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Abstract

Purpose – The purpose of this paper is to examine the impact of farmers' risk perceptions regarding rubber farming on their land use choices, including rubber specialization and crop diversification.
Design/methodology/approach – A cross-sectional survey data of some 600 smallholder rubber farmers in Xishuangbanna in Southwest China is employed. This paper develops a general conceptual framework that incorporates a subjective risk item into a model of farmers' land use choices, thereby developing four econometric models to estimate the role of risk perceptions, and applies instrumental variables to control for the endogeneity of risk perceptions.
Findings – The results demonstrate that risk perceptions play an important role in smallholders' decision-making regarding land use strategies to address potential risks in rubber farming. Smallholders with higher risk perceptions specialize in rubber farming less often and are more likely to diversify their land use, thereby contributing to local environmental conservation in terms of agrobiodiversity. The land use choices of smallholder rubber farmers are also associated with ethnicity, household wealth, off-farm employment, land tenure status, altitude and rubber farming experience.
Originality/value – This study contributes to a better understanding of the implications of farmers' risk perceptions and shows entry points for improving the sustainability of rubber-based land use systems.

Keywords Land use, Risk perceptions, Crop diversification, Rubber specialization

Paper type Research paper

1. Introduction

Since the rural reforms in the late 1970s and technological improvements, many parts of China's rural sector have achieved rapid economic growth and rising incomes (Lin, 1992; Huang and Rozelle, 1996). However, the one-sided pursuit of economic growth has resulted in considerable environmental costs, e.g. soil degradation, agricultural chemical pollution and the loss of agrobiodiversity, particularly in biodiversity hotspots, e.g. Xishuangbanna Dai Autonomous Prefecture (XSBN) in the Southern Yunnan province, which has experienced dramatic changes in land use. The unsustainable planting of monocultures of commercial crops, such as rubber, tea and fruit trees, is quite common (Guo and Padoch, 1995); in particular, rubber plantations have been rapidly expanding in recent years (Ahrends *et al.*, 2015). This expansion severely threatens biodiversity and the natural environment in the region (Newton *et al.*, 2013).

Concerns about the sustainability of specialized rubber farming and its impact on the local environment and the livelihood of XSBN have been raised almost since the beginning of the

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recent rubber expansion. Compared with the profits previously obtained by cultivating other crops, the relatively high profits from rubber farming are widely recognized as the major driver of this expansion (Liu *et al.*, 2006; Maes, 2012; Ahrends *et al.*, 2015). Although rubber plantation expansion has remarkably improved smallholders' incomes and helped them achieve unprecedented wealth (Liu *et al.*, 2006; Fox and Castella, 2013; Fox *et al.*, 2014), this development actually has some negative environmental impacts and potential risks (Xu *et al.*, 2005; Manivong and Cramb, 2008; Fu *et al.*, 2010). On the one hand, the transition from traditional agriculture and forest land to rubber plantations has led to a substantial loss in agrobiodiversity and has caused an imbalance in the local ecological system (Xu *et al.*, 2005; Hu *et al.*, 2008; Fu *et al.*, 2009; Qiu, 2009; Ahlheim *et al.*, 2015). On the other hand, because rubber is a kind of perennial crop and is often grown in monoculture, the relatively high sunk costs of investing in rubber make smallholders subject to potential risks, such as a decline in rubber prices or plant diseases.

While natural rubber is already the primary land use in XSBN, smallholder farmers' expansion of rubber continues (Fu *et al.*, 2010). Rubber plantations are now even expanding into marginal areas (Ahrends *et al.*, 2015; Zhang *et al.*, 2015); fortunately, some smallholders still maintain a portion of their land for other crops. Quite commonly, farmers only partially adopt a new crop or a new technology, as Smale *et al.* (1994), for example, found regarding farmers' partial adoption of new varieties in Malawi. According to these authors, risk aversion is believed to be the reason for this behavior in smallholders. Yesuf and Bluffstone (2009) also found that most households in rural Ethiopia were reluctant to opt for risky high-return investments. Hence, the potential risk of rubber farming is likely a factor that affects the land use behaviors of smallholder rubber farmers, thereby potentially having an impact on rubber specialization and crop diversification in XSBN.

Previous studies suggest that risk normally plays an important role in individual decision-making (Kasper, 1980; Sitkin and Weingart, 1995). In particular, risk perceptions, which typically reflect intuitive risk judgment (Slovic, 1987), are often used to interpret individual decision-making, for example, in investment decision-making (Antonides and Sar, 1990), consumer and marketing disciplines (Cox and Rich, 1964; Stone and Grønhaug, 1993), smoking behavior (Liu and Hsieh, 1995) and the willingness to address climate change (O'Connor *et al.*,1999). Furthermore, researchers are interested in the relationship between risk perceptions and individual behavior in human health (Brewer *et al.*, 2004; Lima, 2004). For instance, Brewer *et al.* (2004) found that increased risk judgment encouraged people to engage in protective behavior. In addition, risk perceptions also can be regarded as a prerequisite for choosing an effective risk-coping strategy because a farmer who is not clearly aware of the risks that he or she faces is unable to manage them effectively (Sulewski and Kłoczko-Gajewska, 2014).

Land use decision-making under risk and uncertainty has also been widely discussed in theoretical and empirical studies (Nowshirvani, 1971; Just and Zilberman, 1983; Collender and Zilberman, 1985; Lence and Hayes, 1995). Generally, the land use decision under risk can be derived by incorporating the risk factor into the production function and then maximizing the expected production, profit or utility function. Almost all prior empirical studies focus on the impacts of general risk preferences or attitudes (e.g. risk-averse, -neutral or -seeking) on the land use decision. Although Lence and Hayes (1995) suggest that related studies regarding land use choices should explicitly account for the estimation risk and assess its potential impact, in practice, the estimation risk is normally proxied using an experience variable such as the experienced weather shocks (Bai *et al.*, 2015).

However, empirical evidence of the effects of subjective risk perceptions on smallholder farmers' land use choices, especially their role in rubber specialization and crop diversification, is lacking. In this study, we use information on farmers' risk perceptions regarding rubber farming, which we measured as a simple survey risk item in the household survey of some 600 smallholder rubber farmers in XSBN. In the survey, we used a comprehensive household questionnaire, which included detailed information on land use, rubber farming, farm and off-farm activities, demographic characteristics and rubber-related questions. Following the measurement of risk perceptions in the study of Weber *et al.* (2002) and referring to subjective assessments of risk attitudes (Dohmen *et al.*, 2011; Hardeweg *et al.*, 2013), we used scores on an eleven-point Likert-scale to measure farmers' risk perceptions regarding rubber farming. Rubber specialization is measured as the share of rubber in the household's total land allocation, while a count index and a Shannon index serve as proxies for crop diversification.

Descriptive statistics are used to analyze the distribution of the perceived risk in rubber farming and to investigate the status quo of land use, rubber specialization, and crop diversification. Furthermore, the subjective risk item is incorporated into the conceptual models of smallholder rubber farmer's land use choices. We employ four econometric models, namely, probit, tobit, poisson and seemingly unrelated regressions to estimate the impacts of risk perceptions on land use choices, including rubber specialization and crop diversification. To control for the potential endogeneity bias, we apply an instrumental variable approach. The risk perception variable is constructed using the cluster effect, that is, the mean of the risk perceptions of other sample smallholders in the village.

