Received 12 August 2020
Revised 2 November 2020
3 February 2021
8 April 2021
Accepted 11 May 2021

The effects of mental budgeting on the intentions to switch to low-toxicity pesticides: evidence from vegetable farmers in Sichuan, China

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Abstract

Purpose – Mental budgeting, as a part of mental accounting theory, is expected to impact a household's budgetary management in terms of expenses. The purpose of this paper is to study whether and how mental budgeting can explain differences in farmers' reactions to different incentives of low-toxicity pesticide use.

Design/methodology/approach – Based on data from a survey of 393 vegetable farmers in the Sichuan Province, this analysis, using a Likert Scale approach, first explores whether farmers utilize mental budgeting. Secondly, using a Probit model, this paper analyzes how mental budgeting affects farmers' intentions to switch to low-toxicity pesticide use when faced with different incentives.

Findings – The results show that the majority of farmers categorize agricultural inputs into different groups and that 26.46% of the investigated farmers utilize mental budgeting for pest control practices. In addition, farmers who utilizing mental budgeting report a higher willingness to switch to low-toxicity pesticides when they're presented with a specific subsidy. Furthermore, if offered a price premium for quality, the willingness to switch to low-toxicity pesticides for farmers utilizing mentally budget is lower compared to other farmers.

Originality/value – This paper examines the existence of mental budgeting among farmers. It provides a better understanding of how farmers categorize agricultural inputs and their mental mechanisms with respect to agricultural expenses. Finally, this paper is the first to study the effects of mental budgeting on farmers' reactions to different incentives aimed at stimulating the adoption of low-toxicity pesticides.

Keywords Mental budgeting, Pest control measures, Mechanism design, Vegetable farming, China

Paper type Research paper

1. Introduction

Pest control is a pivotal activity for maintaining the yield and quality of agricultural production. However, the misuse and overuse of pesticides has caused several food

This work is supported, in part, by a scholarship from the China Scholarship Council (CSC) under the grant CSC NO. 201606910039.

incidents in China, including, for example, that of "poisonous ginger [1]" in 2013 (CCTV, 2013). Incentives such as price premiums or subsidies are typically the main measures used to synchronize pesticide application with good practices (Miyata *et al.*, 2009). However, a poor association between incentives and pesticide use has been documented by scholars to date. For instance, Wilson and Tisdell (2001) show that a price premium results in an overuse of pesticides as long as there is information asymmetry in the market. In addition, Pietola and Lansink (2001) report that more Finnish farmers switch to organic production following a decrease in output prices and an increase in the subsidy for organic farming. Further, Skevas *et al.* (2012) show that subsidies for low-toxicity pesticides does not have a reducing impact on the use of high-toxicity pesticides. Thus, the effects of incentives cannot always be predicted based on rational decision making.

Numerous studies report evidence that individual decision making for spending behavior differs depending on the sources of income (Thaler, 1985; Levav and Mcgraw, 2009; Antonides and Ranyard, 2017). Different income streams will be budgeted into different expenditure categories. These findings contradict neoclassic economic theory, which holds that money is supposed to be fungible (Clot *et al.*, 2015), which means money is substitutable for each category of income or expenditures. However, Thaler (1985) demonstrates that the assumption of fungibility is not supported through experiments and he therefore introduced the concept of mental accounting. In Thaler's theory, money is more fungible within a particular income or expenditure category. Mental budgeting, as a component of mental accounting theory, describes the separation and allocation of money for different categories and purposes (Thaler, 1999). Thus, if farmers view income related to different incentives to be separate from the mental categorization of pesticide use, the varying and only partial success of the policy incentives for encouraging low-toxicity to date may be in line with the assumptions of the concept of mental budgeting.

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

Thus, how different monetary incentives affect the use of low-toxicity pesticides still needs further analysis. Production-related income gained from non-differentiating markets should be used for better pest control practices and other expenses only if money is fungible. Conversely, non-targeted monetary incentives are expected to have less of an effect on encouraging the use of low-toxicity pesticides compared to payments from specific incentives. This paper is aimed at analyzing whether and how mental budgeting can explain differences in farmers' reactions to different incentives for using low-toxicity pesticides. Given that there is, to our knowledge, not a single study looking at the effect of mental budgeting on agricultural input use so far, this new approach helps us to better understand the effectiveness of incentives directed at lowering and using low-toxicity pesticides. More specifically, based on data collected from a field survey with 393 vegetable farmers in Sichuan, China, we first analyze 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 using a Probit model.

