1. Introduction

Farming production is contingent upon various uncertainties, such as resource availabilities, price fluctuations, and weather conditions. Crop choice under such uncertainties may have a significant impact on farmers' livelihoods and food security. Therefore, capturing the background elements of farmers’ crop choice may help build appropriate frameworks for supporting farmers.

This study aims to examine farmers’ crop choice decisions in a southern region of Thailand. Coffee is one of the major products in this region, and this crop contributes significantly to the livelihood of the local population. Coffee production in this region has recently decreased significantly, and there can be several reasons behind this phenomenon. This study focuses on the effects of the recently declining price, coffee tree aging problem, and labor shortage for harvesting. However, these phenomena coexist, and the price trend is not specific to coffee production. Therefore, this study involved choice experiments with farmers in Chumphon Province, the most active province in coffee production, to capture how each phenomenon affects crop choice. Specifically, a different choice design with several scenarios was proposed, to try to disentangle the impact of each factor. We conducted two different types of experiments with farmers: the first asked farmers their crop choice among major products for plain land, and the second asked them to choose a mixed crop option among alternatives for land with coffee trees of a given age. For the second scenario, we also conducted the experiment under a sub-scenario to identify the effects of the tree aging problem and the labor shortage problem.

Our experiments show that the tree aging problem provides incentives to replant old coffee trees, but it does not significantly change the probability of replanting new coffee trees unless the labor shortage constraint is not imposed in the experiment. This seems to suggest that, since coffee has only one harvesting opportunity in a year, the constraint on hiring harvesting labor amplifies the income uncertainty of coffee management.

Key words: crop choice experiment, random parameter logit, coffee, Thailand

What Leads Farmers to Abandon Coffee Production?: An Experimental Study on Crop Choice in Chumphon Province, Thailand

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Our study examines farmers’ crop choice to investigate the motivation behind the recent coffee production decrease in Chumphon, a southern province of Thailand. Through a choice experiment based on a random parameter logit model, which takes into account farmers’ heterogeneous preferences for commodities, we find that the constraint on hiring labor induces farmers to refrain from replanting new coffee trees. In addition, the coffee tree aging problem induces the removal of old coffee trees, but does not affect significantly the replanting of new coffee trees when the hiring labor constraint is not imposed in the experiment. This seems to suggest that, since coffee has only one harvesting opportunity in a year, the constraint on hiring harvesting labor amplifies the income uncertainty of coffee management.

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frequently. Our study implies that efforts for increase in productivity and innovation for labor saving technology are required for sustainable coffee farming production in this region.

The remainder of this study is organized as follows. Section 2 describes the profile of coffee production in the southern part of Thailand compared to other major cash crops, and our research question and hypothesis. Section 3 introduces a literature survey, discusses the validity of our approach, and our choice experiment design and scenarios. Section 4 describes our survey and the profiles of our respondents. The results of the random parameter logit estimation and choice probability simulation are shown in section 5. The last section provides our concluding remarks.

2. Research Question

1) Robusta coffee production in southern Thailand

In 2014, Thailand produced 38 thousand tons of coffee, ranking 22nd in the world and 4th among Asian countries (Office of Agricultural Economics, Agricultural Statistics Yearbook). Even though the coffee industry in Thailand is not globally competitive, coffee is still one of its important crops. More than 20,000 farm households are involved in coffee production, and the production contributes more than 4,400 million baht each year to farmers’ incomes (Office of Agricultural Economics, 2016).

Primarily two types of coffee are produced in Thailand: one is Arabica, mainly cropped in the northern part of the country and representing around 20% of total coffee production, while the southern region is largely devoted to the production of Robusta. Especially in the southern part of Thailand, where the production of cash crops, such as rubber, oil palm, and other fruits is dominant, Robusta coffee production is significantly important for the livelihood and food security of farmers’ households. At present, 68.7% and 29.2% of the total area is planted in Robusta coffee in the Chumphon and Ranong Provinces, respectively. Only 2.1% comprises other provinces, such as Suratthani and Nakorn Sri thammarat (Office of Agricultural Economics, Agricultural Statistics of Thailand).

