Confidence Interval] | |
| Nearest neighbor matching (number of matches=5) | 0.183 | 0.155 | 0.028<br>(0.046) | -0.048 | 0.104 | 0.696 | 0.565 | 0.130<br>(0.060) | 0.031 | 0.229 |
| Kernel matching (bandwidth=0.01) | 0.193 | 0.141 | 0.052<br>(0.047) | -0.025 | 0.129 | 0.697 | 0.574 | 0.124<br>(0.061) | 0.024 | 0.224 |
| Radius matching (caliper=0.01) | 0.193 | 0.143 | 0.050<br>(0.046) | -0.026 | 0.126 | 0.697 | 0.578 | 0.120<br>(0.060) | 0.021 | 0.219 |

*Source: Own calculation using IAMO-SAU vegetable farmer survey.*

*Note: ATT estimations of all these three matches are applying through 'psmatch2' command in Stata. Personal, household, and farming characteristics enter as explanatory variables. Detailed results are available upon request. Coefficients are shown on top of the standard errors in the parentheses.*

After obtaining the results of the PSM, it still needs some balancing tests to ensure the quality of matching (Lee, 2013). In order to evaluate the reliability of ATT estimation on the use of recommended pesticides, this study applies the balancing test based on kernel matching for testing the balanced characteristics of cooperative farmers and others. Table 5.5 shows the results of the balancing test. The standardized differences of personal, household, and farming characteristics are in the range of 0.6% to 13.5%. According to Rosenbaum and Rubin (1985)'s suggestion that the matching can be regarded as successful when all standardized differences are less than 20%, the result of the balancing test matches the expectation.

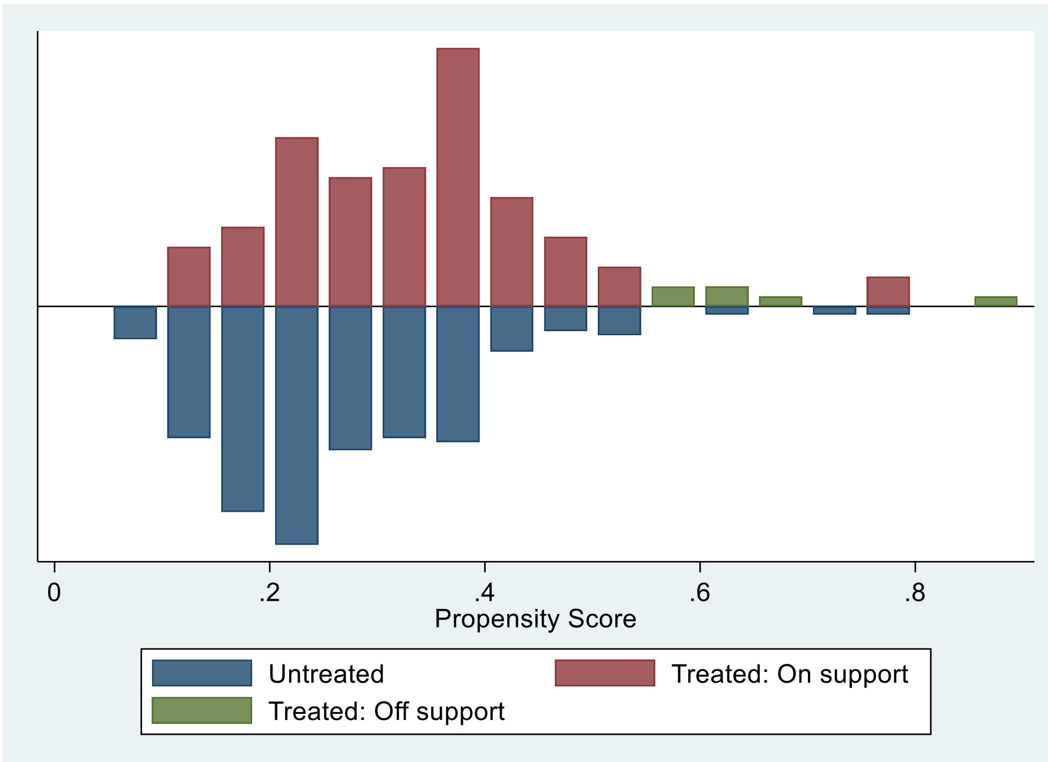
Table 5.5: Test of matching quality

| Variable | Mean | | %bias | %reduction \|bias\| | t-statistics |
|---|---|---|---|---|---|
| | Cooperative member | Non-cooperative member | | | |
| Age | 52.037 | 51.291 | 7.3 | 54.6 | 0.53 |
| Planted area | 43.449 | 28.786 | 13.5 | 61.2 | 1.32 |
| Educational level | 2.881 | 2.919 | -4.1 | 91.2 | -0.30 |
| Off-farm job | 0.670 | 0.709 | -8.1 | 73.5 | -0.62 |
| Distance to fair | 3.805 | 3.832 | -0.6 | 96.9 | -0.05 |
| Household members | 4.578 | 4.734 | -9.3 | 53.9 | -0.71 |
| Selling price | 1.148 | 1.124 | 2.5 | 68.1 | 0.21 |
| Cost of pesticides | 207.1 | 200.07 | 2.9 | 18.7 | 0.22 |

*Source: Own calculation using IAMO-SAU vegetable farmer survey.*

In addition to the balancing test, the distribution of the estimated propensity scores of kernel matching for cooperative-members and non-cooperative-members is shown in Figure 5.2. The distribution figure is obtained through 'psgraph' command in the package of 'psmatch2' in STATA after executing kernel matching (Leuven and Sianesi, 2003). It shows that most of both, cooperative-members and non-cooperative-members, have substantial overlap while just six observations are off support for treated samples.

Figure 5.2: Propensity score of kernel matching




*Source: Own representation using IAMO-SAU vegetable farmer survey.*

### 5.4 Instruments, cooperative, and pesticide choices

After testing the ATT of cooperative, a Logit model is applied to estimate the interaction effect of instruments within cooperatives on the choices of pesticides. Table 5.6 shows the results of the choice model for both pesticide choices whether farmers use restricted pesticides and whether farmers use recommended pesticides. This study uses only matched observations in the Logit model in order to retain consistency with the previous analysis. Thus, 387 observations are included in the Logit model. As the interpretation for the coefficients in the Logit model is indirect, the average marginal effect is also shown following the coefficient in Table 5.6. The first six columns of Table 5.6 show the regression results for the use of restricted pesticides, while the results for the use of recommended pesticides are included in the last six columns.

Table 5.6: Results of Logit regression for pesticide choices

| Variables | Use of restricted pesticides | | | | | | Use of recommended pesticides | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coefficient | [90% Confidence Interval] | | Average marginal effect | [90% Confidence Interval] | | Coefficient | [90% Confidence Interval] | | Average marginal effect | [90% Confidence Interval] | |
| Member of a cooperative | 1.165 | 0.007 | 2.322 | 0.120 | 0.002 | 0.238 | 0.862 | -0.295 | 2.020 | 0.152 | -0.051 | 0.356 |
| | (0.704) | | | (0.072) | | | (0.704) | | | (0.124) | | |
| Training program | -1.203 | -2.028 | -0.378 | -0.124 | -0.208 | -0.040 | 0.315 | -0.246 | 0.876 | 0.056 | -0.043 | 0.155 |
| | (0.502) | | | (0.051) | | | (0.341) | | | (0.060) | | |
| Training program * Cooperative member | -0.103 | -1.662 | 1.455 | -0.011 | -0.171 | 0.150 | -1.282 | -2.727 | 0.162 | -0.227 | -0.480 | 0.026 |
| | (0.947) | | | (0.098) | | | (0.878) | | | (0.154) | | |
| Supply | -0.099 | -1.323 | 1.126 | -0.010 | -0.136 | 0.116 | -0.063 | -0.949 | 0.823 | -0.011 | -0.168 | 0.146 |
| | (0.744) | | | (0.077) | | | (0.539) | | | (0.095) | | |
| Supply * Cooperative member | 0.133 | -1.445 | 1.711 | 0.014 | -0.149 | 0.176 | 0.232 | -1.019 | 1.484 | 0.041 | -0.180 | 0.262 |
| | (0.960) | | | (0.099) | | | (0.761) | | | (0.135) | | |
| Test | 0.961 | 0.133 | 1.789 | 0.099 | 0.014 | 0.184 | 0.092 | -0.491 | 0.675 | 0.016 | -0.087 | 0.119 |
| | (0.503) | | | (0.051) | | | (0.354) | | | (0.063) | | |
| Test* Cooperative member | -0.193 | -1.621 | 1.234 | -0.020 | -0.167 | 0.127 | 0.956 | -0.243 | 2.156 | 0.169 | -0.041 | 0.380 |
| | (0.868) | | | (0.089) | | | (0.729) | | | (0.128) | | |
| Certification | 0.063 | -0.681 | 0.808 | 0.007 | -0.070 | 0.083 | 1.393 | 0.813 | 1.973 | 0.246 | 0.152 | 0.341 |
| | (0.453) | | | (0.047) | | | (0.353) | | | (0.058) | | |
| Certification * Cooperative member | 0.245 | -0.940 | 1.431 | 0.025 | -0.097 | 0.147 | -0.182 | -1.233 | 0.868 | -0.032 | -0.218 | 0.154 |
| | (0.721) | | | (0.074) | | | (0.639) | | | (0.113) | | |
| Record | 0.084 | -0.760 | 0.927 | 0.009 | -0.078 | 0.096 | -0.724 | -1.396 | -0.053 | -0.128 | -0.245 | -0.011 |
| | (0.513) | | | (0.053) | | | (0.408) | | | (0.071) | | |
| Record * Cooperative member | -0.993 | -2.287 | 0.302 | -0.102 | -0.235 | 0.030 | -0.049 | -1.131 | 1.034 | -0.009 | -0.200 | 0.183 |
| | (0.787) | | | (0.081) | | | (0.658) | | | (0.116) | | |
| Age | 0.022 | -0.008 | 0.053 | 0.002 | -0.001 | 0.005 | -0.016 | -0.038 | 0.007 | -0.003 | -0.007 | 0.001 |
| | (0.019) | | | (0.002) | | | (0.014) | | | (0.002) | | |
| Planted area | -0.001 | -0.006 | 0.004 | -0.0001 | -0.001 | 0.000 | 0.006 | 0.001 | 0.010 | 0.001 | 0.000 | 0.002 |
| | (0.003) | | | (0.0003) | | | (0.003) | | | (0.0004) | | |
| Educational level | 0.360 | 0.020 | 0.700 | 0.037 | 0.002 | 0.072 | 0.202 | -0.047 | 0.452 | 0.036 | -0.008 | 0.080 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (0.207) | | | (0.021) | | | (0.152) | | | (0.027) | | |
| Off-farm job | 0.922 | 0.269 | 1.575 | 0.095 | 0.028 | 0.162 | -0.035 | -0.494 | 0.423 | -0.006 | -0.087 | 0.075 |
| | (0.397) | | | (0.041) | | | (0.279) | | | (0.049) | | |
| Distance to fair | 0.086 | 0.035 | 0.136 | 0.009 | 0.004 | 0.014 | 0.008 | -0.042 | 0.058 | 0.001 | -0.007 | 0.010 |
| | (0.031) | | | (0.003) | | | (0.030) | | | (0.005) | | |
| Household members | 0.156 | -0.019 | 0.331 | 0.016 | -0.002 | 0.034 | -0.021 | -0.156 | 0.114 | -0.004 | -0.028 | 0.020 |
| | (0.106) | | | (0.011) | | | (0.082) | | | (0.015) | | |
| Selling price | 0.308 | 0.037 | 0.579 | 0.032 | 0.004 | 0.059 | -0.481 | -0.725 | -0.237 | -0.085 | -0.126 | -0.044 |
| | (0.165) | | | (0.017) | | | (0.149) | | | (0.025) | | |
| Cost of pesticides | 0.0004 | -0.001 | 0.002 | 0.00004 | -0.000 | 0.000 | 0.004 | 0.003 | 0.006 | 0.0008 | 0.001 | 0.001 |
| | (0.0007) | | | (0.00008) | | | (0.001) | | | (0.0001) | | |
| Constant | -6.337 | -8.856 | -3.818 | | | | -1.120 | -1.864 | 1.623 | | | |
| | (1.531) | | | | | | (1.060) | | | | | |
| Observations | | | | | | | | | | | | 387 |

*Source: Own calculation using IAMO-SAU vegetable farmer survey.*
*Note: standard errors are shown in the parentheses*

It is shown that members of a cooperative who do not take any of the selected food safety instruments, which account for a small proportion (about 15%) of cooperative members, are predicted to have a higher likelihood to use restricted pesticides from the first six columns of Table 5.6. The average marginal effect of membership is 0.120, which means that joining a cooperative with no food safety instruments would increase the probability of using restricted pesticides by 12%. Yet the coefficient of cooperative for recommended pesticides has a relatively high standard error. It is, thus, not possible to differentiate both groups of farmers based on their use of recommended pesticides.

Turning to the effect of the instruments analyses, the estimated coefficient of training program is -1.203 with a standard error of 0.502. This coefficient is corresponding to an average marginal effect of -0.124 for training program. It means that a training program helps to decrease the probability of using restricted pesticides for non-cooperative members by 12.4%. In order to test the effect of each instrument for cooperative members, this study follows Wooldridge (2016) who suggests testing a joint hypothesis. Thus, the effect of training program by cooperative is tested through an F-test of the joint hypothesis of instruments and the product of instruments and cooperative dummy. For the variable training program, the value of Prob > chi2 of the F-test of the joint hypothesis is 0.015, which suggests rejecting the null hypothesis that there is no effect of training program for cooperative members on the choice of restricted pesticides. Thus, the average marginal effect of training program on the use of restricted pesticides is -0.135, which means such an instrument would decrease the probability of using restricted pesticides by 13.5% for cooperative members. However, a training program from a cooperative does not show a significant additional impact for members.