2. Literature review

2.1 Mental accounting, mental budgeting and agricultural production decisions

2.1.1 Mental accounting theory. Mental accounting is the set of subjective cognitive operations for the organization, evaluation and keeping track of economic outcomes (Thaler, 1999). In addition to categorization, income labelling and hedonic editing, mental budgeting is one of the components of mental accounting (Zhang and Sussman, 2018; Antonides and Ranyard, 2017; Thaler, 1999). Mental budgeting describes the separation and allocation of money across different expenditure purposes (Zhang and Sussman, 2018). It's argued that mental budgeting exists to simplify decision making processes from 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). However, the existence and expression of mental budgeting can differ across individuals. Consequently, mental accounting theory implies that money is more fungible within a specific mental budget than between different mental budgets. Previous studies provide examples for food consumption (Schady and Rosero, 2008), expenditures of windfall gains (Levav and McGraw, 2009), consumers' reactions to income and price presentation tactics (Homburg *et al.*, 2010), and tax payments of self-employed business owners (Olsen *et al.*, 2019). Categorization, another component of the theory of mental accounting, serves as a pre-condition for a reduced fungibility of money. It describes the behavior of classifying expenses depending on different kinds of demands (Heath and Soll, 1996; Zhang and Sussman, 2018), which can be overlapping for different categories (Heath and Soll, 1996). Goods or inputs categorized into one category are more likely to be set in one budget. Expenses for these inputs would be fungible compared to inputs outside the respective category. Moreover, income labelling assumes that individuals label monetary income according to different budgets for categories that can hardly be substituted (Thaler, 1999; Krishnamurthy and Prokopec, 2010). Finally, hedonic editing explains how people evaluate gains and losses, with different combinations of gains and losses varying in the resulting values among actors.

2.1.2 Mental accounting theory in a farming context. 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 cover the adoption of technology and agricultural input payments (Freudenreich and Mußhoff, 2018; Zhang *et al.*, 2016; Huang *et al.*, 2020; Ocean and Howley, 2019).

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

Based on survey data from 577 Chinese farmers, Zhang *et al.* (2016) test whether farmers categorize agricultural water fees. Their results reveal that farmers use two categories in order to break down expenditures for agricultural water fees, the costs of seeds, pesticides, or fertilizers, former agricultural taxes (abolished in 2004), and rural taxes and fees: agricultural production costs and political charges. However, farmers allocate water fees to both categories. When asked whether agricultural water fees belong to production costs, almost 91% of respondents agree and, at the same time, 95% agree with the question that the fees constitute a political charge. This phenomenon is called cross-typicality.

Using hypothetical scenarios of food reserves and consumption, Huang *et al.* (2020) find that Chinese farmers show mental budgeting in deciding how much to consume from their own-produced food. Ocean and Howley (2019) conducted an experiment among UK farmers trying to understand the heterogeneous effects of different subsidy schemes on environmental management expenses. The results show that there is a statistically significant difference in the allocation of subsidies across three subsidy schemes. While 26.73 and 26.96% of the money is allocated to environmental management, when offered two less restrictive payment schemes, 32.7% of the subsidy would be assigned for this purpose when offered an explicit environmental protection scheme.

2.2 Price premiums and subsidies as incentives for pest control

Based on the hypothesis that farmers would maximize their profits, it is generally accepted that an increase in the effectiveness of pesticide use at the farm level can be achieved by improved knowledge of farmers, providing improved chemical inputs, new plant varieties or promoting non-chemical protection strategies (Feder, 1979; Meissle *et al.*, 2010). However, farmers may not voluntarily change how they use pesticides unless alternative instruments are readily available for adequate pest management (Lamers *et al.*, 2013). A price premium and subsidies are often seen as the appropriate incentives for improving pest control practices. Implementation is typically either governed by state authorities or private organizations that link farmers with markets and consumers (Zhou *et al.*, 2016; Jin and Zhou, 2011; Skevas *et al.*, 2012).

2.2.1 Price premiums and pest control. A price premium can be offered in several ways, such as part of contract farming, or be used by cooperatives and certification schemes to encourage farmers to use better pest control practices (Bijman, 2008; Thiers, 2005). By joining contract farming, cooperatives, or certification schemes, farmers usually receive a price premium in exchange for complying with constraints related to 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).

Although some studies show that a price premium decreases the amount of pesticide use or changes how pest control is used (Yang *et al.*, 2019; Bolwig *et al.*, 2009), other authors provide evidence that a price premium for certified food does not have a significant effect on decreasing the cost of pesticides (Liu *et al.*, 2020), or how it could even increase the use of pesticides (Nie *et al.*, 2018). A price premium has no specific component for encouraging better pesticide usage, but represents an increase in income in exchange for the adjustment of several efforts, such as labor and other inputs. It is still unclear how this change in non-specific income might affect the willingness to join such programs and enhance pesticide use behavior. Thus, if a clear link between the price premium and the use of specific pesticides is established, its effect on the willingness to use low-toxicity pesticides may increase if farmers do not treat money as completely fungible.

2.2.2 Subsidies and pest control. The provision of subsidies conditional upon the adoption of pre-defined pesticides is a widely used technique that directly encourages farmers to use different, select pesticides, often less toxic ones (Skevas *et al.*, 2012). Even though subsidies are aimed at directly affecting decision-making and the use of pesticides, how they exert influence may be different compared to price premiums. Grovermann *et al.* (2017) simulate the effectiveness of different incentives for reducing pesticide use among Thai farmers. The results show that the costs of policies for the government to reach a similar impact differ. In order to achieve a 6.5% reduction in pesticide use, the policy cost of a price premium is 3,900 Thai Baht per household under the premise of introducing integrated pest management. A subsidy scheme, however, corresponds to 3,000 Thai Baht per household and a 6.6% reduction in 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 Sichuan (MOA, 2013). The main purpose of the subsidy scheme is to, on the one hand, mobilize farmers to use low-toxicity, often more expensive, pesticides by compensating for their costs. On the other hand, as the advantages of low-toxicity residues have been recognized, this subsidy intends to help change traditional pesticide practices. Subsidies for low-toxicity pesticides can be regarded as extra income to encourage better pesticide practices. This subsidy is allocated either to farmers after they declare the types and amounts of pesticides used or to pesticide dealers conditional upon selling low-toxicity pesticides at lower prices within the pilot area. However, recent evidence does not show that this pilot subsidy scheme on bio-pesticides achieves a declining use of pesticides among vegetable farmers. More than half of the respondents reported a lack of supervision within the subsidy system and not enough incentives to adjust practices (Yang *et al.*, 2019).