Based on the findings in the literature, we can hypothesize that the perceived risk in rubber farming is an important factor in land use choices. We expect that the higher risk perceptions regarding rubber farming are, the more likely smallholder rubber farmers will be to diversify their land use, thereby reducing rubber specialization and improving crop diversification. This study can help improve our understanding of the land use strategy of smallholder rubber farmers in XSBN and other similar rubber growing areas in the Mekong region. The results of this study can also help identify the potential entry points for improving food security and agrobiodiversity in rubber-based land use systems. Finally, in some sense, this paper contributes to the empirical literature on the relationship between subjective risk perceptions and decision-making regarding land use choices.

The rest of this paper is organized as follows. Section 2 presents the theoretical framework and derives a conceptual model of smallholder rubber farmer's land use under the risk of rubber farming. Section 3 briefly introduces the study area and data collection procedure. Section 4 describes the empirical models that have been developed to estimate the impacts of risk perceptions on land use and crop diversification. Descriptive statistics are presented in Section 5. In Section 6, we report and discuss the model results. The last section presents our summary and conclusions.

2. Conceptual framework

For choices made under risk and uncertainty, expected utility theory is recognized as a major model in behavioral economics (Harrison and Rutström, 2009). Expected utility theory states that the decision-maker chooses between risky prospects by comparing their expected utility values (Mongin, 1997). If an appropriate utility is assigned to each possible consequence and each choice's expected utility is calculated, then the best course of action is the option with the maximum expected utility (Ananda and Herath, 2005). In practice, expected utility theory has been applied in numerous risk impact studies, e.g. Pannell (1991), Liu and Hsieh (1995) and Wang *et al.* (2011). Additionally, expected utility theory has also been widely applied to land use allocation decisions (Nowshirvani, 1971; Just and Zilberman, 1983; Collender and Zilberman, 1985; Smale *et al.*, 1994). For example, the study of Lence and Hayes (1995) examines land use decisions in the presence of risk.

In line with previous studies, we construct a conceptual model to express smallholders' land use strategies under the potential risk of rubber farming. Let the farmer's utility function U be determined by profits from land use. Suppose a farmer chooses a land allocation D ($l_1,\ldots, l_j$) that maximizes the expected utility (EU_D). Considering that land use allocation in this study only concerns smallholder rubber farmers, we can express the maximization problem as follows:

$$\text{Max } \text{EU}_D = U_1[l_1 \times \pi_1] + \sum_{j(j \neq 1)} U_j\left[l_j \times \pi_j\right]$$

$$s.t. \ \sum_j l_j \leqslant L; \ \ l_1 > 0; \ \ l_j \geqslant 0 \tag{1}$$

where U_j represents the expected utility of the jth farming; l_j the land area allocated for the jth farming; and $j = 1$ the rubber farming. L the total land area. π_j the expected unit profit from the jth farming and is given as follows:

$$\pi_j = \begin{cases} f\left(R, \overline{P_1}, \overline{C_1}, Z\right) & \text{if } j = 1 \\ f\left(\overline{P_j}, \overline{C_j}, Z\right) & \text{if } j \neq 1 \end{cases} \tag{2}$$

where $\overline{P_j}$ and $\overline{C_j}$ indicate the expected price and the expected unit input costs of the jth farming, respectively. As an index of risk, R refers to the risk perceptions, reflecting the smallholder's subjective assessment for the riskiness of rubber farming. Z represents a vector of the socioeconomic characteristic variables of smallholder rubber farmers. In function (2), an implicit assumption is that the expected profit from rubber farming is uncertain due to the variations in the perceived risk of rubber farming. Additionally, most other crops are traditional for local smallholders, who generally have a relatively rational understanding of the potential risk of these crops. Thus, we can assume that the riskiness of farming these crops is similar for smallholder rubber farmers in XSBN. For the sake of simplicity, the expected profit function of the other crops does not include the risk factor.

By inserting function (2) and considering the wealth constraints (W) for the expected total input costs of all crop farming, the maximization problem (1) becomes:

$$\text{Max } \text{U}_D = U_1\left[l_1 \times f\left(R, \overline{P_1}, \overline{C_1}, Z\right)\right] + \sum_{j(j \neq 1)} U_j\left[l_j \times f\left(\overline{P_j}, \overline{C_j}, Z\right)\right]$$

$$s.t. \ \sum_j l_j \leqslant L; \ \ l_1 > 0; \ \ l_j \geqslant 0$$

$$\sum_j l_j \times \overline{C_j} \leqslant W; \ \ \overline{C_1} > 0; \ \ \overline{C_j} \geqslant 0 \tag{3}$$

Following the study of Bai *et al.* (2015), we can conceptually derive the optimal choice (D^*) of land allocation by maximizing function (3). Accordingly, D^* is expressed as follows:

$$D^*\left(l_1, \ldots, l_j\right) = f\left(R, \overline{P_1}, \overline{C_1}, \overline{P_j}, \overline{C_j}, W, L, Z\right) \tag{4}$$

The expected output prices $\overline{P_j}$ are the nominal observed market prices (Smale *et al.*, 1994), and the expected unit inputs $\overline{C_j}$ are defined as the nominal input costs of each kind of crop farming. As the present study only concerns the cross-sectional data in XSBN, $\overline{P_j}$ and $\overline{C_j}$ can be treated as constant for all smallholder rubber farmers. Thus, for the sake of simplicity, we can further eliminate $\overline{P_j}$ and $\overline{C_j}$ in the function (4), such that the reduced-form model of smallholders' land allocation under the potential risk of rubber farming can be expressed as follows:

$$D^*\left(l_1, \ldots, l_j\right) = f(R, W, L, Z) \tag{5}$$

Furthermore, because the indicators of rubber specialization and crop diversification are normally calculated directly based on land use status (D^*), their conceptual models also can be expressed as a function of the perceived risk in rubber farming (R), household wealth (W), land constraint (L) and household socioeconomic characteristics (Z).

3. Study area and data sources

As shown in Figure 1, XSBN is in the southern part of Yunnan Province in China and is located in the upper Mekong basin, bordering Laos in the South and Myanmar in the west. In the 1950s, in an attempt to free itself from the world market and to promote economic development, China gradually established several state farms to produce natural rubber in XSBN (Fox *et al.*, 2014). Since the onset of agricultural reforms in the 1980s, rubber trees have been increasingly planted by private corporations and smallholders in XSBN (Xu, 2006). Due to the development over the last 30 years, rubber plantations in XSBN comprised 4.34 million mu[1] in 2012, generating an annual total production of over 292,000 tons of dry rubber (Bureau of Statistics of Xishuangbanna Dai Autonomous Prefecture, 2013). Further expansion of smallholder rubber plantations is expected to occur in XSBN as long as the price of natural rubber remains sufficiently attractive (Li *et al.*, 2008; Fu *et al.*, 2010; Zhang *et al.*, 2015).