Moreover, the estimated coefficient of testing of final products for farmers is 0.961 with a standard error of 0.503. This coefficient is corresponding to an average marginal effect of 0.099. It means that a test of final products outside a cooperative is predicted to increase the likelihood by 9.9%. In addition, the value of Prob > chi2 of the F-test of the joint hypothesis of the variable test is 0.093. Thus, it is suggested to reject the null hypothesis that there is no effect of test for cooperative members on the choice of restricted pesticides. The average marginal effect of test is 0.079. It means the probability of using restricted pesticides would increase by 7.9% for cooperative members when farmer's output is subject to testing. The test from cooperatives shows the opposite effect to the tests outside a cooperative, but not significant in this case.

In addition, educational level, off-farm jobs, distance to fair and selling price are estimated to have a positive effect on the use of restricted pesticides when other things are held constant. The coefficient of educational level is 0.360 which corresponds to an average marginal effect of 0.037. This means that more educated farmers show a higher probability to use restricted pesticides and the likelihood increases by 3.7% restricted. In addition, the coefficients of off-farm jobs and distance to fair are 0.922 and 0.086, respectively, which correspond to an average marginal effect of 0.095 and 0.009. Thus, the probability of using restricted pesticides would raise by 9.5% if household members have an off-farm job(s), while one more kilometer from home to the nearest fair is also related to a higher probability of using restricted pesticides by 0.9%. An off-farm job(s) could be related to time constraints for farming where pesticides with a lower frequency of application and higher effectiveness would be more attractive. Restricted pesticides are normally with high toxicity and may be believed to have such function by farmers. Moreover, the coefficient of selling price is 0.308, corresponding to an average marginal effect of 0.032. It means that an increase of selling price by one Chinese yuan per 500 grams would increase the probability of using restricted pesticides by 3.2%. This may because vegetable farmers believe that restricted pesticides are better suited to ensure the yield and appearance compared to other kinds of pesticides.

The last six columns of Table 5.6 show the estimated results for the use of recommended pesticides. The results show that cooperative members who do not receive any instrument do not differ in the use of recommended pesticides significantly compared to other farmers in a statistical sense. With regard to the results of instruments, certification, and record keeping show an impact on the use of recommended pesticides. The coefficients of certification and record keeping are 1.393 and -0.724, respectively, which corresponds to a marginal effect of 0.246 and -0.116, respectively. The p-value of joint F-test for certification and record keeping are 0.000 and 0.071, respectively. This means cooperative farmers who join a certification program of green food, hazard-free food, and organic food are more likely to use recommended pesticides by 21.4%. Whereas, record keeping harms the use of recommended pesticides. The probability for cooperative members is predicted to decline by 13.7% if farmers record the names of pesticides. Again, cooperatives do not significantly differ in the effect of these two instruments on the use of recommended pesticides compared to other governance structures.

Some personal and farming characteristics such as planted area and cost of pesticides show a positive impact on the use of recommended pesticides. The coefficients of planted area and costs of pesticides are 0.006 and 0.004, respectively. Consequently, the average marginal effect of planted area and costs of pesticides are 0.001 and 0.0008, respectively. These results indicate that an increase of planted area by 100 mu would result in a higher probability of using recommended pesticides by 10%. This might be driven by that large farms might market their products directly to shops and, thus, are forced to focus more on reducing food safety risks. The higher average cost of pesticides by 100 yuan is correlated with a higher probability of using recommended pesticides by 8%. This result might capture the fact that recommended pesticides are normally more expensive than traditional ones. Thus, a causal interpretation is not appropriate here. In contrast, selling price shows the opposite influence. The coefficient and average marginal effect of selling price are -0.481 and -0.085, respectively. This indicates that a higher selling price is related to a lower probability of using recommended pesticides. More specifically, an increase in selling price by one yuan per 500 grams would decrease the probability of using recommended pesticides by 8.5%. This might be caused by the fact that there is no efficient way to distinguish the quality of vegetables currently. Thus, a "Market for Lemons" effect could show up here, where farmers would decrease the use of recommended pesticides for insuring a better appearance and higher yields as soon as vegetable production becomes more profitable due to higher prices. In addition, the existence of a binding budget constraint could be an alternative explanation. Given that recommended pesticides would be more expensive, farmers would not switch to those pesticides for keeping yield as long as farmers have a binding budget constraint for the expenses on pest control.

# 6 Conclusion and implications

## 6.1 Conclusion

Neoclassical economic theory has been criticized for oversimplifying human behavior. However, different responses to perceived values of gains and losses with the same value have been shown in the literature. In addition, the probability weighting is not consistent with a linear assessment of probabilities as assumed by neoclassical economic theory. Thus, the degree of loss aversion and probability weighting may also affect decision-making when facing uncertainty. This research provides empirical evidence for a more heterogeneous behavioral attitude among vegetable farmers by quantifying such parameters of risk preference.

Risk preferences play an important role in explaining pesticide use quantitatively. Given that income from agricultural production is closely related to yield risk, farmers with different risk preferences differ in pesticide use to achieve higher yields and, hence, higher profits. Despite the potential impact of risk preferences on pesticide use, there is still a gap on how risk preferences influence the amount of pesticide use for vegetables, conditional upon prospect theory. This study firstly provides insight into the risk preference parameters based on prospect theory among vegetable farmers. Furthermore, the effect of risk aversion, loss aversion, and weighted probability on pesticide use quantitatively are studied.

The results show that 68.4% of farmers are risk-averse with respect to yield risk. 387 farmers (98.5%), in addition, show cognitive biases in probability weighting, while 129 farmers (32.8%) weigh the probability of potential yield loss due to hazard higher than the probability of gains. Moreover, 59.8% of farmers show aversion to yield loss.

The estimation results show that the risk aversion does not have a consistent association with pesticide use quantitatively when relying on a 90% confidence interval from both measures, the amount and the cost of pesticides. However, loss aversion can positively influence the amount of pesticide use. Farmers who have a greater loss aversion regarding yield loss are more likely to apply more pesticides during the growing season. Moreover, a higher weighted probability of hazards is associated with more pesticide use. From the results of the average cost of pesticides, it is also shown that the number of family members has a positive association with the cost of pesticides.

Taking mental budgeting into account can improve the understanding of farmers' choices of pest control measures. Given that most farmers categorize different agricultural inputs, farmers who engage in mental budgeting seem to react more to monetary incentives from different income sources. This study firstly provides some evidence on whether vegetable farmers engage in mental budgeting in terms of pest control practices. In addition, it contributes to explanatorily extending the potential effect of mental budgeting to production decision making, and provides some evidence on how mental budgeting of different monetary incentives affects pest control among vegetable farmers in Sichuan, China. Moreover, this study provides a better understanding of the decision mechanism by taking psychological factors into account compared to current studies.

The results indicate that the majority of vegetable farmers surveyed categorize agricultural inputs into different groups. Mental budgeting is used by slightly more than one-quarter of the respondents and plays an important role in the effect of incentives. Farmers who engage in mental budgeting report a higher willingness to switch to low-toxicity pesticides than other farmers when they face a specific subsidy. However, among farmers who engage in mental budgeting, there is not sufficient evidence showing that a price premium has a stronger effect on the willingness to switch to low-toxicity pesticides compared to farmers who do not apply mental budgeting.

The choices of pesticides are highly related to the safety of vegetable production. Consequently, cooperative governance is expected to control the choices of pesticides more efficiently as the rising intensity of instruments in cooperative governance. Recent studies show that there is plenty of food safety related instruments that are implemented in cooperatives across China. Such instruments, such as social capital, would have an impact on chemical inputs use (Zhou et al., 2015, Zhou et al., 2016, Zhou et al., 2018). However, empirical studies on the impact of the effect of cooperative governance on pesticide choices are limited. To the author's knowledge, there are limited quantitative micro-econometric studies that examine whether and how far cooperative governance and the instruments inside have an impact on the use of restricted pesticides and recommended pesticides for vegetable farmers in China.

This study also aims at understanding the effect of cooperative governance on the choices of using restricted pesticides and recommended pesticides for vegetable farmers. It is also interesting to understand whether and how far cooperatives and other governance structures differ in the effect of different instruments on the choices of restricted pesticides and recommended pesticides. In order to test such effect of cooperative and instruments, a choice method with interaction variables is used.

The results of the PSM model show that cooperative governance has a positive impact on encouraging the use of recommended pesticides. 12% to 13% of vegetable farmers would use recommended pesticides if they would join a cooperative. In addition, the results of this study do not show evidence that joining a cooperative has an impact on limiting the use of restricted pesticides. The results of the interaction effect support the conclusion that the food safety related instruments have a differentiating effect within and outside cooperatives. Thus, the different use of these instruments across cooperatives might be more important.

The results from the Logit model show that cooperative members who do not receive any selected instruments are predicted to have a higher likelihood of using restricted pesticides. One reason might be that current public food safety related instruments are not quite effective for observing the choices of pesticides. Such information asymmetry may increase the rate of using restricted pesticides by cooperative members who do not receive any selected instruments. Furthermore, a training program regarding pest controls is found to have a negative effect on the choice of restricted pesticides. However, such an instrument in a cooperative does not differ in the effect on decreasing the rate of using restricted pesticides compared to training programs outside a cooperative. As a result of limited training programs, farmers' limited knowledge about restricted pesticides may increase the use of restricted pesticides (Wang et al., 2015). Additionally, a quality test for products shows a negative impact on limiting the use of restricted pesticides for non-cooperative-members. Although tests in a cooperative show an opposite coefficient to the tests outside, there is still evidence showing that a quality test increases the use of restricted pesticides in a cooperative. This probably because current tests are not very suitable for testing all pesticides. Firstly, tests are often found in vegetable supply chains where there is a large number of vegetables. Spot check cannot test every batch of vegetables sold in the markets. Second, rapid pesticide detection, which is widely used for pesticide residue tests, is helpless to test some pesticides such as organochlorine pesticides and other high-toxicity pesticides. Third, rapid pesticide detection is not suitable for some vegetables such as onions, garlic, parsley, and mushrooms. Given the limited quality test systems, farmers may pay more attention to the quality of vegetable appearance rather than safety. With respect to the use of recommended pesticides, no strong evidence showing that joining a cooperative with no food safety related instruments would have an additional impact on the use of such pesticides. Certification shows a positive impact on encouraging the use of recommended pesticides, while record keeping shows an opposite effect for both cooperative members and non-members.

Personal, household, and farming characteristics also show heterogeneity in the choices of using restricted pesticides and recommended pesticides. Households that family members have off-farm jobs are more likely to use restricted pesticides. A higher selling price is related to a higher probability of using restricted pesticides, as well as a lower probability of using recommended pesticides. This may because farmers prefer to keep the yields and current recommended pesticides are less competitive than normal ones. Besides, the distance to the nearest fair is shown a positive impact on the use of restricted pesticides. In addition, farmers with larger vegetable planted areas are more willing to choose recommended pesticides for vegetable production.

## 6.2 Implications

### *6.2.1 Policy implications*

As the use of a higher amount of pesticides and of more average cost on pesticides is associated with farmer's loss aversion, it is crucial in designing appropriate interventions to reflect this behavioral pattern. In order to mitigate unnecessary pesticide use, two aspects are worth to be considered by government and private actors in developing future policies. First, as the pain caused by a potential loss is perceived to be greater than the gain by an equivalent return both in comparison to an expected yield, farmers with higher loss aversion will use more pesticides. Thus, a more stable income should incentivize farmers to use a lower amount of pesticides. A possible strategy could be to promote contract farming where a stable pre-announced payment could be combined with additional payments for delivery in excess of a pre-agreed quantity (Huang and Liang, 2018, Bonazzi and Iotti, 2014). This measure separates the income with higher risk into two parts, a stable part without losses and a risky part with lower risk. It is, second, essential to decrease the weighted probability of potential yield loss. In order to solve such a problem, farmers' perception of the probability of potential hazards is a key factor. A hazard warning system should be provided to help farmers develop more realistic expectations as well as more education and training about different kinds of pesticides. The latter is expected to affect farmer's perception of hazards and will translate into a better informed weighted probability.

The results regarding the effect of mental budgeting point in a similar direction as findings by Ocean and Howley (2019) or Grovermann et al. (2017). Depending on their behavioral attitudes farmers respond differently to general monetary incentives when compared with more targeted incentives. Thus, if governments or private organizations, such as cooperatives, want to change farmers' pest control practices through monetary policies, it is better to use specific incentives such as specific subsidies rather than the pricing of agricultural products that cover more than one category of agricultural inputs. Such types of 'nudge[10]' would be important for future subsidy schemes in order to achieve higher effectiveness for political tools.

However, it is worth noting that current literature also provides evidence that subsidies, such as grain subsidy and fertilizer subsidy, do not always result in the desired impact on changing farmers' production behavior (Huang et al., 2011). The main reason is that some farmers do not know the value of such subsidy, or even misunderstand the subsidy (Huang et al., 2011). This would probably lead to an allocation of money received into other mental budgets rather than the budgets which subsidies aim at. Thus, it is important to reflect upon farmers' understanding of designing and implementing subsidy schemes.

There are also some implications from the results of the effect of cooperative and food safety related instruments. Although there is no evidence shows that food safety related instruments in cooperatives have a stronger effect on limiting the use of restricted pesticides, cooperative members are received a higher intensity of programs than other farmers. Thus, cooperatives still play an important role in food safety control, especially considering the policy perspective. According to the results of the Logit regression, it is essential for cooperatives to increase the quality of training programs in order to improve farmer's knowledge regarding pesticide use and decrease the use of restricted pesticides. Moreover, these results show that not only having instruments, but the effectiveness of each current food safety related instruments also needs to be enhanced, especially quality test which show a negative impact on limiting the use of restricted pesticides and record which show a negative impact on encouraging the use of recommended pesticides. Thus, it is, on the one hand, necessary to refine undesirable instruments beforehand. For example, improve tests and test each batch of vegetables in the quality test and record the results which could affect farmers' credit records. On the other hand, it is also important to expand the implementation of desirable instruments such as training programs and certification.