From the perspective of mental accounting theory, a subsidy is specific to pesticide use if farmers utilize 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 depends on farmers' attitudes whether and the extent to which a subsidy could change a farmer's willingness to use low-toxicity pesticides, especially from a comparative perspective with respect to other incentives.

3. Behavioral hypotheses and methodology

In order to test the effects 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 utilizing mental budgeting and those who do no't utilize it. If a farmer utilizes mental budgeting for pest control measures, any behavioral change induced by a monetary incentive would depend on whether it would be categorized in the same budget as pest control inputs and expenses by this farmer.

However, previous studies have shown that people will categorize incomes into different mental budgets that can hardly be 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 utilizing 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 research, we consider two incentives from different income sources: agricultural revenue with a price premium for product quality and a subsidy 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 might be allocated to general agricultural efforts including labor and other agricultural inputs.

Against this background, we assume that farmers' stated willingness to switch to low-toxicity pesticides when faced with two different incentives differs conditional upon their engagement in mental budgeting. Thus, it is hypothesized that:

> *H.* A farmer utilizing mental budgeting is expected to report a higher willingness to switch to low-toxicity pesticides when she/he receives a specific subsidy compared to an agricultural revenue with a price premium for quality.

In this study, in order to achieve a common understanding of the term "low-toxicity pesticides", we refer to "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 of the People's Republic of China.

In order to test our hypothesis, we apply a Probit model to estimate the probability of the willingness to switch to low-toxicity pesticides as follows:

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

where $\Phi(.)$ is the standard normal cumulative distribution function and X is a vector of variables, including mental budgeting (M) and personal and household characteristics (Z). β_1 and β_2 are coefficients for M and Z, respectively, to be estimated.

4. Data collection and description

4.1 Data collection

4.1.1 Sample area and sample size. The survey was conducted by the corresponding author in October and November 2018 in collaboration with Sichuan Agricultural University. University students, who were trained before the survey, were chosen as assistants. Samples were selected through stratified sampling from 17 districts and counties across ten cities and prefectures in Sichuan Province. In each district and county, three townships were selected. Subsequently, between 20 and 30 farm households in each district and county were randomly chosen. In the survey, we focused on households who plant vegetables commercially rather than backyard farming, which is mainly for self-consumption. The head of the selected households or a family member who leads the farming activities was interviewed individually, resulting in 393 completed interviews. The farmers who participated in the survey were asked questions about their personal, household and farming situations, as well as questions to measure the existence of mental budgeting and the intentions to switch to low-toxicity pesticides. The details of those questions are presented in the following.

4.1.2 Typicality of agricultural inputs. Before understanding whether a farmer utilizes mental budgeting, it is necessary to classify the expenses of agricultural inputs as categorization is a main component of mental accounting theory. Thus, the first step was to identify the categories of these expenses. In this study, we followed a method introduced by Heath and Soll (1996) whereby typicality identification is used for understanding categorization. We focused on three categories of agricultural inputs: seeds, fertilizers and pest control measures. We chose these three agricultural inputs since they form the main variable costs for agricultural production. As small farms predominantly rely on family labor exclusively, labor costs have been excluded from variable costs. Similarly, other costs, such as infrastructure costs, are assumed to be fixed within one season. Following the principles of categorization (Henderson and Peterson, 1992), we assumed that seeds, fertilizers and pest control measures represent easily distinguishable goods [2] 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, we provided farmers with ten specific agricultural inputs and asked them to assign these inputs to the three categories. The ten inputs included 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. Similar to Heath and Soll (1996) research, we used a Likert Scale for testing typicality. We applied a five-point scale, with 1 denoting very typical to 5 for very untypical. When farmers felt an item did not belong to a certain category, they had an option of choosing an "X", which reflected null for the typical rating. All of the participating farmers were asked to answer the typicality for all of the selected agricultural inputs in the questionnaire.

In order to test for mental budgeting, farmers needed to assign inputs to different categories in a consistent way. For instance, vegetable seeds and seedlings should typically fall under the "seeds" category. "Fertilizer" included potash fertilizer, nitrogenous fertilizer, phosphate fertilizer and organic fertilizer. Insect-proof lamps/nets, high-toxicity pesticides, low-toxicity pesticides and sexual attractants were part of "pest control measures".

4.1.3 Mental budgeting scale. We assume that a farmer utilizing mental budgeting regarding the expenses of seeds, fertilizers, and pest control measures forms separate categories subject to a budget plan. Overspending the planned budget for pest control measures, for example, by redirecting money from other categories, like seeds or fertilizers, is unlikely. Additionally, if a farmer spends more money on a specific input, the expenses for other inputs in the same category should decrease while affecting inputs in other categories only minimally or not at all (see an empirical evidence of the strictness of separation for consumption from Heath and Soll (1996)). However, if a farmer does not utilize mental budgeting, she/he is less likely to have a budget plan for each category and money should be fungible between the different agricultural inputs across categories.