A household survey of smallholder rubber farmers in XSBN was conducted in March 2013. The survey instruments were developed through a pre-survey conducted in July 2012, and the questionnaires were pre-tested in December 2012. The household

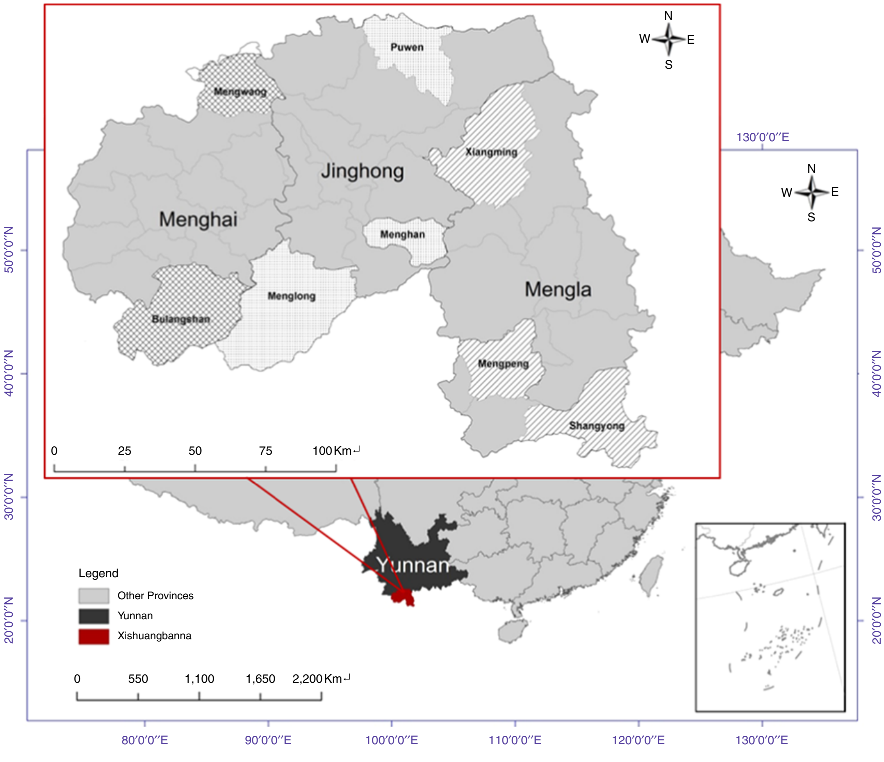

Figure 1.
Location of XSBN and the sample distribution

questionnaire includes detailed information on rubber farming activities for an entire production period in 2012, household characteristics, land use, different farm and non-farm income sources, environmental awareness, shocks experienced and expected risks, as well as some other rubber-related questions.

Sample selection was designed by applying a stratified random sampling approach (stratified by rubber planting area per capita) and considering the distribution of rubber planting areas within each county/city, such that the samples could represent smallholder rubber farming in XSBN as much as possible. First, eight townships were selected from one city (Jinghong) and two counties (Menghai and Mengla). Due to the relatively low intensity of rubber distribution in Menghai, only two sample townships were selected, while three townships were selected from Jinghong and Mengla. Second, a total of 42 villages were chosen from sample townships via stratified random selection. Given the different intensities of rubber distributions, six villages were selected within each sample township in Jinghong and Mengla, whereas only three villages were selected within the Mengwang and Bulangshan township of Menghai. Finally, sample households were randomly selected based on the smallholder rubber farmer list for each village; thus, we interviewed a total of 612 smallholders from 42 villages in eight townships of the three counties (Menghai, Jinghong and Mengla) in XSBN (Figure 1). The collected survey data provide a unique opportunity for this empirical study.

4. Empirical models

4.1 The impacts of risk perception on rubber specialization and land use choices

To capture the impacts of the perceived risk of rubber farming on land use choices and rubber specialization by controlling other variables, we propose two econometric models by defining two distinct measurements of land use strategy: smallholder rubber farmers' cultivation of other crops in addition to rubber and the planting pattern (i.e. the proportion of various crops planted to the total land area).

For the first measure, the dependent variable is dichotomous and expressed as follows:

$$D_i = \begin{cases} 1 & \text{if planting rubber and other crops} \\ 0 & \text{if planting only rubber} \end{cases} \tag{6}$$

According to the standard probit model form, the ith smallholder's probability of planting both rubber and other crops can be expressed as follows:

$$\Pr\left(D_i = 1 \middle| R_i, W_i, L_i, Z_i\right) = \Phi(\alpha_0 + \alpha_1 R_i + \alpha_2 W_i + \alpha_3 L_i + \alpha_4 Z_i) \tag{7}$$

where $\Phi(\bullet)$ denotes the cumulative normal distribution function; R_i the ith smallholder's risk perception of rubber farming; W_i and L_i the wealth and land constraints, respectively, of the ith smallholder; Z_i a vector of household characteristic variables that may affect decision-making regarding the land use of the ith smallholder; and $\alpha_0,\ldots,\alpha_4$ are the parameters to be estimated:

$$\ln L = \sum_i \{D_i \ln[\Phi(\alpha_0 + \alpha_1 R_i + \alpha_2 W_i + \alpha_3 L_i + \alpha_4 Z_i)] + (1 - D_i)\ln[1 - \Phi(\alpha_0 + \alpha_1 R_i + \alpha_2 W_i + \alpha_3 L_i + \alpha_4 Z_i)]\} \tag{8}$$

Then, the log-likelihood equation can be written as in Equation (8), which is estimated using maximum likelihood estimation (MLE).

For the second measure, we follow Kokoye *et al.* (2013). Hence, the planting pattern of the ith smallholder can be expressed as a system, including four equations, as follows:

$$D_i^*(p_{i1}, p_{i2}, p_{i3}, p_{i4}) = \begin{cases} p_{i1} = c_1 + \beta_1 R_i + \chi_1 W_i + \omega_1 L_i + \gamma_1 Z_i + \mu_{i1} \\ p_{i2} = c_2 + \beta_2 R_i + \chi_2 W_i + \omega_2 L_i + \gamma_2 Z_i + \mu_{i2} \\ p_{i3} = c_3 + \beta_3 R_i + \chi_3 W_i + \omega_3 L_i + \gamma_3 Z_i + \mu_{i3} \\ p_{i4} = c_4 + \beta_4 R_i + \chi_4 W_i + \omega_4 L_i + \gamma_4 Z_i + \mu_{i4} \end{cases} \quad (9)$$

where p_{ij} represent the proportions of the planting areas of food crops (maize and rice), rubber, tea and other crops to the total land area of the ith smallholder; c, β, χ, ω, and γ the parameters to be estimated; and μ a random error. The sum of p_{ij} should equal 1, that is, $\sum_{j=1}^{4} p_{ij} = 1$. The system of Equation (9) can be estimated by employing the seemingly unrelated regression, wherein the equation denoting the land allocated for other crops is the reference.

4.2 The impacts of risk perception on crop diversification

The models used to estimate crop diversification are established based on the two different measurements of crop diversification: the count index, which is defined as the number of crops grown per farmer (Di Falco *et al.*, 2010) and the Shannon index, which measures the relative abundance of crops. Here, a higher index indicates greater crop diversity (Pielou, 1977).