[10] Nudge is any aspect of the choice that could predictably influence people's behavior without either forbidding any options or changing economic incentives.

### *6.2.2 Methodological implications*

In addition to policy implications, there are some methodological implications from this thesis with respect to mental budgeting. Although the quantitative results regarding the effect of mental budgeting apply to the sample of this study only, some conclusions do have some external validity. In particular, the methodology can be applied for the study of other aspects in agriculture such as monetary incentive schemes for organic agriculture, resource conservation efforts, agricultural technologies, or adoption of sustainable practices. Given the effect of a 'nudge', a more specific monetary incentive scheme would have a higher effectiveness than general ones. Furthermore, replicating the approach of this study on a nationally representative sample of farmers would allow deriving conclusions with external validity.

Reflecting on the experimental design and analysis and conditional upon availability of resources, some aspects could be changed in follow-up studies. First, in designing the incentive set the scale effect should be taken into account in order to test whether farmers with different farm sizes react differently. Second, other income sources and categories of costs of agricultural production may have an impact on the budget of pesticides when farmers regard additional inputs (e.g. treated seeds) as a pest control tool. Thus, more income sources and categories could be included. Third, future studies could be based on experiments using randomly controlled treatments rather than hypothetical assumptions. Implementing different incentive schemes would provide methodologically soundest results.

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# Appendix

Table A. 1: Approximations of the risk aversion (σ) and the corresponding switching questions

| *σ* | Switch questions in series 1 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Series 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | Never |
| 1 | 1.5 | 1.4 | 1.35 | 1.25 | 1.15 | 1.1 | 1 | 0.95 | 0.9 | 0.85 | 0.8 | 0.75 | 0.65 | 0.55 | 0.5 |
| 2 | 1.4 | 1.3 | 1.25 | 1.15 | 1.1 | 1 | 0.95 | 0.9 | 0.85 | 0.8 | 0.75 | 0.7 | 0.6 | 0.55 | 0.5 |
| 3 | 1.3 | 1.2 | 1.15 | 1.1 | 1 | 0.95 | 0.9 | 0.85 | 0.8 | 0.75 | 0.7 | 0.65 | 0.55 | 0.5 | 0.45 |
| 4 | 1.2 | 1.15 | 1.05 | 1 | 0.95 | 0.9 | 0.85 | 0.8 | 0.75 | 0.7 | 0.65 | 0.6 | 0.5 | 0.45 | 0.4 |
| 5 | 1.15 | 1.05 | 1 | 0.95 | 0.9 | 0.85 | 0.8 | 0.75 | 0.7 | 0.65 | 0.6 | 0.55 | 0.5 | 0.4 | 0.35 |
| 6 | 1.05 | 1 | 0.95 | 0.9 | 0.85 | 0.8 | 0.75 | 0.7 | 0.65 | 0.6 | 0.55 | 0.5 | 0.45 | 0.4 | 0.35 |
| 7 | 1 | 0.95 | 0.9 | 0.85 | 0.8 | 0.75 | 0.7 | 0.65 | 0.6 | 0.55 | 0.5 | 0.45 | 0.4 | 0.35 | 0.3 |
| 8 | 0.95 | 0.9 | 0.85 | 0.8 | 0.75 | 0.7 | 0.65 | 0.6 | 0.55 | 0.5 | 0.45 | 0.4 | 0.35 | 0.3 | 0.25 |
| 9 | 0.9 | 0.85 | 0.8 | 0.75 | 0.7 | 0.65 | 0.6 | 0.55 | 0.5 | 0.45 | 0.4 | 0.35 | 0.3 | 0.25 | 0.2 |
| 10 | 0.85 | 0.8 | 0.75 | 0.7 | 0.65 | 0.6 | 0.55 | 0.5 | 0.45 | 0.4 | 0.35 | 0.3 | 0.25 | 0.2 | 0.2 |
| 11 | 0.8 | 0.7 | 0.65 | 0.65 | 0.6 | 0.55 | 0.5 | 0.45 | 0.4 | 0.35 | 0.3 | 0.25 | 0.2 | 0.15 | 0.15 |
| 12 | 0.75 | 0.65 | 0.6 | 0.55 | 0.5 | 0.5 | 0.45 | 0.4 | 0.35 | 0.3 | 0.25 | 0.2 | 0.2 | 0.15 | 0.1 |
| 13 | 0.65 | 0.6 | 0.55 | 0.5 | 0.45 | 0.45 | 0.4 | 0.35 | 0.3 | 0.25 | 0.2 | 0.15 | 0.15 | 0.1 | 0.1 |
| 14 | 0.6 | 0.55 | 0.5 | 0.45 | 0.4 | 0.35 | 0.35 | 0.3 | 0.25 | 0.2 | 0.15 | 0.1 | 0.1 | 0.1 | 0.05 |
| Never | 0.5 | 0.45 | 0.4 | 0.4 | 0.35 | 0.3 | 0.3 | 0.25 | 0.2 | 0.15 | 0.1 | 0.1 | 0.05 | 0.05 | 0.05 |

*Source: Tanaka et al. (2010).*

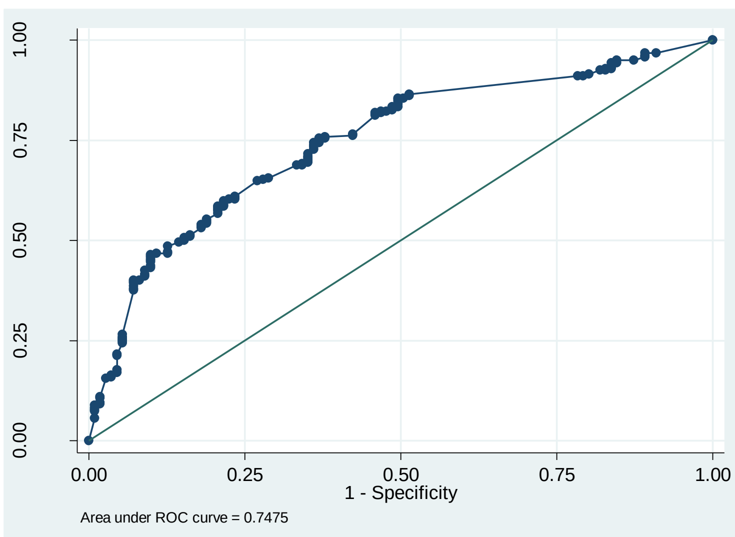
Table A. 2: Approximations of the parameter of probability weighting (δ) and the corresponding switching questions

| $\delta$ | Switch questions in series 1 | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Series 2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | Never |
| 1 | 0.6 | 0.75 | 0.75 | 0.85 | 0.9 | 0.95 | 1 | 1.05 | 1.1 | 1.15 | 1.2 | 1.25 | 1.3 | 1.4 | 1.45 |
| 2 | 0.6 | 0.7 | 0.75 | 0.8 | 0.85 | 0.9 | 0.95 | 1 | 1.05 | 1.1 | 1.15 | 1.2 | 1.25 | 1.35 | 1.4 |
| 3 | 0.55 | 0.6 | 0.7 | 0.75 | 0.8 | 0.85 | 0.9 | 0.95 | 1 | 1.05 | 1.1 | 1.15 | 1.2 | 1.25 | 1.3 |
| 4 | 0.5 | 0.6 | 0.65 | 0.7 | 0.75 | 0.8 | 0.85 | 0.9 | 0.95 | 1 | 1.05 | 1.1 | 1.15 | 1.2 | 1.25 |
| 5 | 0.45 | 0.55 | 0.6 | 0.65 | 0.7 | 0.75 | 0.8 | 0.85 | 0.9 | 0.95 | 1 | 1.05 | 1.1 | 1.15 | 1.2 |
| 6 | 0.45 | 0.5 | 0.55 | 0.6 | 0.65 | 0.7 | 0.75 | 0.8 | 0.85 | 0.9 | 0.95 | 1 | 1.05 | 1.1 | 1.15 |
| 7 | 0.4 | 0.45 | 0.5 | 0.55 | 0.6 | 0.65 | 0.7 | 0.75 | 0.8 | 0.85 | 0.9 | 0.95 | 1 | 1.05 | 1.1 |
| 8 | 0.35 | 0.4 | 0.45 | 0.5 | 0.55 | 0.6 | 0.65 | 0.7 | 0.75 | 0.8 | 0.85 | 0.9 | 0.95 | 1 | 1.05 |
| 9 | 0.3 | 0.35 | 0.4 | 0.45 | 0.5 | 0.55 | 0.6 | 0.65 | 0.7 | 0.75 | 0.8 | 0.85 | 0.9 | 0.95 | 1 |
| 10 | 0.25 | 0.3 | 0.35 | 0.4 | 0.45 | 0.5 | 0.55 | 0.6 | 0.65 | 0.7 | 0.75 | 0.8 | 0.85 | 0.9 | 0.95 |
| 11 | 0.2 | 0.25 | 0.3 | 0.35 | 0.4 | 0.45 | 0.5 | 0.55 | 0.6 | 0.65 | 0.7 | 0.75 | 0.8 | 0.85 | 0.9 |
| 12 | 0.15 | 0.2 | 0.25 | 0.3 | 0.35 | 0.4 | 0.45 | 0.5 | 0.55 | 0.6 | 0.65 | 0.7 | 0.75 | 0.8 | 0.85 |
| 13 | 0.1 | 0.15 | 0.2 | 0.25 | 0.3 | 0.35 | 0.4 | 0.45 | 0.5 | 0.55 | 0.6 | 0.65 | 0.7 | 0.75 | 0.8 |
| 14 | 0.05 | 0.1 | 0.15 | 0.2 | 0.25 | 0.3 | 0.35 | 0.4 | 0.45 | 0.5 | 0.55 | 0.6 | 0.65 | 0.7 | 0.75 |
| Never | 0.05 | 0.05 | 0.1 | 0.15 | 0.2 | 0.25 | 0.3 | 0.35 | 0.4 | 0.45 | 0.5 | 0.55 | 0.6 | 0.65 | 0.6 |

*Source: Tanaka et al. (2010).*

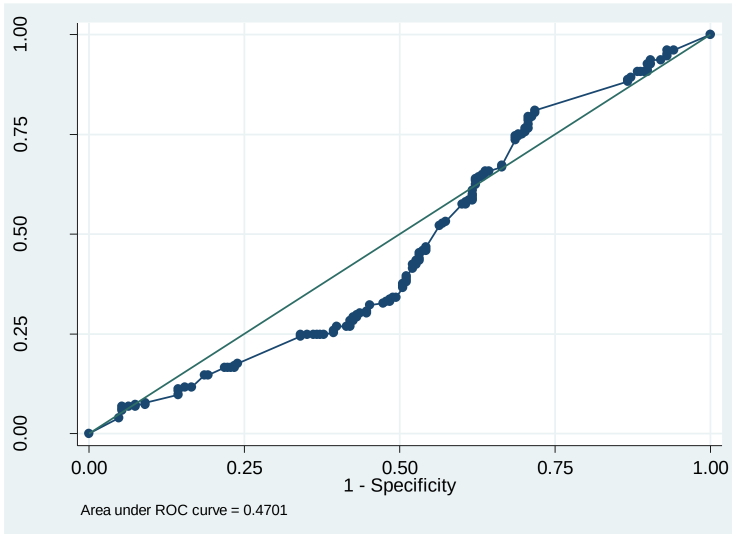
In order to test the ROC of the predictive power of the Probit model, this study uses the opposite number of mental budgeting factor scores because a lower score is related to a higher likelihood to engage in mental budgeting. Then ROC curves are drawn for both situations (with a subsidy and with a price premium). Figure A. 1 and A. 2 show the ROC curves for subsidy and price premium for all samples, respectively. An AUC (area under ROC curve) of 0.7475 shows that the result of the effect of mental budgeting on the willingness to switch to low-toxicity pesticides is moderate, while the result for a price premium does not show a stable effect on such willingness due to an AUC of 0.4701.