In order to test for such behavior, we constructed a mental budgeting scale following Antonides *et al.* (2011) and Homburg *et al.* (2010). The scale is based on the aggregation of farmers' responses to four Likert Scale questions ranging from following budget plans to comparison of expenses across categories. The first question aimed to figure out whether farmers have a total budget for agricultural inputs, while the second question strived to understand whether their budgets are fixed or not. The third question tried to understand whether their money is fungible within one budget and the fourth question aimed at understanding whether money is seen as fungible between the budgets of agricultural inputs and other budgets. These four aspects formed the core particularities used to measure 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 focuses on consumers' financial and expenditure behaviors, in this study we firstly carried out an analysis of an agricultural input mental budgeting scale to provide more evidence for different categories. The specific questions were as follows:

Please indicate the extent to which you agree or disagree with the following statements: (Answer options: 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 final mental budgeting scale consists of a factor score of a farmer's response to the four statements, ranging from 1 (totally agree) to 5 (totally disagree). Hence, a lower score implies that a farmer is more likely to apply mental budgeting.

4.1.4 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, we considered incomes from two different sources: agricultural revenue with a price premium for quality and subsidies for low-toxicity pesticides. For each income source with an equal monetary equivalent, each farmer was asked to reveal his/her willingness to adopt less toxic pesticides via a Likert scale ranging from 1 (totally agree) to 5 (totally disagree):

(1) If you were to receive an additional **agricultural revenue with a price premium for quality** of ￥200 [3], please indicate the extent to which you would agree with the statement, “I prefer to switch to low-toxicity pesticides”.

(2) If you were to receive a **subsidy for low-toxicity pesticides** of ￥200, please indicate the extent to which you agree with the statement, “I prefer to switch to low-toxicity pesticides”.

Before we asked about the willingness, we explained to farmers that low-toxicity pesticides are more environmentally friendly pesticides that are generally more expensive than more commonly used ones. These pesticides are subsidized in some pilot areas. We also showed farmers 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” in order to illustrate the concept of low-toxicity pesticides. In addition, as few farmers (seven) were not using chemical pesticides at all, all farmers were asked to assume that they were growing vegetables in a traditional way where pesticides are used before posing questions on their willingness to change their pesticide use behavior.

4.2 Data description

Table 1 summarizes the basic household and farmland characteristics of the farmers who participated in this research. The final analysis includes 393 farmers; the respondents who refused or did not finish the interviews were omitted from the analysis. The farmers interviewed were 52.85 years old on average and 268 of them were male, accounting for 68% of the total sample. About 44% of the interviewed farmers either never attended school or just finished primary school. Only 3.8% of the farmers held a bachelor degree or above. At least one member in about 56.5% of the households included in our sample had an off-farm job. Each household held 36.08 mu of farmland on average and the median farm size was 5 mu, including rented farmland. Not all of the surveyed farmers’ farmland was planted with vegetables, but vegetable production represents a major part of the households’ cultivation.

5. Results and discussion

5.1 Typicality

Table 2 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”,

Variable	Mean (SD)
Age (years)	52.85 (10.51)
Gender (“1” for male)	0.68 (0.47)
Educational level (“1” for not educated, “2” for primary school, “3” for secondary school, “4” for high school or technical secondary school, “5” for undergraduate or junior college, “6” for graduate school)	2.62 (0.96)
Farm size (mu)	36.09 (105.83)
Planted area, vegetables[1] (mu)	33.66 (95.41)
Off-farm job (“1” for yes)	0.56 (0.50)
Observations	393

Note(s): [1]Planted area means the planted farmlands that used to grow vegetables during the whole year. Due to multiple harvests in one year, the planted area could be larger than farm size. For example, vegetable farmers may plant several kinds of vegetables on the same plot in one year. In addition, some farmers do not just cultivate vegetables, but also other crops

Table 1. Summary statistics of households and farming characteristics

	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 fertilizer	2.00 (1.41)	2	0.51	1.16 (0.47)	388	98.73	3.00 (1.41)	8	2.04
Nitrogenous fertilizer	1.00 (–)	1	0.25	1.17 (0.44)	388	98.73	2.00 (0.89)	6	1.53
Phosphate fertilizer	1.00 (–)	1	0.25	1.16 (0.48)	384	97.71	2.00 (0.71)	5	1.27
Organic fertilizer	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

Note(s): 1) Obs. refers to the number of observations for which farmers did not 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

Table 2.
Typicality rating for agricultural inputs

respectively; the corresponding ratings are 1.05 and 1.39. Just a few farmers classify these two inputs as "fertilizers" and five farmers classify them as "pest control measures". Four of them farm less 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" are 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, few farmers feel insect proof-lamps/nets, (high-/low-toxicity) pesticides, and sexual attractants are "seeds" and "fertilizers", but, not surprisingly, "pest control measures". The exact numbers of each corresponding typicality rating term are 382 (97.20%), 370 (94.15%), 385 (97.96%), and 364 (92.62%), respectively.