Assume that the count of the ith smallholder's planted crops is N_i. According to the Shannon index formula (Shannon and Weaver, 1949), the crop diversity index of the ith smallholder can be expressed as follows:

$$H_i = -\sum_{n_i=1}^{N_i} \left[\left(\text{land\_share}_{n_i}\right) * \ln\left(\text{land\_share}_{n_i}\right) \right] \quad (10)$$

where land_share$_{n_i}$ $(n_i \in |1, N_i|)$ denotes the share of the nth crop's planting area of the total land area of the ith smallholder. When $N_i = 1$, the smallholder plants only rubber; accordingly, $H_i = 0$.

Given the nature of the count index dependent variable, a poisson regression model is employed (Di Falco *et al.*, 2010). Assume that the response variable $N_i = \{1, 2, \ldots, m\}$ has a poisson distribution and that the natural logarithm of its expected value can be modeled using a linear combination of predictor variables as follows:

$$\ln\left[E\left(N_i | R_i, W_i, L_i, Z_i\right)\right] = \theta_0 + \theta_1 R_i + \theta_2 W_i + \theta_3 L_i + \theta_4 Z_i + \varepsilon_i \quad (11)$$

where ε is an error term, and $\theta_0, \ldots, \theta_4$ are the parameters to be estimated. According to the poisson regression procedures, this model can be estimated using MLE. However, sometimes the response variable does not fit the assumption of a poisson distribution well, and it can be classified as over- or under-dispersion. To test whether estimating the count index using a standard poisson model is valid, the goodness-of-link test suggested by Pregibon (1980) is further used. If this model is invalid, the generalized poisson regression (GPR) will be applied as an alternative model. The GRP, which was introduced by Consul and Jain (1973) and was extensively studied by Consul (1989), is widely recognized to estimate the count data that suffer from over- or under-dispersion (Consul and Famoye, 1992; Harris *et al.*, 2012).

The crop diversity index H_i is atypically limited dependent variable. Hence, we propose to model the crop diversity index as a tobit regression model, which can be developed as follows:

$$H_i = \begin{cases} H_i^* = \rho_0 + \rho_1 R_i + \rho_2 W_i + \rho_3 L_i + \rho_4 Z_i + \tau_i & \text{if } H_i^* > 0 \\ 0 & \text{otherwise} \end{cases} \quad (12)$$

where τ is an independent and identical error term that is assumed to be normally distributed. The parameters $\rho_0, \ldots, \rho_4$ can be estimated according to the tobit regression procedures using MLE.

4.3 Model estimation

To overcome the possible endogeneity of the risk perception variable in the land use model, we employ an instrumental variable approach. Because the risk perceptions of smallholder rubber farmers may be influenced by land use strategies in previous years, the estimation of the impacts of risk perceptions on land use and crop diversification are likely endogenous. In the literature, the cluster-effect instrumental variable, which is normally defined as the mean value of the corresponding variable for peers, has been widely applied to control for endogeneity (Benjamin, 1992; Ji *et al.*, 2012). Considering the existence of peer effects in agricultural knowledge transfer (Foster and Rosenzweig, 1995; Patel *et al.*, 2013; Amadu, 2014; Songsermsawas *et al.*, 2014) and risky behaviors (Card and Giuliano, 2013), we believe that an individual's risk perceptions regarding rubber farming are likely influenced by his or her neighbors' risk perceptions through social interactions, knowledge sharing and daily communication in the village. Here, the variable for smallholder risk perceptions of rubber farming is thus supposed to be constructed using the cluster-effect. The mean value of the risk perceptions regarding rubber farming of other sample smallholders in the village can be used as an instrumental variable.

We use Equations (7) and (9) to estimate smallholder rubber farmers' land use choices and Equations (11) and (12) to estimate crop diversity decisions. To test for the endogeneity of risk perceptions in the land use model of smallholder rubber farmers and the validity of the instrumental variable, we estimate Equation (7) using two methods: a standard probit regression and a probit regression with endogenous regressors (IV-probit). The latter utilizes an instrumental variable for risk perceptions and reports the result of a Wald test of the exogeneity of the instrumental variable. If the Wald test result significantly rejects the null hypothesis, the risk perception is endogenous; hence, the regression using the instrumental variable is superior to the standard regression. Likewise, the estimates for land use (Equation (9)) and crop diversification (Equations (11) and (12)) should also consider adopting the risk perception variable constructed by instrumental variables.

5. Descriptive statistics

The descriptive analysis results of the survey data collected from the complete sample of 612 households are presented in this section to illustrate the status quo of land use, crop diversification and the distribution of smallholders' risk perceptions regarding rubber farming, as well as detailed definitions and statistics for all the other independent variables.

5.1 Land use status, rubber specialization and crop diversification

We summarize the land use status of smallholder rubber farmers in XSBN on two levels. First, the household level: of the 612 smallholders, almost 34 percent allocate all land for planting rubber and are thereby fully specialized in rubber farming, while approximately 66 percent allocate land for planting both rubber and other crops. Second, the farm level: of the total land area of the 612 smallholders, 85 percent is rubber, followed by food crops (maize and rice) at 6 percent, tea at 5 percent, and other crops (including bananas, beans and coffee) at 4 percent.

Although the specialization of rubber farming among smallholders in XSBN is quite high, some smallholders still allocate a very small proportion of their total land area to plant other crops.

Figure 2 shows the distribution of the count index (N_i) and the Shannon index (H_i), demonstrating the relatively low crop diversification of smallholder rubber farmers in XSBN. With the increase in the count index and the Shannon index, the distribution of smallholders decreases dramatically. However, by jointly considering the land areas planted with different crops, the Shannon index distribution is more balanced than the count index distribution. In particular, in addition to 34 percent of smallholders who plant only rubber, approximately 33 percent of smallholders plant only one other crop besides rubber. Overall, the average number of planted crops is 2.14, resulting in a Shannon index of 0.37. In addition to rubber plants, smallholder rubber farmers in XSBN plant, on average, only one other kind of crop.

5.2 Risk perceptions in rubber farming

Figure 3 shows several types of rubber farming risks have been perceived by smallholder rubber farmers, although only a small portion of smallholders perceived the decline in rubber prices as a major risk. Regardless of their order, natural disasters and diseases and pests always rank as the top two major risks. Only approximately 23 percent of households regarded a decline in rubber prices as the first risk in rubber farming, while less than

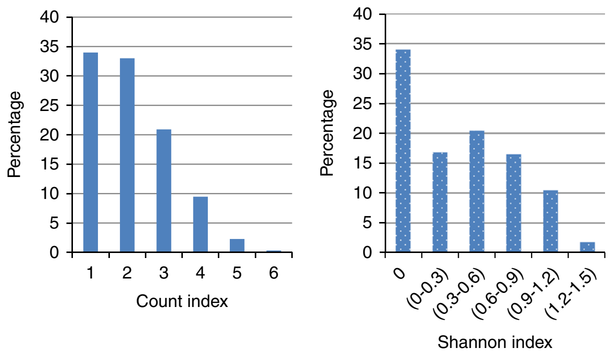

Figure 2.
Distribution of crop diversification

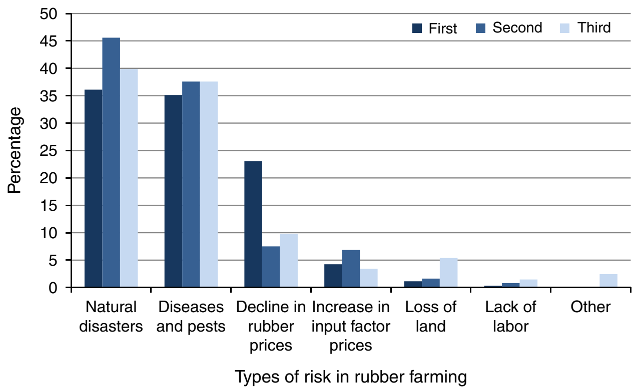

Figure 3.
Three major risks in rubber farming

10 percent of households regarded it as the second or third risk. As for other types of risks, they were rarely perceived by smallholder rubber farmers.