Figure A. 1: ROC curve for subsidy for total sample




*Source: Own representation using IAMO-SAU vegetable farmer survey.*

Figure A. 2: ROC curve for price premium for total sample




*Source: Own representation using IAMO-SAU vegetable farmer survey.*

Table A. 3: Probit regression results for the willingness to switch of low-toxicity pesticides by re-grouping mental budgeting scales

| Variables | Agricultural revenue with price premiums for quality | | | | | | Subsidy | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Coefficient | [90% Confidence Interval] | | Average marginal effect | [90% Confidence Interval] | | Coefficient | [90% Confidence Interval] | | Average marginal effect | [90% Confidence Interval] | |
| Mental budgeting dummy 2 | -0.497 | -0.722 | -0.272 | -0.186 | -0.265 | -0.106 | 1.021 | 0.739 | 1.303 | 0.300 | 0.227 | 0.372 |
| | (0.137) | | | (0.048) | | | (0.171) | | | (0.044) | | |
| Age | -0.017 | -0.028 | -0.005 | -0.006 | -0.011 | -0.002 | -0.015 | -0.028 | -0.002 | -0.005 | -0.008 | -0.001 |
| | (0.007) | | | (0.003) | | | (0.008) | | | (0.002) | | |
| Farm size | 0.00005 | -0.001 | 0.001 | -0.0002 | -0.000 | 0.000 | 0.001 | -0.001 | 0.003 | 0.0003 | -0.000 | 0.001 |
| | (0.007) | | | (0.0003) | | | (0.001) | | | (0.0004) | | |
| Educational level | -0.067 | -0.199 | 0.064 | -0.025 | -0.074 | 0.024 | 0.066 | -0.079 | 0.210 | 0.019 | -0.023 | 0.061 |
| | (0.080) | | | (0.030) | | | (0.088) | | | (0.026) | | |
| Off-farm job | -0.390 | -0.622 | -0.159 | -0.146 | -0.230 | -0.062 | -0.133 | -0.381 | 0.114 | -0.039 | -0.112 | 0.033 |
| | (0.140) | | | (0.051) | | | (0.151) | | | (0.044) | | |
| Lnincome | 0.136 | 0.035 | 0.237 | 0.051 | 0.014 | 0.088 | 0.112 | 0.020 | 0.203 | 0.033 | 0.006 | 0.059 |
| | (0.062) | | | (0.023) | | | (0.055) | | | (0.016) | | |
| Constant | 0.055 | -1.249 | 1.359 | | | | -0.202 | -1.526 | 1.121 | | | |
| | (0.793) | | | | | | (0.805) | | | | | |
| Obs. | | | | | | | | | | | | 393 |

*Source: Own calculation using IAMO-SAU vegetable farmer survey.*
*Notes: 'mental budgeting dummy 2' = 1 if farmers agreed with all four statements or were neutral (i.e. answering 1 or 3 for all statements). Standard errors are presented in parentheses. As the coefficients cannot be interpreted as effects of explanatory variables on the probability of the outcome, we calculate the average marginal effect by using 'margins, dydx(*)' command in STATA after Probit regression.*

Table A. 4: Probit regression results for the willingness to switch to low-toxicity pesticides facing agricultural revenue with a price premium by re-grouping intentions

| Variables | Coefficient | Average marginal effect | [90% Confidence Interval of average marginal effect] | | Coefficient | Average marginal effect | [90% Confidence Interval] | | Coefficient | Average marginal effect | [90% Confidence Interval of average marginal effect] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mental budgeting | -0.028<br>(0.041) | -0.010<br>(0.015) | -0.035 | 0.015 | | | | | | | | |
| Mental budgeting dummy | | | | | -0.206<br>(0.150) | -0.077<br>(0.055) | -0.167 | 0.014 | | | | |
| Mental budgeting dummy 2 | | | | | | | | | -0.195<br>(0.136) | -0.073<br>(0.050) | -0.155 | 0.010 |
| Age | -0.022<br>(0.007) | -0.008<br>(0.003) | -0.012 | -0.004 | -0.023<br>(0.007) | -0.008<br>(0.003) | -0.013 | -0.004 | -0.022<br>(0.007) | -0.008<br>(0.003) | -0.012 | -0.004 |
| Farm size | -0.0007<br>(0.0007) | -0.0002<br>(0.0002) | -0.001 | 0.000 | -0.0004<br>(0.0007) | -0.0001<br>(0.0003) | -0.001 | 0.000 | -0.0004<br>(0.0007) | -0.0002<br>(0.0002) | -0.001 | 0.000 |
| Educational level | -0.110<br>(0.079) | -0.041<br>(0.029) | -0.090 | 0.007 | -0.112<br>(0.080) | -0.042<br>(0.029) | -0.090 | 0.007 | -0.110<br>(0.080) | -0.041<br>(0.029) | -0.089 | 0.007 |
| Off-farm job | -0.153<br>(0.138) | -0.057<br>(0.051) | -0.141 | 0.027 | -0.163<br>(0.138) | -0.061<br>(0.051) | -0.145 | 0.024 | -0.158<br>(0.138) | -0.059<br>(0.051) | -0.143 | 0.025 |
| Lnincome | 0.079<br>(0.052) | 0.030<br>(0.019) | -0.002 | 0.061 | 0.079<br>(0.053) | 0.029<br>(0.019) | -0.003 | 0.061 | 0.079<br>(0.053) | 0.029<br>(0.019) | -0.002 | 0.061 |
| Constant | 0.995<br>(0.734) | | | | 1.086<br>(0.741) | | | | 1.064<br>(0.739) | | | |
| Obs. | | | | | | | | | | | | 393 |

*Source: Own calculation using IAMO-SAU vegetable farmer survey.*
*Notes: 'mental budgeting dummy 2' = 1 if farmers agreed with all four statements or were neutral (i.e. answering 1 or 3 for all statements). And the intentions equal to 1 if farmers answered "totally agree", "agree", and "neutral".*
*Standard errors are presented in parentheses. As the coefficients cannot be interpreted as effects of explanatory variables on the probability of the outcome, we calculate the average marginal effect by using 'margins, dydx(*)' command in STATA after Probit regression.*

Table A. 5: Probit regression results for the willingness to switch to low-toxicity pesticides facing subsidy by re-grouping intentions

| Variables | Coefficient | Average marginal effect | [90% Confidence Interval of average marginal effect] | | Coefficient | Average marginal effect | [90% Confidence Interval of average marginal effect] | | Coefficient | Average marginal effect | [90% Confidence Interval of average marginal effect] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mental budgeting | -0.434<br>(0.056) | -0.103<br>(0.011) | -0.121 | -0.086 | | | | | | | | |
| Mental budgeting dummy | | | | | 1.311<br>(0.265) | 0.349<br>(0.067) | 0.239 | 0.459 | | | | |
| Mental budgeting dummy 2 | | | | | | | | | 1.376<br>(0.221) | 0.348<br>(0.050) | 0.265 | 0.430 |
| Age | -0.012<br>(0.009) | -0.003<br>(0.002) | -0.006 | 0.001 | -0.011<br>(0.008) | -0.003<br>(0.002) | -0.007 | 0.001 | -0.015<br>(0.009) | -0.004<br>(0.002) | -0.007 | -0.000 |
| Farm size | 0.0006<br>(0.001) | 0.0001<br>(0.0003) | -0.000 | 0.001 | 0.0006<br>(0.001) | 0.0002<br>(0.0003) | -0.000 | 0.001 | 0.0006<br>(0.001) | 0.0002<br>(0.0003) | -0.000 | 0.001 |
| Educational level | -0.025<br>(0.094) | -0.006<br>(0.022) | -0.043 | 0.031 | -0.005<br>(0.092) | -0.001<br>(0.024) | -0.042 | 0.039 | -0.010<br>(0.093) | -0.002<br>(0.024) | -0.041 | 0.036 |
| Off-farm job | 0.094<br>(0.164) | 0.023<br>(0.039) | -0.042 | 0.087 | 0.096<br>(0.157) | 0.026<br>(0.042) | -0.043 | 0.094 | 0.103<br>(0.160) | 0.026<br>(0.040) | -0.040 | 0.093 |
| Lnincome | 0.050<br>(0.058) | 0.012<br>(0.014) | -0.011 | 0.034 | 0.053<br>(0.057) | 0.014<br>(0.015) | -0.011 | 0.039 | 0.056<br>(0.057) | 0.014<br>(0.014) | -0.009 | 0.038 |
| Constant | 1.045<br>(0.858) | | | | 0.553<br>(0.835) | | | | 0.619<br>(0.844) | | | |
| Obs. | | | | | | | | | | | | 393 |

*Source: Own calculation using IAMO-SAU vegetable farmer survey.*

*Notes: 'mental budgeting dummy 2' = 1 if farmers agreed with all four statements or were neutral (i.e. answering 1 or 3 for all statements). And the intentions equal to 1 if farmers answered "totally agree", "agree", and "neutral".*

*Standard errors are presented in parentheses. As the coefficients cannot be interpreted as effects of explanatory variables on the probability of the outcome, we calculate the average marginal effect by using 'margins, dydx(*)' command in STATA after Probit regression.*

# 农户问卷

# Questionnaire to farmers

早上/下午/晚上好，我是________________________________。我代表德国莱布尼兹转型经济体农业发展研究所和四川农业大学来此进行调查。本项目的目的是研究蔬菜病虫害防治的情况。在此基础上，研究者可以更好地了解菜农的病虫害防治行为，以期改善病虫害防治的效果和方式。

Good morning/afternoon/evening, I am ________________________________ and I am conducting a survey on behalf of the German research institute IAMO & Sichuan agricultural university. The purpose of the project is to study the situation of pest control measures. Your input will help to identify the way that vegetable farmers use pest control measures. Based on the study, the researchers could have a better understanding of farmer's behavior in pest control measures.

**这是一项科学研究调查。您提供的信息只用于研究需要，不会用作政府报告。整个问卷访问过程将是匿名和严格保密的。调研数据将在 IAMO 和四川农业大学存档，且可供其他研究人员根据当前的数据共享条款使用。**

**This is a research survey. The information you provide is only for research needs and will not be presented to the government. The whole process will be anonymous and strictly confidential. Anonymized research data will be archived at IAMO and Sichuan agricultural university in order to make them available to other researchers in line with current data sharing practices.**

**注意：**

1. 仅对种植**蔬菜**的农户进行提问，其他类型的农户放弃提问。
2. 受访人须是**家庭主要决策者**。如果不能采访这个人，另一个参与农业决策的家庭成员可以代替采访。
3. 每户仅使用**一份**问卷。

**Rules:**

1. If farmers grow **vegetables**, continue to ask the following questions. Otherwise, give up and find another farmer.
2. The person to be interviewed shall be the one who **leads farming activities**. If not possible to interview this person, another knowledgeable household member involved in decision making about farming can be interviewed instead.
3. **Only one** questionnaire for each household.

| | | | |
|---|---|---|---|
| 调查员姓名<br>Name of the interviewer | | 调查日期<br>Date of the interview | |
| 市/自治区<br>City/Prefecture | | | |
| 县/区<br>County /District | | | |
| 乡/镇<br>Township /Town | | | |
| 村<br>Village | | | |

**A.** 个人基本信息

**A. Personal characteristics**

| | | | |
|---|---|---|---|
| A01 | 性别 (Gender) | 1.男 (Male) 0.女 (Female) | |
| A02 | 年龄 (Age) | 岁 (Years old) | |
| A03 | 教育水平 (Educational level) | 1.没受过教育 (Not educated)<br>2.小学 (Primary school)<br>3.初中 (Secondary school)<br>4.高中/中专 (High school/Technical secondary school)<br>5.本科/大专 (Undergraduate/Junior college)<br>6.研究生 (Graduate school) | |

**B. 家庭特征信息**

**B. Household characteristics**

| | | | | |
|---|---|---|---|---|
| B01 | 家庭成员数量 (How many family members living in your household?) | 数量 (Number) | | |
| B02 | 家庭劳动力人数 (How many of them are labors?) | 数量 (Number) | | |
| B03 | 家庭成员中有多少人从事农业以外的工作？<br>(How many household members do off-farm jobs?)<br>**如果没有，则跳到 B05**<br>**(If ”0”, go to B05)** | 数量 (Number) | | |
| B03_1 | 请说明他们中当天往返及不往返的人数<br>Please specify the number of returning daily or not returning daily | 当天往返 (Returning daily) | 数量 (Number) | |
| | | 当天不往返 (Not returning daily) | 数量 (Number) | |
| B03_2 | 家庭成员中有多少人只从事除农业以外的工作？<br>(How many household members just do off-farm jobs?) | 数量 (Number) | | |
| B04 | 家庭成员中有多少人只从事农业工作？<br>(How many household members are engaged in full time agricultural activities?) | 数量 (Number) | | |
| B05 | 家庭成员中有多少人完成了 9 年义务教育（初中）？<br>(How many people finished 9 years compulsory education (Secondary school)?) | 数量 (Number) | | |
| B06 | 您家离最近的集市有多远？<br>(How far is your home to the nearest country fair?) | 千米 (km) | | |
| B07 | 您家离最近的农资店有多远？<br>(How far is your home to the nearest shop for agricultural inputs?) | 千米 (km) | | |
| B08 | 您家离最近的银行有多远？<br>(How far is your home to the nearest bank?) | 千米 (km) | | |
| B09 | 您家离最近的汽车站有多远？ | 千米 (km) | | |

| | | | |
|---|---|---|---|
| | (How far is your home to the nearest public transport stop?) | | |
| B10 | 您家的房屋结构是？<br>(What type of house do you live in?) | 1.土坯 (Adobe)<br>2.石木结构 (Stone and wood)<br>3.砖混 (Brick)<br>4.钢筋混凝土 (Reinforced concrete)<br>5.其他（请说明）(Others (Please specify)) | |
| B11 | 您家的交通工具有哪些？（可多选）<br>(Which modes of transport you have in your family?) (Multiple choices available) | 1.没有 (No)<br>2.自行车 (Bicycles)<br>3.三轮车/电动车 (Tricycle/electric vehicles)<br>4.摩托车 (Motorcycle)<br>5.汽车 (Car)<br>6.其他（请说明） (Others (Please specify)) | |

**C. 收入和消费信息**
**C. Income and expenditure characteristics**

| | | | |
|---|---|---|---|
| C01 | 您家去年（2017）纯收入是多少？<br>(How much income of your household last year (2017)?) | ￥ | |
| C02 | 您家去年（2017）农业纯收入是多少？<br>(How much income from agricultural activities last year (2017)?) | ￥ | |
| C03 | 您家去年（2017）工资收入是多少？<br>(How much income from wage work last year (2017)?) | ￥ | |
| C04 | 您家去年（2017）财产性收入（地租，房租，分红等）是多少？<br>(How much capital income, such as land rent, house rent, dividends, etc., last year (2017)?) | ￥ | |
| C05 | 您家去年（2017）转移性收入（补贴收入，养老金，低保，贫困补助，赠予等）是多少？<br>(How much transfer income, such as subsidies, pension, dibao, poverty allowance, donations, etc., last year (2017)?)<br>**如果没有转移性收入，跳到 C06**<br>**(If there is no transfer income, jump to C06)** | ￥ | |
| C05_1 | 转移性收入中有多少农业补贴？<br>(How much agricultural subsidies in transfer income?) | ￥ | |
| C05_2 | 转移性收入中有多少低保？<br>(How much dibao in transfer income?) | ￥ | |
| C05_3 | 转移性收入中有多少贫困补助？<br>(How much poverty allowance in transfer income?) | ￥ | |
| C06 | 您是否会对日常生活开支记账？<br>(Do you keep a book for daily expenses?) | 1.会 (Yes) 0.不会 (No) | |

| | | | |
|---|---|---|---|
| C07 | 您在多大程度上同意以下说法？<br>(To what extent do you agree with the following statements?) | 1 =非常同意，2＝同意，3＝不确定，4＝不同意，5＝非常不同意<br>(1=strongly agree, 2=agree, 3=uncertain, 4=disagree, 5=strongly disagree) | |
| | | a) 你必须为花费大量资金来购买农业投入品<br>(I have to invest substantial monetary efforts to be able to buy agricultural inputs.) | |
| | | b) 你必须投入大量时间来搜寻所需要的农业投入品<br>(I have to invest a lot of time to receive the agricultural inputs I need.) | |
| | | c) 你没法在当地买到所需要的农业投入品<br>(I cannot buy the agricultural inputs I need locally at all.) | |
| | | d) 农业投入品的质量难以达到你的预期<br>(The quality of agricultural inputs is not matching the quality I would like to have.) | |