In sum, 299 farmers (76.08%) categorize all agricultural input types according to professional practice. In this case, when farmers classify selected inputs as typical in uncommon categories, this was regarded as unconventional wisdom. For example, if a farmer noted that vegetable seeds are somehow typical for "fertilizers", this was marked as unconventional wisdom. Besides, as some farmers are not very familiar with some inputs, like sexual attractants for example, 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 [4]. Additionally, 354 (90.08%) respondents show completely conventional wisdom if we neglect the less commonly used inputs (seedlings, insect-proof lamps/nets and sexual attractants). For the category of "pest control measures", 362 (92.11%) show conventional typicality according to professional practice.

5.2 Mental budgeting scale

For this step, we followed the method by Antonides *et al.* (2011), whereby a principal component analysis is applied to determine the mental budgeting scale. The Cronbach's alpha for the four mental budgeting statements listed above 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 labelled as "mental budgeting". The density of the predicted factor scores, relative to the neutral response, is shown in Figure 1. This indicator will be used as the 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 the existence of mental budgeting. In addition, given that the mental budgeting scale is a continuous variable, its interpretation in the econometric analysis is less straightforward. As an additional explanatory variable, we constructed a dummy variable ("mental budgeting dummy") where farmers who agree with all four statements (i.e. answering 1 or 2 for all statements) were assigned a value of "1", and a value of "0" was assigned for others who show disagreements or were neutral.

Table 3 shows the percentage of farmers who responded with "totally agree" or "agree" for the mental budgeting scale statements. Between 35 and 64% of respondents agree with the individual statements. Aggregating responses resulted in a subsample of 104 farmers (26.46%) who agreed with all four statements and would be classified as utilizing mental budgeting. However, 79 farmers disagreed with all four statements, accounting for 20.10%, while the others remained neutral or switched positions across statements. In addition, 187 farmers (47.58%) 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.

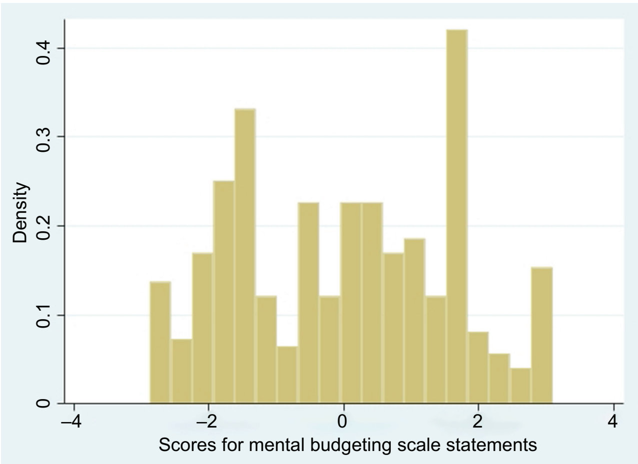

Figure 1. Factor scores derived from mental budgeting scale statements

Table 3. 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, such as seeds, fertilizer, pest control measures etc.	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

5.3 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 displays the farmers' responses when faced with the two hypothetical options during the interviews. Based on the responses, using the five-point Likert Scale, we aggregate farmers who answered "totally agree" and "agree" into one group. They were assigned a value of "1", while farmers who reported disagreement or a neutral response were assigned a value of "0". Although it would be possible to analyze the answered categories separately, our main interest was the degree of agreement in order to distinguish farmers who utilize mental budgeting from those who do no't. Comparing the two options, more farmers are willing to adopt low-toxicity pesticides when presented with a subsidy compared to a price premium. 194 farmers would adopt low-toxicity pesticides under both scenarios, i.e. they do not react differently to a price premium or a subsidy. However, 81 farmers would neither adopt when offered a price premium nor when offered a subsidy. Separating the sample by farm size, respondents report a rather similar willingness on average when offered a price premium: 2.861 for farms below 10 mu compared to 2.783 for farms strictly larger than 10 mu, while smaller farms tend to be more willing to switch to low-toxicity pesticides when receiving a subsidy (2.293) than larger farms (1.953).

5.4 Mental budgeting and pest control intentions

The results of the Probit model testing the effect of mental budgeting on farmers' willingness to switch to low-toxicity pesticides are shown in Table 5. Following the suggestion from Berry (2016) about the use of p-values, our study simply provides some exploratory evidence. In order to test the robustness of our model by dichotomizing mental budgeting, we also applied the Receiver Operating Characteristic (ROC) tool following Streiner and Cairney (2007). The results of the ROC tests are shown in the appendix.

Turning to the correlation of our behavioral variable with a farmer's willingness to adopt low-toxicity pesticides, displayed in the first and third columns of Table 5, the coefficient of mental budgeting is −0.346 when faced with a subsidy. Thus, a farmer showing the existence of mental budgeting is more likely to change their pesticide choice when offered a subsidy than a companion farmer who treats money as fungible. The average marginal effect implies that a farmer holding a one lower mental budgeting factor score would have an almost 10% higher likelihood to switch pesticides in case of receiving the ¥200 [5]. Although the coefficient and average marginal effect of a price premium is opposite to a subsidy, the standard error for a price premium is comparatively high. Thus, we cannot derive empirical evidence of a strong correlation between the behavioral variable and the willingness to switch to low-toxicity pesticides.