To provide an integrated measure of the extent of risk in rubber farming, we use risk perceptions, which are normally defined as intuitive risk judgments and serve as very general measurements of risk. Following the measurement of risk perceptions in the study of Weber *et al.* (2002) and referring to the subjective assessments of risk attitudes in prior studies (e.g. Dohmen *et al.*, 2011; Hardeweg *et al.*, 2013), an eleven-point Likert-scale was applied in this study to measure farmers' risk perceptions regarding rubber farming.

Figure 4 shows a histogram of risk perceptions regarding rubber farming, wherein a value of 0 implies "no risk in rubber farming" and a value of 10 means "extreme risk in rubber farming." The results show the perceived risk in rubber cultivation is relatively low, and the frequency of each risk score declines as risk score value increases. Over 70 percent of smallholders have indicated that the riskiness of rubber farming is less than 5; furthermore, about 19 percent of smallholders believe that rubber farming involves no risk. The average risk perception of the 612 smallholders is only 3.15, which illustrates that smallholder rubber farmers in XSBN perceive rubber farming to be relatively low risk. This perception may be a result of high rubber prices prior to the survey period.

In fact, the price of natural rubber has been declining to a great extent since our survey in March 2013. The risk perceptions of smallholder rubber farmers regarding rubber farming have likely changed due to the unexpected increase in the rubber price risk. Thus, if risk perceptions have a significant impact on the land use of smallholder rubber farmers, this relationship will provide an interesting perspective from which to better understand the possible land use situations of smallholder rubber farmers in the context of recently declining rubber prices.

Table I reports the test results of Spearman's rank correlation coefficients between the perceived risk in rubber farming and land use status and crop diversification. The results show that the perceived risk in rubber farming is positively associated with the household's decision to plant rubber and other crops, the proportion of land allocated to food crops, and the proportion of land allocated to other crops; however, it is negatively associated with the proportion of land allocated to rubber. Additionally, a significant and positive correlation exists between risk perceptions regarding rubber farming and crop diversification, including both the count index and the Shannon index. The results imply that smallholders with higher risk perceptions may be less likely to fully specialize in rubber farming and, in turn, tend to diversify their land use. By controlling other possible explanatory variables, the causal impact of risk perceptions on land use status and crop diversification can be further captured.

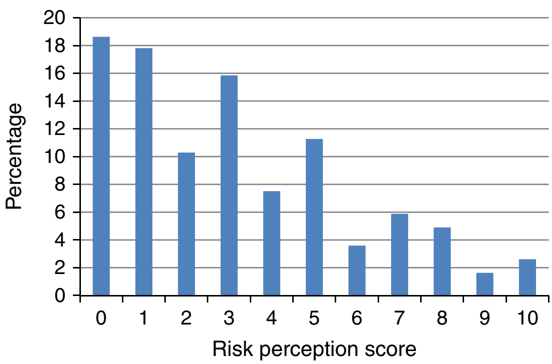

Figure 4. Distribution of risk perceptions regarding rubber cultivation

Table I. Correlations between perceived risk and land use status and crop diversification

Land use status and crop diversification	Risk perceptions Spearman's ρ
Whether households plant both rubber and other crops	0.16***
Land use pattern	
Proportion of land allocated to food crops (maize and rice)	0.16***
Proportion of land allocated to rubber	−0.17***
Proportion of land allocated to tea	0.04
Proportion of land allocated to other crops	0.13***
Crop diversification	
Count index	0.18***
Shannon index	0.19***

Note: ***Significant at the 10 percent level

5.3 Summary of independent variables

Table II provides detailed definitions and statistics for all the other independent variables used in this study. We check for their correlations and possible collinearity. The pairwise correlations of all relevant variables are small (see correlation matrices in Table AI). The possible collinearity is tested using VIFs (variance inflation factors). In all cases the VIFs are below 2 (see Table AII) and hence there is no collinearity. In this study these variables are treated as control variables to discover the impacts of risk perceptions, and they can be used to identify the other determinants of land use and crop diversification.

Household wealth (W_i) is often treated as an important constraint for land use (Perz, 2001; Walker *et al.*, 2002); in line with Teklewold *et al.* (2013), we define it as the total value of all non-land productive and non-productive assets, including house(s), home appliances, and means of transportation. The average household wealth of smallholder rubber farmers in XSBN is approximately 69,540 yuan/person with a large standard deviation, implying a large gap between rich and poor smallholder rubber farmers in XSBN.

Table II. Descriptive statistics of the independent variables

Variables	Definition and description	Mean	SD
Sample size		612	
Wealth (W_i)	Values of household assets, including house(s), home appliances and means of transportation (1,000 yuan/person)	69.537	81.075
Land (L_i)	Total area of household land (mu/person)	12.907	12.988
Certificate	Land tenure certificate (1 = yes; 0 = otherwise)	0.526	0.500
Age (Z_i)	Age of household head (years)	47.977	10.520
Education	Can household head read and write Chinese characters (1 = yes; 0 = otherwise)?	0.711	0.454
Ethnicity	Ethnicity of household head		
Han	Han ethnicity (1 = yes; 0 = otherwise)	0.046	0.210
Dai	Dai ethnicity (1 = yes; 0 = otherwise)	0.582	0.494
Hani	Hani ethnicity (1 = yes; 0 = otherwise)	0.114	0.319
Others	Other minorities, such as Yi, Bulang, and Jinuo (1 = yes; 0 = otherwise)	0.258	0.438
Household size	Number of household members	5.114	1.458
Experience	Household duration of engaging in rubber cultivation (years)	17.209	8.691
Off-farm employment	Does any household member engage in off-farm employment (1 = yes; 0 = otherwise)?	0.310	0.463
	Did any household member engage in off-farm employment in 2008 (1 = yes; 0 = otherwise)?	0.109	0.312
Altitude	Altitude of household location (meters above sea level (MASL))	756.106	160.268

Source: Authors' survey

Land constraint (L_i) is an essential factor that determines farmers' decision-making regarding land use (Pichón, 1997; Browder *et al.*, 2004). In this study, we set household land area as an independent variable, which is an average of 12.91 mu/person. Land tenure security is considered an important factor that affects farmers' agricultural activities in China (Hu, 1997; Deininger and Jin, 2003; Ma *et al.*, 2013; Qin and Xu, 2013; Xu *et al.*, 2014). Hence, we include a dummy variable for whether a household possesses an official certificate of land tenure. The results show only 52 percent of smallholder rubber farmers have land tenure certificates of all land, implying that land use right verification in XSBN is, to some extent, capable of further improvement.