**D. 农田和蔬菜生产信息**

**D. Farm and vegetable production characteristics in last year (2017)**

| | | | |
|---|---|---|---|
| D01 | 您家去年（2017）耕种的耕地有多少亩？<br>(What is the size of farmland used in 2017?) | 亩 (Mu) | |
| D02 | 您家的耕地去年（2017）有多少是租用的？<br>(How much farmland has been rented from other farmers in 2017?)<br>**如果租用面积为”0”，跳到 D03**<br>**(If “0”, jump to D03)** | 亩 (Mu) | |
| D02_1 | 每亩租金是多少钱？<br>(What is the land rent per Mu?) | 元/亩(Yuan/Mu) | |
| D03 | 您家的耕地去年（2017）有多少转租给了他人？<br>(How much farmland has been leased to other farmers in 2017?) | 亩 (Mu) | |

D04 请具体描述去年（2017）蔬菜种植和销售情况。（列出种植面积最多的四种）

D04 Please specify the situation of vegetable production and selling last year (2017) (List four species with the largest planting area)

| 蔬菜种类 (Name of vegetable) | 种植面积/亩 (Planting area/Mu) | 蔬菜质量认证 (Certification) 有填"1"，没有填"0" Fill in "1" if there is. Otherwise, fill in "0". | | | 产量/斤 (Yield /500g) | 蔬菜出售渠道，出售量与金额 (Marketing channel, amount of vegetables sold, and revenue) | | | 种植成本：元/亩 (Costs of production: yuan/mu) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 无公害蔬菜 (Hazard free vegetable) | 绿色蔬菜 (Green vegetable) | 有机蔬菜 (Organic vegetable) | | 出售渠道 (Marketing channel)<br>1.卖给合作社 (To the cooperative)<br>2.卖给公司 (To the company)<br>3.自己在市场中出售 (In the market by myself)<br>4.卖给中间商 (To middleman)<br>5.其他（请说明） (Others (Please specify)) | 出售量/斤 (Amount sold/500g) | 金额：元/斤 (Revenue: yuan/500g) | 种子 (Seeds) | 肥料 (Fertilizer) | 地膜 (Mulch film) | 农药 (Pesticides) | 物理病虫害防治 (Physical PCMs) | 生物病虫害防治 (Biological PCMs) | 农机租赁 (Agri-machinery rent) | 用工成本 (Costs for labor) | 其他 (Others) |
| | | | | | | | | | | | | | | | | | |
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**D05 您觉得下列产品的价格比普通蔬菜的市场价格贵多少**

***1.**与普通蔬菜价格持平* ***2.**是普通蔬菜价格的1 到2 倍* ***3.**是普通蔬菜价格的2 到3 倍* ***4.**是普通蔬菜价格的3 到4 倍* ***5.**是普通蔬菜价格的4 倍以上*

**C05 Please compare the prices of the following products and the market price of conventional vegetables.**

***1.** Equal to normal vegetables* ***2.** 1 to 2 times higher than normal vegetables* ***3.** 2 to 3 times higher than normal vegetables* ***4.** 3 to 4 times higher than normal vegetables* ***5.** More than 4 times higher than normal vegetables*

| | | | | | |
|---|---|---|---|---|---|
| D05_1 | 无公害蔬菜 (hazard free vegetable) | D05_2 | 绿色蔬菜 (green vegetable) | D05_3 | 有机蔬菜 (organic vegetable) |
| | | | | | |

**D06 改变销售渠道的意愿**

**D06 Willingness to change current marketing channel**

| | | | |
|---|---|---|---|
| D06 | 你想改变你当前的蔬菜销售渠道吗？<br>(Do you want to change your current marketing channel for selling vegetables?)<br>**如果选择 3./4./5.，跳到 E**<br>**(If 3./4./5., jump to E)** | 1.非常想 (Really want to)<br>2.有点想 (Want to somewhat)<br>3.没决定 (Not decided)<br>4.不太想 (Do not want to somewhat)<br>5.非常不想 (Do not want to at all) | |
| D06_1 | 为什么？<br>(What is the reason?) | 1.收购价太低 (The price of vegetable is low)<br>2.近年出现了许多新的销售渠道 (New marketing channels appear recently)<br>3.当前渠道的质量要求太严格 (Quality requirement is too tight)<br>4.其他（请说明） (Others (Please specify)) | |

**E.组织特征信息**

**E. Organizational characteristics**

| | | | |
|---|---|---|---|
| E01 | 您是否加入了合作社？<br>(Are you currently a member of a cooperative?)<br>**如果没有，跳到 E02**<br>**(If no, go to E02)** | 1.加入了 (Yes) 0.没加入 (No) | |
| E01_1 | 您家是否向合作社入股？<br>(Do you have shares of the cooperative?)<br>**如果否，跳到 E01_3**<br>**(If no, go to E01_3)** | 1.是 (Yes) 0.否 (No) | |
| E01_2 | 您是否与合作社有蔬菜种销合同？<br>(Do you have a contract with cooperatives for vegetable marketing and farming?) | 1.有 (Yes) 0.没有 (No) | |

| | | | |
|---|---|---|---|
| | **如果没有，跳到 E01_4**<br>**(If no, go to E01_4)** | | |
| E01_3 | 合同的形式是？<br>(What's the contract form?) | 1.书面合同 (Written) 0.口头承诺 (Oral) | |
| E01_4 | 您参与年度合作社社员大会的频率怎样？<br>(How often do you engage in annual general assembly meeting in your cooperative?) | 1.每次都参与 (Engage in decision-making every time)<br>2.经常参与 (Often engage in decision-making)<br>3.一般 (Neither often nor rarely)<br>4.偶尔参与 (Sometimes engage in decision-making)<br>5.从不参与 (Never engage in decision-making) | |
| E01_5 | 您参与合作社特殊议程会议的频率怎样？<br>(How often do you engage in special agenda meeting in your cooperative?) | 1.每次都参与 (Engage in decision-making every time)<br>2.经常参与 (Often engage in decision-making)<br>3.一般 (Neither often nor rarely)<br>4.偶尔参与 (Sometimes engage in decision-making)<br>5.从不参与 (Never engage in decision-making) | |
| E01_6 | 您所在合作社社员大会的决策方式是？<br>(What is the type of decision-making in the cooperative meeting?) | 1.一人一票 ("One member, one vote")<br>2.按股份投票 (Based on the proportion of shares)<br>3.其他（请说明）(Others (Please specify)) | |
| E01_7 | 是否能自由退出合作社？<br>(Can you quit the cooperative freely?) | 1.能 (Yes) 0.不能 (No) | |
| E01_8 | 您在多大程度上同意以下陈述？<br>(To what extent do you agree with the following statements?) | 1 =非常同意，2＝同意，3＝不确定，4＝不同意，5＝非常不同意<br>(1=strongly agree, 2=agree, 3=uncertain, 4=disagree, 5=strongly disagree) | |
| | | a) 合作社总是关心农民的利益<br>(Cooperative always cares about the interest of farmers.) | |
| | | b) 合作社的管理对所有成员都是公平的<br>(The management of the cooperative is fair to all members.) | |
| | | c) 合作社的管理具有高的可信度<br>(The management of the cooperative has a high degree of credibility.) | |
| | | d) 与合作社的关系令人满意<br>(The relationship with the cooperative is satisfactory.) | |
| | | e) 你知道合作社的组织目标<br>(I know the organizational goals of the cooperative.) | |
| | | f) 你知道合作社的财务状况和盈利能力<br>(I know the financial status and profitability of cooperative.) | |
| | | g) 合作社与农民共同努力实现共同目标<br>(Cooperative and farmers work together to achieve | |

| | | | |
|---|---|---|---|
| | | common goals.) | |

| | | | |
|---|---|---|---|
| E02 | 您是否与公司有蔬菜种销合同?<br>(Do you have a contract with a company for vegetable marketing and farming?)<br>**如果没有加入合作社且没与公司签订合同，跳到 F**<br>**如果与合作社有种销合同(E01_2)，则跳到 E03**<br>**(If not a cooperative member and no contract with a company, go to F)**<br>**(If have a contract with cooperative, go to E03)** | 1.有 (Yes) 0.没有 (No) | |
| E02_1 | 合同的形式是?<br>(What's the contract form?) | 1.书面合同 (Written) 0.口头承诺 (Oral) | |
| E02_2 | 合同的类型是?<br>(What's the type of contract?) | 1.销售合同 (Sales contract)<br>2.销售加种植服务合同 (Sales and services contract)<br>3.销售加种植基地合同 (Sales and base contract) | |
| E02_3 | 您能否自由退出当前合同?<br>(Can you quit your current contract freely?) | 1.能 (Yes) 0.不能 (No) | |
| E02_4 | 您在多大程度上同意以下陈述?<br>(To what extent do you agree with the following statements?) | 1 =非常同意，2＝同意，3＝不确定，4＝不同意，5＝非常不同意<br>(1=strongly agree, 2=agree, 3=uncertain, 4=disagree, 5=strongly disagree) | |
| | | a) 公司总是关心农民的利益<br>(Company always cares about the interest of farmers.) | |
| | | b) 公司的管理对所有农民都是公平的<br>(The management of the company is fair to all farmers.) | |
| | | c) 公司的管理具有高的可信度<br>(The management of the company has a high degree of credibility.) | |
| | | d) 与公司的关系令人满意<br>(The relationship with the company is satisfactory.) | |
| | | e) 你知道公司的组织目标<br>(I know the organizational goals of the company.) | |
| | | f) 你知道公司的财务状况和盈利能力<br>(I know the financial status and profitability of the company.) | |
| | | g) 公司与农民共同努力实现共同目标<br>(Company and farmers work together to achieve common goals.) | |

**E03 合作纠纷的解决**

**E03 Resolution of concerns**

| | | | |
|---|---|---|---|
| E03_1 | 合同/协议中是否存在关于"实际出售蔬菜的结算款与当初商定的不一致"的解决办法？<br>Is there a settlement procedure agreed upon for concerns on inconsistent payment of vegetables?<br>**如果没有，跳到 E03_3**<br>**(If no, go to E03_3)** | 1.有 (Yes) 0.没有 (No) | |
| E03_2 | 合同/协议中是否规定有额外的补偿金作为实际结算款与协议不一致时的补偿？<br>(Is there any extra fee for compensating inconsistent payment in the agreement?) | 1.有 (Yes) 0.没有 (No) | |
| E03_3 | 当您遇到实际结算款与合同/协议不一致时，您会寻求谁的帮助？<br>(Who do you ask for assistance if you face inconsistent payment?) | 1.与买家谈判 (Discuss with buyers)<br>2.当地政府 (Local government)<br>3.法院 (Court)<br>4.其他（请说明） (Others (Please specify)) | |
| E03_4 | 去年(2017)您遇到过实际结算款与合同/协议不一致的情况么？<br>(Have you suffered inconsistent payment in 2017?) | 1.有 (Yes) 0.没有 (No) | |

**E04 在您种植蔬菜的过程中，公司或者合作社对下列哪些方面有明确要求**

**E04 Please confirm which specifications are required by the company or cooperative in the process of growing vegetables**

| | | | |
|---|---|---|---|
| E04_1 | 只能使用公司或合作社提供的农药、物理或生物病虫害防治材料<br>(Only can use pesticide, physical or biological pest control materials provided by company/cooperative) | 1.有 (Yes) 0.没有 (No) | |
| E04_2 | 蔬菜的质量<br>(Quality of vegetables) | 1.有 (Yes) 0.没有 (No) | |
| E04_3 | 农药、物理或生物病虫害防治措施的种类<br>(Type of pesticide, physical or biological pest control measures) | 1.有 (Yes) 0.没有 (No) | |
| E04_4 | 农药、物理或生物病虫害防治措施的使用数量<br>(Amount of using pesticide, physical or biological pest control measures) | 1.有 (Yes) 0.没有 (No) | |
| E04_5 | 农药、物理或生物病虫害防治措施的使用频率<br>(Frequency of using pesticide, physical or biological pest control measures) | 1.有 (Yes) 0.没有 (No) | |
| E04_6 | 收获之前，农药的停药期<br>(Gap period of pesticide) | 1.有 (Yes) 0.没有 (No) | |
| E04_7 | 其他要求（请说明） (Other requirements (Please specify)) | | |

**F. 病害虫防治的实施情况**

**F. Practice of pest control measures**

| | | | |
|---|---|---|---|
| F01 | 您在种植蔬菜的过程中使用农药吗？<br>(Do you use pesticides during vegetable production?)<br>**如果不使用，跳到 F12**<br>**(If no, go to F12)** | 1.使用 (Yes) 0.不使用 (No) | |

F02 去年（2017）农药使用情况（注意：若农药为免费提供，单价写”0”）

F02 Situation of pesticide use last year (2017) (Tips: If the pesticides are supplied freely, fill “0” in price of pesticide)