The second and forth columns of Table 5 present results for when a dichotomous variable for mental budgeting was used. Similar to the continuous measure, a farmer who utilizes mental budgeting is predicted to be more willing to switch to low-toxicity pesticides. When faced with a subsidy, farmers utilizing mental budgeting are expected to be more likely to

Table 4. Frequency and percentage of agreement with selected pest control measures

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

Note(s): Obs. refers to the number of observations of farmers who "totally agree" and "agree" with the pest control statements

Table 5. Probit regression results for the willingness to switch to low-toxicity pesticides

Variables	Agricultural revenue with price premiums for quality				Subsidy			
	(1)		(2)		(3)		(4)	
	Coefficient	Average marginal effect	Coefficient	Average marginal effect	Coefficient	Average marginal effect	Coefficient	Average marginal effect
Mental budgeting	0.054 (0.041)	0.021 (0.015)	–	–	−0.346*** (0.049)	−0.098*** (0.011)	–	–
Mental budgeting dummy	–	–	−0.371** (0.150)	−0.141** (0.055)	–	–	1.098*** (0.209)	0.329*** (0.058)
Age	−0.017** (0.007)	−0.006** (0.003)	−0.017** (0.007)	−0.007** (0.003)	−0.013 (0.008)	−0.004 (0.002)	−0.012 (0.008)	−0.004 (0.002)
Farm size	−0.0002 (0.0007)	−0.0001 (0.0003)	−0.00002 (0.0007)	−7.75e–6 (0.0003)	0.001 (0.001)	0.0003 (0.0004)	0.001 (0.001)	0.0003 (0.0004)
Educational level	−0.064 (0.079)	−0.024 (0.030)	−0.069 (0.079)	−0.026 (0.030)	0.053 (0.088)	0.015 (0.025)	0.067 (0.088)	0.020 (0.026)
Off-farm job	−0.381*** (0.139)	−0.146*** (0.052)	−0.392*** (0.140)	−0.149*** (0.051)	−0.136 (0.154)	−0.038 (0.043)	−0.119 (0.150)	−0.036 (0.045)
Lnincome	0.138** (0.062)	0.053** (0.023)	0.137** (0.062)	0.052** (0.023)	0.110* (0.057)	0.031* (0.016)	0.111** (0.056)	0.033** (0.016)
Constant	−0.159 (0.790)	–	0.010 (0.794)	–	0.092 (0.818)	–	−0.301 (0.805)	–
Obs	393	393	393	393	393	393	393	393

Note(s): 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

***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

switch pesticides by 32.9%. However, with a negative coefficient of -0.371, the price premium suggests the opposite direction and the estimate is more precise. Thus, a farmer who utilizes mental budgeting is predicted to show a 14.1% lower probability of adopting low-toxicity pesticides compared to the other farmers when offered a price premium. These results indicate that, compared to a price premium a subsidy would be more effective for encouraging farmers who utilize mental budgeting.

In addition, in order to check the robustness of the results, we re-grouped "mental budgeting dummy 2" to include farmers who agreed with all four statements or were neutral (i.e. answering 1 or 3 for all statements), and only those who always disagreed were assigned a value of "0". The results of "mental budgeting dummy 2" are similar to the previous "mental budgeting dummy" specifications. Farmers who utilize or are neutral to mental budgeting show a higher probability of adopting low-toxic pesticides when offered a subsidy (30%), but a lower probability when faced with a price premium (18.6%). The detailed results are shown in Table A1.

Similarly, when assigning all farmers who are not explicitly unwilling to switch to low-toxicity pesticides a "1" as the dependent variable, the results are similar. Farmers utilizing mental budgeting are more willing to switch to low-toxicity pesticides when offered a subsidy, but the coefficient is negative and not statistically different from zero when faced with a price premium. The detailed regression results are shown in Table A2.

In general, a subsidy generates income effects specific to the mental budgeting of pest control and our results suggest that increased budgets will change the demand structure for pest control measures if a farmer uses such a budgeting procedure in decision making. A price premium is perceived to be less specific to the choice of pesticides. In our case, the price premium, probably by lifting budget constraints, even results in a lower willingness to choose low toxicity pesticides for farmers utilizing mental budgeting. However, the results do no't allow us to conclude that a price premium would have no effect.

These results support our hypothesis stated above. A price premium for quality does not have the same impact as a subsidy. There might be several possible reasons for this. First, as assumed above, a quality price premium might be more likely to be allocated to general agricultural efforts, while pest control decisions would benefit more from a specific subsidy for pesticides. Another reason could be the uncertainty whether to receive a price premium. Compared to a specific subsidy, a price premium might dissipate once all farmers switch to less toxic pesticides. However, the role of the predictability of the incentive has not been analyzed here and would require further study.

6. Conclusion

Taking mental budgeting into account can improve our understanding of farmers' choices of pest control measures. Given that most farmers form categories across different agricultural inputs, farmers seem to react differently to monetary incentives from different income sources. Our study first provides evidence that more than a quarter of vegetable farmers in our sample utilize mental budgeting. In addition, it contributes to explanatorily extending the potential effect of mental budgeting on production decision making. Finally, the analysis provides evidence that monetary incentives can affect pest control measures among vegetable farmers in Sichuan differently.