Furthermore, we include a series of control variables regarding household socioeconomic characteristics (Z_i). As the household head often plays an important role in smallholder decision-making regarding land use in China (Huang *et al.*, 2014), we include the age, education and ethnicity of the household head. The average age of the household head is approximately 47.98 years old. However, only 71 percent of household heads can read and write Chinese characters, implying relatively high level of local illiteracy. The household head's ethnicity is established through four dummy variables that refer to the Han majority, Dai, Hani and other minorities. At the household level, in line with prior studies (Kokoye *et al.*, 2013), household size, rubber cultivation experience, off-farm employment and altitude are included. However, to avoid the endogeneity problem of the off-farm employment variable in estimating the land use strategy (Che, 2016), we exploit the off-farm employment of family members in 2008 as a predetermined variable. As shown in Table II, averagely a household has approximately five members; over 30 percent of sample households have at least one member engaging in off-farm employment, while this proportion was just 11 percent in 2008. For all sample households, on average, the experience in rubber farming is over 17 years. Finally, we also control for the altitude of the household location, which is considered as an essential variable for the analysis of land use in developing countries (Nelson and Geoghegan, 2002).

6. Results and discussion

6.1 Land use decision to plant other crops

Table III reports the estimation results of Equation (7), i.e. whether smallholder rubber farmers plant other crops in addition to rubber, wherein Column 2 and Column 3 present the results of standard probit regression and IV-probit regression, respectively. The Wald test of exogeneity from the IV-probit regression rejects the null hypothesis at the 1 percent significance level, revealing the endogeneity concerning smallholders' risk perceptions in explaining land use. Thus, the results using the IV-probit regression are indeed superior to the results in Column 2, which directly use the risk perception score as an independent variable. Hence, the instrumental variable approach is appropriate, such that Equations (9), (11) and (12) are estimated by adopting the constructed variable for risk perceptions using instrumental variables. The first-step regression results for risk perceptions are provided in Table AIII, revealing a significant and positive effect of neighbors' risk perceptions regarding rubber farming. As such, through social interaction, knowledge sharing and daily communication in the village, an individual's risk perception regarding rubber farming can seemingly be changed.

Farmers' decisions regarding various agricultural activities in developing countries are significantly affected by risks (Yesuf and Bluffstone, 2009), and the land use strategies of smallholder rubber farmers in XSBN are no exception. The results in Column 3 of Table III demonstrate that the perceived risk in rubber farming has a positive and significant impact on the farmer's probability of planting other crops in addition to rubber. Even in the case that does not address endogeneity (in Column 2), the estimated risk perception parameter is still significant at the 1 percent level. Hence, for smallholders in XSBN, perceiving higher risks in

Table III.
Estimation results of Equation (7)

	Whether planting other crops in addition to rubber	
Variables	Probit regression	IV-probit regression
Risk perception/IV-risk perception	0.090*** (0.028)	0.286*** (0.033)
Wealth	−0.003*** (0.001)	−0.002*** (0.001)
Land	0.019*** (0.007)	0.015*** (0.006)
Certificate	0.590*** (0.128)	0.607*** (0.112)
Age	0.001 (0.006)	0.003 (0.006)
Education	0.095 (0.143)	0.003 (0.127)
Ethnicity		
Han	−0.605* (0.330)	−0.386 (0.297)
Dai	−0.543*** (0.191)	−0.340** (0.172)
Hani	−0.571** (0.260)	−0.381* (0.232)
Others	Omitted	
Household size	0.065 (0.050)	0.032 (0.044)
Experience	−0.026*** (0.009)	−0.018** (0.008)
Off-farm employment	−0.398** (0.200)	−0.359* (0.186)
Altitude	0.005*** (0.001)	0.004*** (0.001)
Constant	−3.270*** (0.734)	−3.356*** (0.643)
Observations	612	612
Log-pseudo likelihood	−250.199	−1,638.209
Wald χ^2 (joint significance)	157.360***	250.440***
Wald χ^2 (exogeneity)	–	25.070***
Pseudo R^2	0.362	–

Notes: Robust standard errors are in parentheses. *,**,***Significant at the 1, 5, and 10 percent levels, respectively

rubber farming can reduce their likelihood of fully specializing in rubber farming; thus, planting other crops seems to be a strategy for coping with the potential risk in rubber farming.

As expected, household wealth and land constraints have significant impacts on smallholder rubber farmers' decisions regarding the cultivation of other crops. The estimated coefficient of household wealth is negative and significant at the 1 percent level, suggesting that an increase in the household wealth of smallholder rubber farmers reduces the probability that they will plant other crops. Land is an important constraint for smallholder development in XSBN and in China in general. Table III shows that both land area and land tenure certificate have significant and positive impacts on the probability of land use for the cultivation of other crops.

While the household head's age and education level and the household size do not have a significant effect on land use decisions regarding the planting of other crops, household-level ethnicity, rubber farming experience, off-farm employment and altitude are significant explanatory variables. As shown in Table III, the Dai and Hani people obviously tend to specialize in rubber farming and are thereby less likely to plant other crops. Smallholders with more years of rubber farming experience are less likely to plant other crops. Off-farm employment reduces the likelihood of planting other crops in addition to rubber. Consistent with expectations, the results also indicate that altitude has a statistically significant impact on smallholder land use decisions; that is, altitude positively affects the probability of land use for the planting of other crops.

6.2 Land use patterns

Table IV presents the results for planting patterns (Equation (9)), which were estimated by a seemingly unrelated regression, while the equation denoting the land allocated for other crops was automatically omitted as the reference. The results show smallholders' planting patterns

Variables	Rice and maize	Planting pattern Rubber	Tea
IV-risk perception	0.011*** (0.003)	−0.009* (0.005)	−0.010*** (0.003)
Wealth	−0.00004 (0.00005)	0.0001 (0.0001)	−0.0001 (0.0001)
Land	0.0002 (0.0003)	0.0001 (0.0005)	0.0003 (0.0003)
Certificate	0.035*** (0.007)	−0.036** (0.012)	−0.016** (0.008)
Age	0.001* (0.0004)	−0.001 (0.001)	-8.64×10^{-8} (0.0004)
Education	−0.004 (0.008)	−0.002 (0.014)	−0.006 (0.009)
Ethnicity			
Han	−0.064*** (0.018)	−0.009 (0.030)	−0.059*** (0.020)
Dai	−0.044*** (0.009)	0.075*** (0.016)	−0.060*** (0.010)
Hani	−0.057*** (0.013)	0.077*** (0.022)	−0.072*** (0.015)
Others		Omitted	
Household size	0.003 (0.003)	0.002 (0.004)	0.0002 (0.003)
Experience	−0.001* (0.0005)	0.004*** (0.001)	−0.002*** (0.001)
Off-farm employment	−0.017 (0.011)	0.026 (0.019)	−0.007 (0.013)
Altitude	0.0001*** (0.00003)	−0.0004*** (0.00004)	0.0001*** (0.00003)
Constant	−0.080** (0.032)	1.090*** (0.053)	0.078**(0.035)
Observations	612	612	612
F-statistics	16.160***	29.190***	14.890***
R^2	0.256	0.383	0.240