农药名称可参见下表填写号码，若无表中所列农药，则明确农药名称

The name of pesticides can be found in the table below. If there is no pesticide listed in the table, please specify the name of the pesticide.

| | | | | |
|---|---|---|---|---|
| 1.甲拌磷 (Phosphorus)<br>2.对硫磷 (Parathion)<br>3.杀螟威 (Chlorfenvinphos)<br>4.甲胺磷 (Methamidophos)<br>5.三硫磷 (Trithion)<br>6.氧化乐果 (Omethoate) | 7.灭线磷 (Ethoprophos)<br>8.涕灭威 (Aldicarb)<br>9.灭多威 (Methomyl)<br>10.敌百虫 (Trichlorfon)<br>11.六六六 (Hexachlorocyclohexane) 12.克百威 (Carbofuran) | 13.灭幼脲 (Chlorbenzuron)<br>14.阿维菌素 (Avermectin)<br>15.草甘膦 (Glyphosate)<br>16.草铵膦 (Glufosinate)<br>17.恶霉灵 (Hymexazol)<br>18.代森锰锌 (Mancozeb) | 19.四霉素 (Tetramycin)<br>20.多菌灵 (Carbendazim)<br>21.异菌脲 (Iprodione)<br>22.灭蝇胺 (Cyromazine)<br>23.腐霉利 (Procymidone)<br>24.三唑酮 (Triadimefon) | 25.烯酰锰锌 (Enoyl mancozeb)<br>26.甲基硫菌灵 (Thiophonate-methyl)<br>27.甲氨基阿维菌素苯甲酸盐 (Emamectin-benzoate) |

| F02_1 | F02_2 | F02_3 | F02_4 | F02_5 | F02_6 | F02_7 | F02_8 | F02_9 | F02_10 |
|---|---|---|---|---|---|---|---|---|---|
| 蔬菜名称 (Name of vegetable) | 农药的类型 (Type of pesticide) | 农药的名称 (Name of pesticide) | 农药的规格 (Size of pesticide per box/bottle) | 农药的单价 (Price of pesticide per box/bottle) | 农药的用量 (Amount of used bottles, boxes, and bags) | 收获前停药天数 (Gap period before harvest/days) | 农药使用时的保护措施 (Productive measures during pesticide application)<br>可多选 (Multiple choices available)<br>0.无 (No)<br>1.口罩 (Mask)<br>2.防护手套 (Rubber gloves)<br>3.防护服 (Protective clothes)<br>4.防护鞋 (Protective shoes)<br>5.防护眼镜 (Protective glasses) | 施用农药设备 (Device for applying pesticide)<br>1. 手动背包式喷灌机 (Manual backpack sprinkler)<br>2. 农药喷洒烟雾机 (Pesticide spray fogging machine)<br>3.机动喷雾器 (Mobile sprayer)<br>4. 农药喷洒车 (Spraying vehicle)<br>5. 其他（请说明） (Other (Please specify)) | 使用该种农药获得的补贴/元 (Obtained subsidies for the pesticide/yuan) |
| | 1.杀虫剂 (Insecticide)<br>2.杀菌剂 (Fungicide)<br>3.除草剂 (Herbicide) | | 单位 (Unit)：<br>毫升/瓶 (ml/bottle)<br>克/每盒 (g/box)<br>克/每袋 (g/bag) | 单位(Unit)：<br>元/瓶(盒,袋) (yuan/bottle, box or bag) | 单位 (Unit)：<br>瓶/盒/袋 (Bottle, box, or bag) | | | | |
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| F03 | 您去年（2017）为种植蔬菜向第三方购买过病虫害防治服务吗？<br>(Did you buy a pest control service for vegetable production from a third party last year (2017)?)<br>**如果没有，跳到 F04 (If no, jump to F04)** | 1.有 (Yes) 0.没有 (No) | |
| F03_1 | 您所购买的第三方病虫害防治服务的价格是多少？<br>(How much is that pest control service?) | 元/亩(Yuan/Mu) | |
| F04 | 您是否会混合使用多种农药？<br>(Do you use a mixture of pesticides?) | 1.总是会 (Always)<br>2.有时候会 (Sometimes)<br>3.从来不会 (Never) | |
| F05 | 您如何处理农药包装？<br>(How to deal with pesticide packaging?) | 1.清洗后再用 (Reuse after cleaning)<br>2.直接丢弃 (Discard)<br>3.深埋 (Deep burial)<br>4.烧掉 (Burn)<br>5.卖给废品收购者 (Sell to a scrap buyer)<br>6.送到农药废弃物回收站 (Send to pesticide waste recycling station)<br>7.其他（请说明） (Other (Please specify)) | |
| F06 | 您怎么处理剩余的农药？<br>(How to deal with remaining pesticides after application?) | 1.下一次接着用 (Keep for the next use)<br>2.丢弃 (Discard)<br>3.增加当次使用量并将其用完(Increase current usage and use it out)<br>4.送到农药废弃物回收站 (Send to pesticide waste recycling station)<br>5.其他（请说明） (Other (Please specify)) | |
| F07 | 您是否会在使用完农药后立即更换衣服？<br>(Do you change your clothes right after finishing pesticide application?) | 1.总是会 (Always)<br>2.有时候会 (Sometimes)<br>3.从来不会 (Never) | |
| F08 | 您是否会在使用完农药后立即洗澡？<br>(Do you take a shower right after finishing pesticide application?)<br>**如果总是会，跳到 F11**<br>**(If always, jump to F11)** | 1.总是会 (Always)<br>2.有时候会 (Sometimes)<br>3.从来不会 (Never) | |
| F09 | 您是否会在使用完农药后立即洗手？<br>(Do you wash your hands right after finishing pesticide application?) | 1.总是会 (Always)<br>2.有时候会 (Sometimes)<br>3.从来不会 (Never) | |
| F10 | 您是否会在使用完农药后立即洗脸？<br>(Do you wash your face right after finishing pesticide application?) | 1.总是会 (Always)<br>2.有时候会 (Sometimes)<br>3.从来不会 (Never) | |

| | | | |
|---|---|---|---|
| F11 | 您是否会在使用农药前查看天气预报？<br>(Do you check the weather forecast before application?) | 1.总是会 (Always)<br>2.有时候会 (Sometimes)<br>3.从来不会 (Never) | |
| F12 | 您在种植蔬菜的过程中使用物理或生物病虫害防治措施吗？<br>(Do you use physical or biological pest control measures during vegetable production?)<br>**如果不使用，跳到 F14**<br>**(If no, go to F14)** | 1.使用 (Yes) 0.不使用 (No) | |
| F13 | 请选择您所使用的物理和生物防治措施（可多选）<br>Please specify which of the following physical and biological pest control measures you are using (Multiple choices available)<br>1.无土栽培 (Hydroponics)<br>2.乙醇 (Ethanol)<br>3.小苏打 (Baking soda)<br>4.甲壳素/几丁聚糖 (Chitin)<br>5.石蜡 (Paraffin)<br>6.木霉菌 (Trichoderma)<br>7.防虫网 (Insect net)<br>8.防虫粘板 (Insect resistant board)<br>9.性诱剂 (Sexual attractant)<br>10.害虫天敌栖息地 (Habitat of natural enemies of pests)<br>11.防虫灯 (Insect lamp)<br>12.苏云金杆菌 (Bacillus thuringiensis)<br>13.多粘类芽胞杆菌 (Paenibacillus polymyxa) 14.高锰酸钾 (Potassium permanganate)<br>15.波尔多液 (Bordeaux mixture) | 16.苦参碱 (Matrine)<br>17.除虫菊素 (Pyrethrins)<br>18.多杀霉素 (Spinosad)<br>19.低聚糖素 (Oligosaccharin)<br>20.其他（请说明） (Other (Please specify)) | |
| F14 | 在使用病虫害防治措施之前您是否会阅读使用说明？<br>(Do you read the instructions for use before using pest control measures?) | 1.总是会 (Always)<br>2.有时候会 (Sometimes)<br>3.从来不会 (Never) | |

| | | | |
|---|---|---|---|
| F15 | 如果你继续使用当前的病虫害防治措施，您认为病虫害情况将来会如何变化？<br>(If you continue your current pest control measures, how do you think pest hazards would change in the future?)<br>**如果选择不变，则跳到 F16**<br>**(If "Stay constant", go to F16)** | 1.增加 (Increase)<br>2.不变 (Stay constant)<br>3.减少 (Decrease) | |
| F15_1 | 具体会有多少可能性？<br>(How likely do you think pest hazard would change?) | Low (%) 0-10-20-30-40-50-60-70-80-90-100 High (%) | |
| F16 | 如果你继续使用当前的病虫害防治措施，您认为皮肤病、头痛和恶心的风险在将来发生什么变化？<br>(If you continue your current pest control measures, how do you think that skin irritation, headaches, and nausea would change in the future?)<br>**如果选择不变，则跳到 F17**<br>**(If "Stay constant", go to F17)** | 1.增加 (Increase)<br>2.不变 (Stay constant)<br>3.减少 (Decrease) | |
| F16_1 | 具体会有多少可能性？<br>(How likely do you think skin irritation, headaches, and nausea would change?) | Low (%) 0-10-20-30-40-50-60-70-80-90-100 High (%) | |

| | | | |
|---|---|---|---|
| F17 | 如果病虫害控防治原料的价格下降，你有多少可能增加病虫害防治措施的使用？<br>(If the prices of pest control measures go down, how likely will you increase the use of pest control measures?) | Low (%) 0-10-20-30-40-50-60-70-80-90-100 High (%) | |

**G. 病虫害防治措施的管理情况**

**G. Technique to manage the use of PCMs**

**G01 请选择您在种植蔬菜的过程中接受了下列哪些机构所提供的服务或监督？（可多选）**

**G01 Please confirm which service(s) & supervision(s) has/have offered by the following entities and which ones you have taken (Multiple choices available)**

| | | 提供主体 (Entity) | | | |
|---|---|---|---|---|---|
| | | 公司<br>(Company) | 合作社<br>(Cooperative) | 政府机构<br>(Government) | 其他(请说明)<br>(Other (Please specify)) |
| | | 1.提供了 (Offered)<br>2.使用了 (Taken)<br>3.部分免费获得<br>(Partly free taken)<br>4.免费获得<br>(Freely taken) | 1.提供了 (Offered)<br>2.使用了 (Taken)<br>3.部分免费获得<br>(Partly free taken)<br>4.免费获得<br>(Freely taken) | 1.提供了 (Offered)<br>2.使用了 (Taken)<br>3.部分免费获得<br>(Partly free taken)<br>4.免费获得<br>(Freely taken) | 1.提供了 (Offered)<br>2.使用了 (Taken)<br>3.部分免费获得<br>(Partly free taken)<br>4.免费获得<br>(Freely taken) |
| G01_1 | 蔬菜生产培训 (Vegetable production training)<br>**如果选择了提供，则提问 G02 (If “1” in offered, ask G02)** | | | | |
| G01_2 | 统一提供农药、物理或生物防治原料<br>(Supplement of pesticides, physical or biological pest control materials)<br>**如果选择了提供，则提问 G03 (If “1” in offered, ask G03)**<br>**如果没使用，则提问 G04 (If no in taken, ask G04)** | | | | |
| G01_3 | 统一储藏管理农药、物理或生物防治原料<br>(Storage of pesticides, physical or biological pest control materials) | | | | |
| G01_4 | 提供蔬菜市场信息<br>(Offer market information of vegetables) | | | | |
| G01_5 | 产品质量检测 (Verification of product quality)<br>**如果选择了提供，则提问 G05 (If “1” in offered, ask G05)** | | | | |

| | | | |
|---|---|---|---|
| G02 | 您每年参加生产培训多少次？<br>(How many times of production training per year do you attend?) | 次数 (Times) | |

| | | | |
|---|---|---|---|
| G03 | 相较于市场价格，您觉得由公司/合作社/政府统一提供的农药、物理或生物防治原料价格如何？<br>(Compare to the market price, how do you think the cost of pesticides, physical or biological pest control materials supplied by company/cooperative/government and public advisory institute?) | 1.比市场价格高 2 倍以上(More than 2 times higher than market price)<br>2.比市场价格高 1 到 2 倍 (1 to 2 times higher than market price)<br>3.与市场价基本持平 (Almost equal to market price)<br>4.比市场价格低 1 到 2 倍 (1 to 2 times lower than market price)<br>5.比市场价格低 2 倍以上(More than 2 times lower than market price) | |
| G04 | 您从哪里购买农药、物理或生物防治原料？<br>(Where do you buy pesticides, physical or biological pest control materials?) | 1.附近农资店 (Agricultural materials store nearby)<br>2.网上购买 (Online purchase)<br>3.其他（请说明） (Other (Please specify)) | |
| G05 | 您所遇到的产品质量检测的频率如何？<br>(What is the frequency of product quality verification?) | 1.每个批次都被检测 (Test for each batch)<br>2.经常被检测 (Often tested)<br>3.一般 (Neither often nor rarely)<br>4.偶尔被检测 (Sometimes tested)<br>5.没遇到过检测 (No actual verification) | |