Our results indicate that farmers utilizing mental budgeting report a higher willingness to switch to low-toxicity pesticides when offered a specific subsidy than other farmers. However, among farmers utilizing mental budgeting, there is not sufficient evidence showing that a price premium would have a similar effect on the willingness to switch to low-toxicity pesticides.

Our results point in a similar direction as findings by Ocean and Howley (2019) and 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 subsidies rather than pricing of agricultural products that cover more than one category of agricultural inputs. These kinds of "nudges [6]" would be important for future incentive schemes in order to achieve a higher effectiveness and the desired outcomes.

However, it is worth noting that the current literature also provides evidence that subsidies, such as grain subsidies or fertilizer subsidies, do not always result in the desired impact of changing farmers' production behaviors (Huang *et al.*, 2011). A main reason is that some farmers do not know the value of such subsidies, or even misunderstand the subsidies (Huang *et al.*, 2011). This would probably lead to an allocation of money received into other mental budgeting categories, rather than the budget categories that the subsidies are aimed at. Thus, it is important to consider farmers' understanding when designing and implementing subsidy schemes.

Although the quantitative results apply to our sample only, some conclusions do have some external validity. In particular, our methodology can be applied to the study of other aspects in agriculture, such as monetary incentive schemes for organic agriculture, resource conservation efforts, agricultural technologies or the adoption of other sustainable practices. Given the effect of a "nudge", a more specific monetary incentive scheme would have a higher effectiveness than general ones. Furthermore, replicating our approach on a nationally representative sample of farmers would allow for conclusions with external validity to be derived.

Reflecting upon the experimental design and analysis and conditional upon the availability of resources, some aspects could be changed in follow-up studies. First, when 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 how pesticides are budgeted for when farmers consider 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 the methodologically soundest results.

Notes

1. On May 10, 2013, the CCTV (China Central Television) reported that a banned pesticide, namely aldicarb, was being used for producing ginger in Weifang, Shangdong.
2. Cross typicality exists for some inputs. For example, BT cotton may have both typicality of seeds and pest control measures. The majority of inputs, however, are expected to have just one typicality.
3. According to the National Bureau of Statistics, per capita disposable income of farmers in 2018 was 14,617 Chinese Yuan (¥). ¥200 yuan is close to a week's worth of income. We use weekly income rather than daily income because the effect of daily income would be too small to have an effect on planned decision making. Another reason for setting ¥200 as the incentive amount is that before having more detailed knowledge of the local situation, the weekly per capita income appeared to be the most reliable information. Furthermore, based on the neoclassical assumption of the fungibility of money, we opted for an incentive which would be unaffected by the existence of mental budgeting behavior. From the data we collected, the average cost of pesticides for vegetable farmers in Sichuan Province is 205.882 ¥/mu (Mu is a typical area unit in China; 15 mu equals 1 hectare) with a standard deviation of 226.880. The costs are similar between farms of less than 10 mu (206.354 ¥/mu with a standard deviation of 218.561) and those strictly larger than 10 mu (204.605 ¥/mu with a standard deviation of 249.111). Thus, the incentive is rather close to the pesticide costs for vegetable production in our sample.

4. Earlier studies document a similar pattern: for instance, for Heath and Soll (1996), 25 of 26 respondents 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.
5. The final mental budgeting scale represents a factor score summing up farmer’s responses to the four statements based on Principal Component Analysis.
6. A “nudge” is any aspect of the choice that could predictably influence people’s behavior without either forbidding any options or changing economic incentives.

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Appendices

Appendix 1. In order to test the receiver operating characteristic (ROC) of the predictive power of the Probit model, we use the opposite number of mental budgeting factor scores as a lower score is related to a higher likelihood to engage in mental budgeting. We then draw ROC curves for both situations (with a subsidy and with a price premium). Figure A1 and A2 show the ROC curves for a subsidy and price premium, respectively.