Notes: Standard errors are in parentheses. *,**,***Significant at the 1, 5, and 10 percent levels, respectively

Table IV. Results of seemingly unrelated regression for Equation (9)

are significantly affected by their risk perceptions regarding rubber farming. Increased risk perceptions motivate smallholders to plant more food crops (maize and rice) but less rubber and tea. In other words, in response to the potential risks of rubber cultivation, smallholder rubber farmers with higher risk perceptions regarding rubber farming tend to allocate more land to plant other crops, particularly food crops. In some sense, this finding is inconsistent with the prior study of Zhang *et al.* (2015), which predicts smallholder rubber farmers in XSBN to continue to expand until most of the low-return crops in areas where rubber trees can grow are converted into rubber plantations. However, according to our results, the existence of potential risks in rubber cultivation likely slows the expansion of rubber farming. As long as smallholders can perceive the potential risks in rubber farming, they will always retain some areas of land for planting other crops in addition to rubber.

Different from the results in Table III, household wealth does not significantly influence the planting proportions of other crops. This result is similar to that of Walker *et al.* (2002), who found that household wealth provides no explanatory value for land use; however, the study of Perz (2001) indicated that household wealth negatively influences land use for annuals but that it is insignificant for perennials.

Although land area has insignificant impact on land use patterns, interestingly, we find that a land tenure certificate encourages smallholders to plant more food crops but less rubber and tea. Because smallholder behavior is affected by the period in question and the uncertainties of land tenure (Hu, 1997; Kimura *et al.*, 2011; Ma *et al.*, 2015), the concept of land tenure insecurity may provide a rational explanation of this result. However, our result differs from the conclusions of Robinson *et al.* (2014), who argued that land tenure security is positively associated with less deforestation. In fact, in many areas where individual land rights are not yet well specified, the actual possession of land with perennial crops, such as trees, is likely to be an alternative to address tenure insecurity due to a lack of a land tenure certificate; therefore, smallholders prefer to plant rubber and tea when they do not have land tenure certificates. This finding is consistent the early evidence from Sumatra in Indonesia (Otsuka *et al.*, 1997) and Malawi in sub-Saharan African (Lunduka, 2009).

Furthermore, the household head's age, ethnicity, rubber farming experience and the altitude of the household location also have a significant impact on the land use patterns of smallholder rubber farmers. For instance, the household head's age positively influences the planting proportion of food crops. Compared with younger farmers, older farmers prefer to plant more food crops. Consistent with the findings from a study in Vietnam (Muller and Zeller, 2002), various ethnic groups differ in their land use. The Dai and Hani people allocate more land for rubber but less land for food crops and tea, confirming the general consensus that the rapid commercial of rubber farming has remarkably changed local land use systems and traditional indigenous agricultural cultures. Additionally, we find that smallholders with more years of rubber farming experience tend to allocate more land for rubber but less land for food crops. Altitude positively affects land allocation for food crops and tea but negatively affects that for rubber. Due to less favorable climatic conditions, the productivity of rubber farming declines in higher altitude areas, which may explain this result (Min *et al.*, 2015).

6.3 Crop diversification

The estimation results for crop diversification are shown in Table V. The count index (Equation (11)) was estimated using two methods, i.e. standard poisson regression (Column 2) and GPR (Column 3). However, the result of the goodness-of-link test indicates standard poisson regression is not appropriate for estimating the number of planted crops. The count index is actually under-dispersed because its mean (2.14) is larger than its variance (1.17). Hence, the results of the GPR are superior. The Shannon index (Equation (12)) was estimated by tobit regression, and the results are presented in Column 4 in Table V.

The results illustrate that the risk perceptions regarding rubber farming have a positive impact on crop diversification, including the number of planted crops and the Shannon index of crop diversity. While the purpose of crop diversification by smallholder rubber farmers is to reduce the potential risks in rubber farming, this strategy has a positive

Table V. Results of poisson regression for Equation (11) and tobit regression for Equation (12)

	Count index		
Variables	Poisson	Generalized poisson	Shannon index
IV-risk perception	0.074*** (0.013)	0.070*** (0.015)	0.060*** (0.014)
Wealth	−0.001** (0.0002)	−0.0004 (0.0002)	−0.001** (0.0003)
Land	0.004*** (0.001)	0.004*** (0.001)	0.0001 (0.001)
Certificate	0.302*** (0.034)	0.290*** (0.034)	0.200*** (0.034)
Age	0.003* (0.002)	0.003** (0.002)	0.003** (0.001)
Education	0.057 (0.037)	0.079* (0.041)	0.028 (0.037)
Ethnicity			
Han	0.118* (0.067)	0.132* (0.069)	0.010 (0.085)
Dai	−0.038 (0.040)	0.013 (0.039)	−0.130*** (0.038)
Hani	−0.018 (0.062)	0.024 (0.065)	−0.121** (0.059)
Others		Omitted	
Household size	0.014 (0.012)	0.034*** (0.013)	−0.002 (0.012)
Experience	−0.010*** (0.002)	−0.011 (0.002)	−0.011*** (0.002)
Off-farm employment	−0.137*** (0.050)	−0.176*** (0.057)	−0.129** (0.053)
Altitude	0.001*** (0.0001)	0.001*** (0.0001)	0.001*** (0.0001)
Constant	−0.270 (0.144)	−0.544*** (0.161)	−0.706*** (0.157)
Observations	612	612	612
Log-pseudo likelihood	−876.553	−747.300	−303.120
Wald χ^2/F-statistics	426.120***	347.230***	28.610***
Pseudo R^2	0.074	0.174	0.377

Notes: Robust standard errors are in parentheses. *,**,***Significant at the 1, 5, and 10 percent levels, respectively externality for environmental conservation. Hence, by helping farmers better understand the potential risks in rubber farming, a knowledge transfer project may be an effective way to restore and improve the local environment in XSBN.

The effects of household wealth on both the number of planted crops and the Shannon index of crop diversity are significantly negative. One likely explanation is that poor smallholder rubber farmers have a relatively limited ability to withstand economic shocks, such that they tend to plant more diverse crops to cope with potential risks. Our results also imply that rapid economic development through the adoption of mono-cropping systems, such as rubber farming, can cause a significant loss of agrobiodiversity. Thus, managing the trade-off between economic improvement and environmental conservation in rural XSBN remains a serious challenge; hence, developing and introducing sustainable land use systems requires further research.

Our results also show that land is an important constraint for smallholder rubber farmers' crop diversification. Land area positively affects the number of planted crops but insignificantly affects diversity, as shown by the Shannon index. Possessing a land tenure certificate significantly promotes crop diversification, which is measured using either the count index or the Shannon index. Thus, the further promotion of land rights confirmation in XSBN will have a positive externality for local environmental conservation.