**G06 在种植蔬菜的过程中你记录了哪些病虫害防治措施的使用信息？**
**G07 哪些方面会受到视频或第三人监督？**
**G06 Which following information of pest control practice do you record during vegetable production?**
**G07 And which aspects are monitored by video or supervisor?**

| | | | |
|---|---|---|---|
| 农药、物理或生物病虫害防治原料的来源<br>Source of pesticides, physical or biological pest control measures | G06_1 | 1.记录了(Record) 0.没记录(Not record) | |
| | G07_1 | 1.受到监督(Supervised) 0.没受监督(Unsupervised) | |
| 农药、物理或生物病虫害防治原料的名称<br>Name of pesticides, physical or biological pest control measures | G06_2 | 1.记录了(Record) 0.没记录(Not record) | |
| | G07_2 | 1.受到监督(Supervised) 0.没受监督(Unsupervised) | |
| 农药、物理或生物病虫害防治的施用方式<br>Application measure of pesticides, physical or biological pest control measures | G06_3 | 1.记录了(Record) 0.没记录(Not record) | |
| | G07_3 | 1.受到监督(Supervised) 0.没受监督(Unsupervised) | |
| 农药、物理或生物病虫害防治的施用日期<br>Application date of pesticides, physical or biological pest control measures | G06_4 | 1.记录了(Record) 0.没记录(Not record) | |
| | G07_4 | 1.受到监督(Supervised) 0.没受监督(Unsupervised) | |
| 农药、物理或生物病虫害防治的使用量<br>Amount of pesticides, physical or biological pest control measures | G06_5 | 1.记录了(Record) 0.没记录(Not record) | |
| | G07_5 | 1.受到监督(Supervised) 0.没受监督(Unsupervised) | |
| 蔬菜收获前，农药的停药期<br>Gap period of pesticides before harvest | G06_6 | 1.记录了(Record) 0.没记录(Not record) | |
| | G07_6 | 1.受到监督(Supervised) 0.没受监督(Unsupervised) | |
| 其他（请说明）<br>Others (Please specify) | G06_7 | 记录了(Record) | |
| | G07_7 | 受到监督(Supervised) | |

**H. 病虫害防治信息来源和专业技术培训**
**H. Information source and extra professional education**

| | | | |
|---|---|---|---|
| H01 | 您从何处了解当前所使用的病虫害防治手段？（可多选）<br>(Where do you get the information about current pest control measures? (Multiple choices available)) | 1.电视 (TV)<br>2.邻居 (Neighbors)<br>3.商标 (Label)<br>4.农资商 (Seller)<br>5.农业推广机构 (Agricultural extension agent)<br>6.合作社 (Cooperative)<br>7.公司 (Company)<br>8.其他（请说明） (Other (Please specify)) | |
| H02 | 您是否接受过病虫害防治指导？<br>(Have you received instructions for using pest control measures?)<br>**如果没有，跳到 H03**<br>**(If no, go to H03)** | 1.有 (Yes) 0.没有 (No) | |
| H02_1 | 您从何处获得病虫害防治手段的指导？（可多选）<br>(Where do you receive instructions for using pest control measures? (Multiple choices available)) | 1.电视 (TV)<br>2.邻居 (Neighbors)<br>3.政府 (Government)<br>4.农资商 (Pesticide seller)<br>5.农业推广机构 (Agricultural extension agent)<br>6.合作社 (Cooperative)<br>7.公司 (Company)<br>8.其他（请说明） (Other (Please specify)) | |
| H03 | 您的病虫害防治主要基于？<br>(What is the main basis of your use of pest control measures?) | 1.自身经验 (Own experience)<br>2.邻居介绍 (Introduction from neighbors)<br>3.商标 (Label)<br>4.农资商介绍 (Introduction from Seller)<br>5.农业推广机构指导 (Instruction from Agricultural extension agent)<br>6.合作社指导 (Instruction from Cooperative)<br>7.公司指导 (Instruction from Company)<br>8.其他（请说明） (Other (Please specify)) | |

**I. 心理账户实验 I. Experiment for mental accounts**

**I1 农业生产投入的典型性 I1 Typicality of agricultural input items**

**请说明您认为下列农业投入品在多大程度上属于 A，B 和 C**

**Please indicate that to what extent you think the following agricultural inputs are a typical kind of A, B, and C?**

**（回答：1 =非常典型，2＝典型，3＝不确定，4＝不典型，5＝非常不典型；x＝不属于这一类）**

**(Answers: 1=very typical, 2=typical, 3=not sure, 4=atypical, 5=very atypical ; X=not belong to this category)**

| | | A. 种子 (Seed) | B. 化肥 (Fertilizer) | C. 病虫害防治措施 (Pest control measures) |
|---|---|---|---|---|
| I01 | 菜种 (Vegetable seed) | | | |
| I02 | 菜苗 (Vegetable seedling) | | | |
| I03 | 钾肥 (Potash fertilizer) | | | |
| I04 | 氮肥 (Nitrogenous fertilizer) | | | |
| I05 | 磷肥 (Phosphate fertilizer) | | | |
| I06 | 有机肥 (Organic fertilizer) | | | |
| I07 | 防虫网/灯 (Insect proof lamp/net) | | | |
| I09 | 高毒农药 (High-toxicity pesticide) | | | |
| I09 | 低毒农药 (Low-toxicity pesticide) | | | |
| I10 | 性诱剂 (Sexual attractant) | | | |

**I2 心理预算量表**

**I2 Mental budget scale**

**根据以上（I1）的分类，请说明您不同意或同意以下声明的程度**

**Base on the classification above (I1), please indicate that to what extent do you disagree or agree about the following statements.**

**（回答：1 =强烈同意，2＝同意，3＝不确定，4＝不同意，5＝强烈不同意）**

**(Answers: 1=strongly agree, 2=agree, 3=uncertain, 4=disagree, 5=strongly disagree)**

| | | | |
|---|---|---|---|
| I11 | 你会事先想好在种子、化肥、病虫害防治等不同种类农业支出上的花费。<br>I set up a budget plan or reserve money for different agricultural expenses, such as seed, fertilizer, pest control measures, etc. | 程度<br>(Degree) | |
| I12 | 当种子、化肥、病虫害防治等某一方面农业支出的花费超过一定的金额时，你不会再为其多花钱。<br>I never spend more than a fixed amount on seed, fertilizer, pest control measures, etc. | 程度<br>(Degree) | |
| I13 | 当你在某一项农业投入上的花费变多时，你会在减少这一方面其他投入项目的花费。<br>If I spend more on one agricultural input, I spend less on other inputs in the same categories. | 程度<br>(Degree) | |
| I14 | 当种子、化肥、病虫害防治等某一方面的花费变多时，并不会影响你在其他两方面的花费。<br>If I spend more on one of seed, fertilizer, pest control measures, etc., the expenses on other categories remain as before. | 程度<br>(Degree) | |

**J. 收入标签与心理预算实验**

**J. Experiment for the effect of income labeling and accounting**

**请说明，当您从不同渠道多获得 200 元钱时，您对以下陈述的看法是否赞同？**

**Please indicate that when you get more money by ￥200 from different sources, to what extent do you agree about the following statements.**

**（回答：1 =强烈同意，2＝同意，3＝不确定，4＝不同意，5＝强烈不同意**

**(Answers: 1=strongly agree, 2=agree, 3=uncertain, 4=disagree, 5=strongly disagree)**

| | J01 你会减少农药的使用量 (J01 I will decrease the amount of pesticide use.) | J02 你不会放弃正常农药的使用，但会更加倾向于使用更多的低毒农药 (J02 I will not give up using normal pesticides, but prefer to use more low-toxicity ones.) | J03 你会转而使用低毒农药 (J03 I will switch to use low-toxicity ones.) | J04 你会放弃使用农药，转而使用物理或生物防治 (J04 I will switch from pesticides to non-chemical measures.) |
|---|---|---|---|---|
| 1.农产品销售金额 (1.Agricultural revenue) | | | | |
| 2.有质量要求的农产品销售金额 (2.Agricultural revenue with a requirement on quality) | | | | |
| 3.非农就业收入 (3.Off-farm income) | | | | |
| 4.合作社或公司的分红 (4.Dividend from a cooperative or company) | | | | |
| 5.病虫害防治补贴 (5.A subsidy for low-toxicity pesticides) | | | | |

K. 产量风险感知实验

K. Experiment for yield risk

K01

回想过去几年的蔬菜产量，假设蔬菜价格是固定的。有一个农药 A 使你有 30%的机会使你的蔬菜收入增加 80 元，70%的机会增加 20 元。如果此时有另一个农药 B 会给你 10%的机会使你的蔬菜收入增加 X 元，90%的机会使你的蔬菜收入增加 10 元。

你会放弃机会 A 而选择机会 B 吗？（在表格中填“1”，没有则填”0”）

提示：如果农民在任一选择改变为 B，(例如，在第 5 个选项变为 B，在此处填“1”)，忽略以后的问题。如果农民不改变，那么标记选项 A。

Try to recall the vegetable yield of the last years and imagine that the price is fixed and there is a pesticide A where you have a 30% chance to increase your vegetable income by ￥80 and 70% to increase by ￥20. Now there is another pesticide B of different probabilities and increasing incomes, if opportunity B offers you a 10% chance to increase your vegetable income by ￥X and 90% to increase by ￥10. Do you want to switch the opportunity from A to B? (Fill “1” if needed to record or monitored, otherwise “0”)

Tips: If farmers switch, for example, at the 5th option, mark it and ignore subsequent questions. If farmers do not switch, then mark option A.

| | | | |
|---|---|---|---|
| 选择 A (Option A) | 概率 (Probability) | 30% | 70% |
| | 0. 增加的蔬菜收入 (Increased vegetable income) (____) | 80 | 20 |
| 选择 B (Option B) | 概率 (Probability) | 10% | 90% |
| | 1. 增加的蔬菜收入 (Increased vegetable income) (____) | 136 | 10 |
| | 2. 增加的蔬菜收入 (Increased vegetable income) (____) | 150 | 10 |
| | 3. 增加的蔬菜收入 (Increased vegetable income) (____) | 166 | 10 |
| | 4. 增加的蔬菜收入 (Increased vegetable income) (____) | 186 | 10 |
| | 5. 增加的蔬菜收入 (Increased vegetable income) (____) | 212 | 10 |
| | 6. 增加的蔬菜收入 (Increased vegetable income) (____) | 250 | 10 |
| | 7. 增加的蔬菜收入 (Increased vegetable income) (____) | 300 | 10 |
| | 8. 增加的蔬菜收入 (Increased vegetable income) (____) | 370 | 10 |
| | 9. 增加的蔬菜收入 (Increased vegetable income) (____) | 440 | 10 |
| | 10. 增加的蔬菜收入 (Increased vegetable income) (____) | 600 | 10 |
| | 11. 增加的蔬菜收入 (Increased vegetable income) (____) | 800 | 10 |
| | 12. 增加的蔬菜收入 (Increased vegetable income) (____) | 1200 | 10 |
| | 13. 增加的蔬菜收入 (Increased vegetable income) (____) | 2000 | 10 |
| | 14. 增加的蔬菜收入 (Increased vegetable income) (____) | 3400 | 10 |

K02

回想过去几年的蔬菜产量，假设蔬菜价格是固定的。有一个农药 C 使你有 90%的机会使你的蔬菜收入增加 80 元，10%的机会增加 60 元。如果此时有另一个农药 D，从中你有 70%的机会使你的蔬菜收入增加 X 元，30%的机会使你的蔬菜收入增加 10 元。

你会放弃机会 C 而选择机会 D 吗？（在表格中填“1”，没有则填”0”）

提示：如果农民在任一选择改变为 D，(例如，在第 5 个选项变为 D，在此处填“1”)，忽略以后的问题。如果农民不改变，那么标记选项 C。

Try to recall the vegetable yield of the last years and imagine that the price is fixed and there is a pesticide C where you have a 90% chance to increase your vegetable income by ￥80 and 10% to increase by ￥60. Now there is another pesticide D of different probabilities and increasing incomes, if opportunity B offers you a 70% chance to increase your vegetable income by ￥X and 30% to increase by ￥10.

Do you want to switch the opportunity from C to D? (Fill “1” if needed to record or monitored, otherwise “0”)

Tips: If farmers switch, for example, at the 5th option, mark it and ignore subsequent questions. If farmers do not switch, then mark option C.

| | | | |
|---|---|---|---|
| 选择 C (Option C) | 概率 (Probability) | 90% | 10% |
| | 0. 增加的蔬菜收入 (Increased vegetable income) (____) | 80 | 60 |
| 选择 D (Option D) | 概率 (Probability) | 70% | 30% |
| | 1. 增加的蔬菜收入 (Increased vegetable income) (____) | 108 | 10 |
| | 2. 增加的蔬菜收入 (Increased vegetable income) (____) | 112 | 10 |
| | 3. 增加的蔬菜收入 (Increased vegetable income) (____) | 116 | 10 |

| | | | |
|---|---|---|---|
| | 4. 增加的蔬菜收入 (Increased vegetable income) (____) | 120 | 10 |
| | 5. 增加的蔬菜收入 (Increased vegetable income) (____) | 124 | 10 |
| | 6. 增加的蔬菜收入 (Increased vegetable income) (____) | 130 | 10 |
| | 7. 增加的蔬菜收入 (Increased vegetable income) (____) | 136 | 10 |
| | 8. 增加的蔬菜收入 (Increased vegetable income) (____) | 144 | 10 |
| | 9. 增加的蔬菜收入 (Increased vegetable income) (____) | 154 | 10 |
| | 10. 增加的蔬菜收入 (Increased vegetable income) (____) | 166 | 10 |
| | 11. 增加的蔬菜收入 (Increased vegetable income) (____) | 180 | 10 |
| | 12. 增加的蔬菜收入 (Increased vegetable income) (____) | 200 | 10 |
| | 13. 增加的蔬菜收入 (Increased vegetable income) (____) | 220 | 10 |
| | 14. 增加的蔬菜收入 (Increased vegetable income) (____) | 260 | 10 |

K03

**回想过去几年的蔬菜产量，假设蔬菜价格是固定的。有一个农药 E 使你有 50%的机会增加你的蔬菜收入 X 元，50%的机会减少 Y 元。如果此时有另一个农药 F，从中你有 50%的机会增加你的蔬菜收入 X 元和 50%的机会减少 Y 元。**

**你会放弃机会 E 而选择机会 F 吗？（在表格中填"1"，没有则填"0"）**

**提示：如果农民在任一选择改变为 F，(例如，在第 5 个选项变为 F，在此行的 F 填"1")，忽略以后的问题。**

Try to recall the vegetable yield of the last years and imagine that the price is fixed and there is a pesticide E where you have a 50% chance to increase your vegetable income by ￥X and 50% to decrease by ￥Y. Now there is another pesticide F of different probabilities and increasing incomes, if opportunity F offers you a 50% chance to increase your vegetable income by ￥X and 50% to decrease by ￥Y.