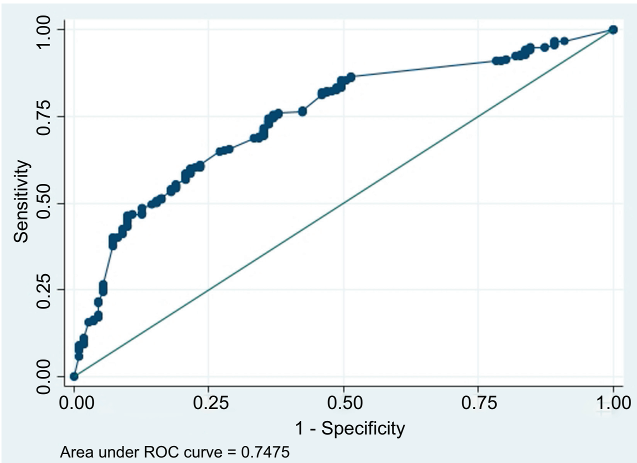

Figure A1.
ROC curve for probit model with subsidy

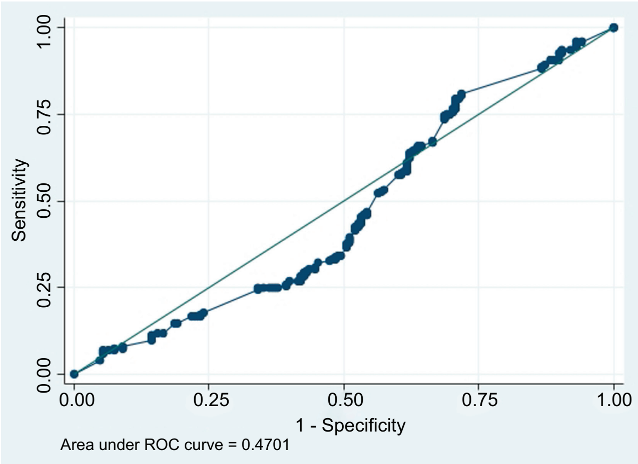

Figure A2.
ROC curve for probit model with price premium

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.

Variables	Agricultural revenue with price premiums for quality: Coefficient	Agricultural revenue with price premiums for quality: Average marginal effect	Subsidy: Coefficient	Subsidy: Average marginal effect
Mental budgeting dummy 2	−0.497*** (0.137)	−0.186*** (0.048)	1.021*** (0.171)	0.300*** (0.044)
Age	−0.017** (0.007)	−0.006** (0.003)	−0.015* (0.008)	−0.005** (0.002)
Farm size	0.00005 (0.007)	−0.0002 (0.0003)	0.001 (0.001)	0.0003 (0.0004)
Educational level	−0.067 (0.080)	−0.025 (0.030)	0.066 (0.088)	0.019 (0.026)
Off-farm job	−0.390*** (0.140)	−0.146*** (0.051)	−0.133 (0.151)	−0.039 (0.044)
Lnincome	0.136** (0.062)	0.051** (0.023)	0.112** (0.055)	0.033** (0.016)
Constant	0.055 (0.793)	–	−0.202 (0.805)	–
Obs.	393	393	393	393

Note(s): "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
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Table A1.
Probit regression results for the willingness to switch to low-toxicity pesticides by re-grouping mental budgeting scales

Table A2. Probit regression results for the willingness to switch to low-toxicity pesticides by re-grouping intentions

	Agricultural revenue with price premiums for quality						Subsidy					
	(1)		(2)		(3)		(4)		(5)		(6)	
Variables	Coefficient	Average marginal effect	Coefficient	Average marginal effect	Coefficient	Average marginal effect	Coefficient	Average marginal effect	Coefficient	Average marginal effect	Coefficient	Average marginal effect
Mental budgeting	−0.028 (0.041)	−0.010 (0.015)	–	–	–	–	−0.434*** (0.056)	−0.103*** (0.011)	–	–	–	–
Mental budgeting dummy	–	–	−0.206 (0.150)	−0.077 (0.055)	–	–	–	–	1.311*** (0.265)	0.349*** (0.067)	–	–
Mental budgeting dummy 2	–	–	–	–	−0.195 (0.136)	−0.073 (0.050)	–	–	–	–	1.376*** (0.221)	0.348*** (0.050)
Age	−0.022*** (0.007)	−0.008*** (0.003)	−0.023*** (0.007)	−0.008*** (0.003)	−0.022*** (0.007)	−0.008*** (0.003)	−0.012 (0.009)	−0.003 (0.002)	−0.011 (0.008)	−0.003 (0.002)	−0.015* (0.009)	−0.004* (0.002)
Farm size	−0.0007 (0.0007)	−0.0002 (0.0002)	−0.0004 (0.0007)	−0.0001 (0.0003)	−0.0004 (0.0007)	−0.0002 (0.0002)	0.0006 (0.001)	0.0001 (0.0003)	0.0006 (0.001)	0.0002 (0.0003)	0.0006 (0.001)	0.0002 (0.0003)
Educational level	−0.110 (0.079)	−0.041 (0.029)	−0.112 (0.080)	−0.042 (0.029)	−0.110 (0.080)	−0.041 (0.029)	−0.025 (0.094)	−0.006 (0.022)	−0.005 (0.092)	−0.001 (0.024)	−0.010 (0.093)	−0.002 (0.024)
Off-farm job	−0.153 (0.138)	−0.057 (0.051)	−0.163 (0.138)	−0.061 (0.051)	−0.158 (0.138)	−0.059 (0.051)	0.094 (0.164)	0.023 (0.039)	0.096 (0.157)	0.026 (0.042)	0.103 (0.160)	0.026 (0.040)
Lnincome	0.079 (0.052)	0.030 (0.019)	0.079 (0.053)	0.029 (0.019)	0.079 (0.053)	0.029 (0.019)	0.050 (0.058)	0.012 (0.014)	0.053 (0.057)	0.014 (0.015)	0.056 (0.057)	0.014 (0.014)
Constant	0.995 (0.734)	–	1.086 (0.741)	–	1.064 (0.739)	–	1.045 (0.858)	–	0.553 (0.835)	–	0.619 (0.844)	–
Obs.	393	393	393	393	393	393	393	393	393	393	393	393

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
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$

Appendix 2. The supplementary files are available online for this article.

The data file for this paper is caer-08-2020-0191-File013-1.xlsx. The .do file named caer-08-2020-0191-File014-1.do produces the tables in the paper.

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