Furthermore, most of the other independent variables regarding smallholders' household socioeconomic characteristics are found to have significant impacts on crop diversification. Inconsistent with the findings of Huang *et al.* (2014), our results show that the household head's age positively influences crop diversification, as revealed by both the count index and the Shannon index. Compared with younger farmers, older farmers in XSBN prefer to diversify their land use and thus have higher levels of crop diversification. In line with the findings from a study in Mexico (Brush and Perales, 2007), various ethnic groups also differ in terms of their crop diversification. Surprisingly, the Dai and Hani ethnicities, the major indigenous groups in XSBN who used to diversify their land use, now plant more rubber trees and have relatively low levels of crop diversification. Furthermore, rubber cultivation experience and off-farm employment negatively affect crop diversification. Consistent with Brush and Perales (2007), our results suggest that smallholders located at higher altitudes probably plant more kinds of crops and have a higher Shannon index of crop diversity.

In sum, our results confirm that smallholders' risk perceptions regarding rubber farming have significant impacts on their land use decisions. Risk plays an important role in the trade-offs between farm diversification and specialization (Chavas and Di Falco, 2012). For smallholders, perceiving higher risks in rubber farming can hinder rubber specialization, but it can also facilitate crop diversification. Furthermore, smallholders who are Dai and Hani people, who are wealthier, who have less land area, who have more years of rubber farming experience, who lack land tenure certificates, who engage in off-farm employment, and who are located at lower altitudes tend to specialize in rubber farming; those who do not share these characteristics tend to diversify their land use.

7. Summary and conclusions

As an important biodiversity hotspot in southern China, XSBN has experienced dramatic changes in land use over the past three decades, i.e. the transition of traditional agriculture and tropical forests to rubber plantations. This trend caused a series of negative environmental effects, including decreased agrobiodiversity and the potential risk of livelihood. Livelihood diversification, especially crop diversification, may be an effective strategy for coping with these risks (Ellis, 2000). To better understand smallholders' land use given the risk of rubber farming, in this study, we used a representative household survey data of some 600 smallholder rubber farmers in XSBN. After controlling for the endogeneity of risk perceptions, our econometric results demonstrate that farmers' risk perceptions regarding rubber farming play an important role in decision-making regarding land choices. Smallholder rubber farmers who are aware of the higher risks of rubber farming are less likely to specialize in rubber farming and are more likely to plant other crops in addition to rubber. They prefer to plant a higher proportion of food crops and a lower proportion of rubber and tea, and they have higher crop diversification indices. The results imply that smallholder rubber farmers in XSBN are risk-averse, though only moderately so due to generally low risk perceptions and land use diversification. In some sense, this finding is consistent with the long-held recognition that risk-averse farmers may diversify their portfolios of productive enterprises to reduce income variation (O'Donoghue *et al.*, 2009). While diversifying land use seems to be a strategy for coping with potential risks in rubber farming, it also has positive externalities for environmental conservation. Moreover, we also find that smallholder rubber farmers' land uses are highly associated with household wealth, land tenure status, ethnicity, off-farm employment, altitude and rubber farming experience.

We believe that the findings of this study have important policy implications for promoting sustainable land use and improving the local environment in XSBN. Helping smallholder rubber farmers better understand the potential risks in rubber farming is likely an efficient way to slow the expansion and specialization of rubber farming and to improve land use diversification, thereby contributing to local environmental conservation. To some extent, this measure also has spillover effects due to the peer effects of risk perceptions among smallholder rubber farmers; hence, an extension service for knowledge sharing among farmers may also be conducive to improved agrobiodiversity (Jackson *et al.*, 2012). As possessing a land tenure certificate positively affects a smallholder's crop diversification, to improve the local environment, we also recommend authorities further promote the implementation of land rights confirmation in XSBN.

In the context of the recent decline in rubber prices, smallholder rubber farmers in XSBN face higher risks in rubber farming. If the low prices remain for a longer period of time, farmers' risk perceptions may change. Given the findings of the present study, we predict that the expansion of smallholder rubber farming in XSBN will slow down. In addition to allocating a larger land area for planting other crops to cope with current risks, some smallholder rubber farmers are likely to change their land use from rubber plantations to other crops. Hence, we recommend that local policymakers and relevant agencies take this opportunity to provide a suitable incentive system that can guide smallholder rubber farmers toward a more sustainable and diversified land use strategy.

Note

1. 1 mu = 1/15 hectares.

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Appendix

Variables	Wealth	Land	Certi	Age	Edu	Han	Dai	Hani	Other	Hsize	Exp	Off	Altitude
Wealth	1.000												
Land	0.049	1.000											
Certificate	−0.009	0.045	1.000										
Age	−0.009	−0.044	0.044	1.000									
Education	−0.013	0.108	−0.021	−0.309	1.000								
Ethnicity													
Han	−0.022	−0.033	−0.027	−0.069	0.071	1.000							
Dai	0.155	−0.279	−0.002	0.124	−0.073	−0.258	1.000						
Hani	0.017	0.141	−0.122	−0.027	0.025	−0.079	−0.424	1.000					
Others	−0.177	0.228	0.103	−0.088	0.030	−0.129	−0.696	−0.212	1.000				
Household size	−0.155	−0.103	0.005	0.181	−0.098	−0.033	0.092	−0.028	−0.067	1.000			
Experience	−0.179	−0.175	−0.173	0.032	−0.005	−0.054	0.267	0.119	−0.361	0.178	1.000		
Off-farm 2008	0.121	−0.0001	−0.024	0.114	0.016	0.049	−0.010	0.006	−0.016	0.088	−0.012	1.000	
Altitude	−0.217	0.272	0.057	−0.009	0.162	0.093	−0.297	−0.050	0.327	−0.107	−0.406	−0.043	1.000

Source: Authors' calculation

Table AI.
Pairwise correlations across all regressors

Table AII.
Variance inflation factors (VIF)

Variables	VIF	1/VIF
Dai	1.750	0.572
Hani	1.430	0.700
Altitude	1.400	0.712
Experience	1.390	0.721
Land	1.190	0.842
Age	1.180	0.850
Wealth	1.160	0.860
Education	1.160	0.862
Han	1.150	0.866
H-size	1.130	0.884
Off-farm 2008	1.050	0.950
Certificate	1.050	0.952
Other[a]	Omitted	
Mean VIF	1.250	

Note: [a]Omitted in the regression as reference group
Source: Authors' calculation

Table AIII.
First-stage regression results for risk perceptions

Variables	Risk perception
Mean risk perception in village	0.991*** (0.076)
Wealth	0.002* (0.001)
Land	−0.007 (0.007)
Certificate	−0.140 (0.201)
Age	−0.007 (0.011)
Education	0.353 (0.233)
Ethnicity	
Han	−0.636 (0.485)
Dai	−0.236 (0.270)
Hani	−0.026 (0.416)
Others	Omitted
Household size	0.080 (0.069)
Experience	0.005 (0.016)
Off-farm employment	−0.019 (0.297)
Altitude	0.0004 (0.001)
Constant	−0.467 (0.893)
Observations	612
F-statistics	16.830***
R^2	0.226

Notes: Robust standard errors are in parentheses. *,***Significant at the 1 and 10 percent levels, respectively

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