Do you want to switch the opportunity from E to F? (Fill "1" if needed to record or monitored, otherwise "0")

Tips: If farmers switch, for example, at the **5th** option, mark it in option F and ignore subsequent questions.

| | 选择 E (Option E) | | | 选择 F (Option F ) | | |
|---|---|---|---|---|---|---|
| | 概率 (Probability) | 50% | 50% | 概率 (Probability) | 50% | 50% |
| 1 | 改变的蔬菜收入 Changed vegetable income (____) | 50 | -8 | 改变的蔬菜收入 Changed vegetable income (____) | 60 | -42 |
| 2 | 改变的蔬菜收入 Changed vegetable income (____) | 8 | -8 | 改变的蔬菜收入 Changed vegetable income (____) | 60 | -42 |
| 3 | 改变的蔬菜收入 Changed vegetable income (____) | 2 | -8 | 改变的蔬菜收入 Changed vegetable income (____) | 60 | -42 |
| 4 | 改变的蔬菜收入 Changed vegetable income (____) | 2 | -8 | 改变的蔬菜收入 Changed vegetable income (____) | 60 | -32 |
| 5 | 改变的蔬菜收入 Changed vegetable income (____) | 2 | -16 | 改变的蔬菜收入 Changed vegetable income (____) | 60 | -32 |
| 6 | 改变的蔬菜收入 Changed vegetable income (____) | 2 | -16 | 改变的蔬菜收入 Changed vegetable income (____) | 60 | -28 |
| 7 | 改变的蔬菜收入 Changed vegetable income (____) | 2 | -16 | 改变的蔬菜收入 Changed vegetable income (____) | 60 | -22 |

L. 健康风险感知时实验

L. Experiment for health risk

L01

回想过去几年的医疗支出，假设医疗价格是不变。有一个选择 A，你有 30%的机会使你的社保卡余额增加 40 元，70%的机会增加 10 元。如果此时有另一个选择 B，从中你有 10%的机会使你的社保卡余额增加 X 元，90%的机会使你的社保卡余额增加 5 元。

你会放弃机会 A 而选择机会 B 吗？（在表格中填“1”，没有则填”0”）

提示：如果农民在任一选择改变为 B，(例如，在第 5 个选项变为 B，在此处填“1”)，忽略以后的问题。如果农民不改变，那么标记选项 A。

Try to recall the medical expenditure of the last years and imagine that the medical price is fixed and there is an opportunity A where you have a 30% chance to increase the balance of your social insurance card by ￥40 and 70% to increase by ￥10. Now there is another opportunity B of different probabilities and increasing balances, if opportunity B offers you a 10% chance to increase the balance of your social insurance card by ￥X and 90% to increase by ￥5.

Do you want to switch the opportunity from A to B? (Fill “1” if needed to record or monitored, otherwise “0”)

Tips: If farmers switch, for example, at the **5th** option, mark it and ignore subsequent questions. If farmers do not switch, then mark option A.

| | | | |
|---|---|---|---|
| 选择 A (Option A) | 概率 (Probability) | 30% | 70% |
| | 0. 增加的余额 (Increased balance) (____) | 40 | 10 |
| 选择 B (Option B) | 概率 (Probability) | 10% | 90% |
| | 1. 增加的余额 (Increased balance) (____) | 68 | 5 |
| | 2. 增加的余额 (Increased balance) (____) | 75 | 5 |
| | 3. 增加的余额 (Increased balance) (____) | 83 | 5 |
| | 4. 增加的余额 (Increased balance) (____) | 93 | 5 |
| | 5. 增加的余额 (Increased balance) (____) | 106 | 5 |
| | 6. 增加的余额 (Increased balance) (____) | 125 | 5 |
| | 7. 增加的余额 (Increased balance) (____) | 150 | 5 |
| | 8. 增加的余额 (Increased balance) (____) | 185 | 5 |
| | 9. 增加的余额 (Increased balance) (____) | 220 | 5 |
| | 10. 增加的余额 (Increased balance) (____) | 300 | 5 |
| | 11. 增加的余额 (Increased balance) (____) | 400 | 5 |
| | 12. 增加的余额 (Increased balance) (____) | 600 | 5 |
| | 13. 增加的余额 (Increased balance) (____) | 1000 | 5 |
| | 14. 增加的余额 (Increased balance) (____) | 1700 | 5 |

L02

回想过去几年的医疗支出，假设医疗价格是不变。有一个选择 C，你有 90%的机会使你的社保卡余额增加 40 元，10%的机会增加 30 元。如果此时有另一个选择 D，从中你有 70%的机会使你的社保卡余额增加 X 元，30%的机会使你的社保卡余额增加 5 元。

你会放弃机会 C 而选择机会 D 吗？（在表格中填“1”，没有则填”0”）

提示：如果农民在任一选择改变为 D，(例如，在第 5 个选项变为 D，在此处填“1”)，忽略以后的问题。如果农民不改变，那么标记选项 C。

Try to recall the medical expenditure of the last years and imagine that the medical price is fixed and there is an opportunity C where you have a 90% chance to increase the balance of your social insurance card by ￥40 and 10% to increase by ￥30. Now there is another opportunity D of different probabilities and increasing balances, if opportunity B offers you a 70% chance to increase the balance of your social insurance card by ￥X and 30% to increase by ￥5.

Do you want to switch the opportunity from C to D? (Fill "1" if needed to record or monitored, otherwise "0")

| | | | |
|---|---|---|---|
| 选择 C (Option C) | 概率 (Probability) | 90% | 10% |
| | 0. 增加的余额 (Increased balance) (____) | 40 | 30 |
| 选择 D (Option D) | 概率 (Probability) | 70% | 30% |
| | 1. 增加的余额 (Increased balance) (____) | 54 | 5 |
| | 2. 增加的余额 (Increased balance) (____) | 56 | 5 |
| | 3. 增加的余额 (Increased balance) (____) | 58 | 5 |
| | 4. 增加的余额 (Increased balance) (____) | 60 | 5 |
| | 5. 增加的余额 (Increased balance) (____) | 62 | 5 |
| | 6. 增加的余额 (Increased balance) (____) | 65 | 5 |
| | 7. 增加的余额 (Increased balance) (____) | 68 | 5 |
| | 8. 增加的余额 (Increased balance) (____) | 72 | 5 |
| | 9. 增加的余额 (Increased balance) (____) | 77 | 5 |
| | 10. 增加的余额 (Increased balance) (____) | 83 | 5 |
| | 11. 增加的余额 (Increased balance) (____) | 90 | 5 |
| | 12. 增加的余额 (Increased balance) (____) | 100 | 5 |
| | 13. 增加的余额 (Increased balance) (____) | 110 | 5 |
| | 14. 增加的余额 (Increased balance) (____) | 130 | 5 |

L03

**回想过去几年的医疗支出，假设医疗价格是不变。有一个选择 E，你有 50%的机会增加你的社保卡余额 X 元，50%的机会减少 Y 元。如果此时有另一个选择 F，从中你有 50%的机会增加你的社保卡余额 X 元，50%的机会减少 Y 元。**

**你会放弃机会 E 而选择机会 F 吗？（在表格中填"1"，没有则填"0"）**

**提示：如果农民在任一选择改变为 F，(例如，在第 5 个选项变为 F，在此行的 F 填"1")，忽略以后的问题。**

Try to recall the medical expenditure of the last years and imagine that the medical price is fixed and there is an opportunity E where you have a 50% chance to the balance of your social insurance card by ￥X and 50% to decrease by ￥Y. Now there is another opportunity D of different probabilities and increasing incomes, if opportunity F offers you a 50% chance to increase the balance of your social insurance card by ￥X and 50% to decrease by ￥Y.

Do you want to switch the opportunity from E to F? (Fill "1" if needed to record or monitored, otherwise "0").

Tips: If farmers switch, for example, at the **5th** option, mark it in option F and ignore subsequent questions.

| | 选择 E (Option E) | | | 选择 F (Option F ) | | |
|---|---|---|---|---|---|---|
| | 概率 (Probability) | 50% | 50% | 概率 (Probability) | 50% | 50% |
| 1 | 余额变化 (Changed balance) (____) | 25 | -4 | 余额变化 (Changed balance) (____) | 30 | -21 |
| 2 | 余额变化 (Changed balance) (____) | 4 | -4 | 余额变化 (Changed balance) (____) | 30 | -21 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3 | 余额变化 (Changed balance) (____) | 1 | -4 | 余额变化 (Changed balance) (____) | 30 | -21 |
| 4 | 余额变化 (Changed balance) (____) | 1 | -4 | 余额变化 (Changed balance) (____) | 30 | -16 |
| 5 | 余额变化 (Changed balance) (____) | 1 | -8 | 余额变化 (Changed balance) (____) | 30 | -16 |
| 6 | 余额变化 (Changed balance) (____) | 1 | -8 | 余额变化 (Changed balance) (____) | 30 | -14 |
| 7 | 余额变化 (Changed balance) (____) | 1 | -8 | 余额变化 (Changed balance) (____) | 30 | -11 |

**附录 (Appendix)**

**赠送给农户的礼物和数量为(The gifts presented to farmers is/are)**

| | | |
|---|---|---|
| 肥皂 (Soap) | 数量 (Number) | |
| 毛巾 (Towel) | 数量 (Number) | |
| 牙刷 (Toothbrush) | 数量 (Number) | |
| 手套 (Gloves) | 数量 (Number) | |

Eidesstattliche Erklärung / Declaration under Oath

Ich erkläre an Eides statt, dass ich die Arbeit selbstständig und ohne fremde Hilfe verfasst, keine anderen als die von mir angegebenen Quellen und Hilfsmittel benutzt und die den benutzten Werken wörtlich oder inhaltlich entnommenen Stellen als solche kenntlich gemacht habe.

*I declare under penalty of perjury that this thesis is my own work entirely and has been written without any help from other people. I used only the sources mentioned and included all the citations correctly both in word or content.*

Datum / *Date* Unterschrift des Antragstellers / *Signature of the applicant*

Ich erkläre, die wissenschaftliche Arbeit an keiner anderen wissenschaftlichen Einrichtung zur Erlangung eines akademischen Grades eingereicht zu haben.

*I declare that the thesis has not been used previously at this or any other university in order to achieve an academic degree.*

Datum / *Date*

Unterschrift des Antragstellers / *Signature of the applicant*

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## EDUCATION

**2016/10-Present** **Ph.D student** in Agricultural Economics,
Leibniz Institute of Agricultural Development in Transition Economies (IAMO)

**2013/09-2016/06** **M.S.** in Agricultural Economics & Management,
Faculty of Management, Sichuan Agricultural University, China

**2008/09-2012/06** **B.S.** in Electronic and Information Engineering,
Faculty of Electronic Engineering, Chengdu University of Information Technology, China

## FIELDS OF INTERESTS

Agricultural Policies, Food Safety, Production Behavior, Experimental Economics.

## RESEARCH EXPERIENCES

- Investigation organizer of "Farmer's pest control practice and the role of incentives in China", Sichuan, Oct.-Nov. 2018;
- Investigation team member for collecting data of "Research of Precise Poverty-Alleviation on the Disabled in Bazhong", Sichuan, Aug. 2015;
- Investigation team member and report writer of "Agricultural Industrial Transformation and Development of Agricultural Modernization in Qinba Mountain Area", Sichuan, Aug. 2014 to Nov. 2014;
- Writer of the research report for "Ecological Compensation Mechanism and Supporting Policies in Minjiang River Basin", May. 2014;
- Writer of the research report for "Development of Modern Agriculture and Innovation of New Agricultural Management System in Sichuan Quake-hit Areas", Dec. 2013;
- Investigation team member for "Farmers' Mental Accounts, Hierarchy of Needs and the Decision-making of Payment of Agricultural Water: Evidence from Sichuan Province Irrigation District", Aug. 2013 to Sep. 2013.

## PUBLICATIONS

[1]. Weikang Zhang, **Yangyi Zeng**, Xinhong Fu, Yuying Liu, Weizhong Zeng. 2014. Reference point, willingness to pay and irrigation water price: Empirical evidence from 567 farmers in Sichuan Province. Recourses science, 10, 2020-2028. (In Chinese)

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[3]. Zeng, Y. and Herzfeld, T. 2021. The effects of mental budgeting on the intentions to switch to low-toxicity pesticides: evidence from vegetable farmers in Sichuan, China, China Agricultural Economic Review, Vol. ahead-of-print No. ahead-of-print. https://doi.org/10.1108/CAER-08-2020-0191.

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[2]. **Yangyi Zeng**, Thomas Herzfeld. 2021. The Effect of Cooperatives and Food Safety Related Instruments on the Choices of Pesticides: Evidence from Vegetable Farmers in Sichuan, China. In process.

[3]. **Yangyi Zeng**, Yuying Liu, Thomas Herzfeld. 2021. The effect of off-farm job on the choices of pesticides: Evidence of vegetable farmers in Sichuan, China. In process.

## Presentations

[1]. Yangyi Zeng. Farmer's pesticide use and the role of incentives in China. Ph.D Seminar. Halle, Germany. 23 April 2018.

[2]. Yangyi Zeng. Survey report: Farmer's pest control measures and the role of incentives in China. China Group Annual Meeting 2018. Halle, Germany. 7 December, 2018.

[3]. Yangyi Zeng, Thomas Herzfeld. Effect of farmer's risk preferences on pesticide use behavior: Evidence from vegetable farmers in Sichuan, China. 23rd International Consortium on Applied Bioeconomy Research (ICABR) Conference. Ravello, Italy. 4-7 June, 2019.