However, the area planted in Robusta coffee has been decreasing in the southern region since the 2000s (Figure 1). In the last decade, the coffee planted area in Chumphon Province, the main province that produces Robusta coffee, has been decreasing, from 246,332 rai in 2000 to 129,829 rai in 2015.¹ The

¹ 1 rai = 0.16 hectare.
causes. First, this region has been producing Robusta in Chomphon Province has several been delivering lower bean productivity than Arabica. maturing humidity, higher bean productivity, and quicker fruit disease-resistance, tolerance for temperature and production. Robusta was introduced due to its higher (north-eastern Thailand and settled there since 1987 provinces. In these regions, farmers who moved from rubber and oil palm. These days, Chumphon and Suratthani, and Nakorn Sri Thamarat Provinces, but, in the southern part of Thailand, especially in Krabi, Development Agency coffee seeds from Saudi Arabia Province in 1904, when one Thai-Muslim man brought coffee for 20–30 years. Public statistical figures (Office of Agricultural Economics, Agricultural Statistics Yearbook) provide evidence that coffee productivity has declined 1.30% annually in the last decade. Productivity declines as trees age, and after 20–25 years of production, the time has come to replace the coffee trees. Second, the labor shortage constraint has become more binding. Coffee farmers in this region have depended on seasonal immigrant labor from the north-eastern part of Thailand for their harvesting work; however, they have recently faced difficulties in hiring harvesting labor. Of course, farmers’ decision to abandon coffee production is not independent from the characteristics of alternative crops in Chumphon Province, such as palm oil, rubber, coconut, and fruits, especially durian.

Based on the interviews conducted with farmers in our study region, we identified the characteristics of coffee, palm, rubber, and durian. Coffee, palm, rubber, and durian can be harvested after around 3–4, 4, 6–7, and 4–7 years, respectively. These crops are harvestable until the trees are 20–30 years old. The labor requirements are also different, and maintenance work for coffee, palm, and durian, such as fertilizer application, herbicides, and watering, is primarily provided by family labor. In particular, durian is sensitive to water scarcity, and water control is important in dry periods. The fruit growth cycle is also different among these perennial crops. Coffee and durian have one main harvesting period in a year, while palm and rubber can be more frequently harvested: once or twice a month for palm and almost every day, except during the summer, for rubber. This implies a different management of harvesting labor among crops. Permanent labor on a contract basis is commonly introduced in rubber management. However, casual labor from local villages is mobilized for harvesting durian and palm. The buyers of durian and palm can sometimes provide harvesting labor to farmers. For coffee, our interviews with farmers in this region found that seasonal immigrant labor from the north-eastern area of the country has been an important source of harvesting labor, and this is supported by other studies (Suksavead et al., 2012; Napaporn, 2014). Unlike rubber and palm, coffee harvesting is done once a year in the span of only a few months; this makes it difficult to find labor on a regular basis through the year. For harvesting coffee, hiring a sufficient labor force for suitable harvesting periods is a significant factor and affects the quality of coffee. Since picking coffee cherries is an intensive work and the maturing of cherries happens almost contemporaneously across villages, farmers often face difficulties to hire local

| Crop           | year 1990 | year 2000 | year 2015 |
|---------------|-----------|-----------|-----------|
|               | Planted area (rai) | Planted area (rai) | Planted area (rai) |
| Palm          | 98,410    | 317,648   | 922,940   |
| Rubber        | 77,390    | 371,817   | 581,047   |
| Coconut       | n.a.      | 350,610   | 195,944   |
| Robusta coffee| 246,634   | 246,332   | 129,829   |
| Durian        | 123,236   | 139,663   |           |

Source: Agricultural Statistics of Thailand, Office of Agricultural Economics.

Note: 1 rai = 0.16 hectare.

As a result, coffee’s share in the cropping pattern of Chumphon Province keeps getting smaller, as shown in Table 1. However, this table shows that coffee was a dominant crop in this province at the beginning of the 1990s, with areas comparable to those of palm and rubber in 2000. This figure provides us with a simple research question. Why are farmers moving away from coffee, which was once their major crop? This study examines two factors related to this question: the coffee tree aging problem and labor hiring constraint in the harvesting season. Before explaining our hypothesis, a brief history of coffee production in the region is introduced.

Robusta coffee production started in Songkhla Province in 1904, when one Thai-Muslim man brought coffee seeds from Saudi Arabia (Agricultural Research Development Agency). The production expanded in the southern part of Thailand, especially in Krabi, Suratthani, and Nakorn Sri Thamarat Provinces, but, in later years, those areas turned to other cash crops, like rubber and oil palm. These days, Chumphon and Ranong are the leading Robusta coffee production provinces. In these regions, farmers who moved from north-eastern Thailand and settled there since 1987 (Napaporn, 2014), significantly contribute to Robusta production. Robusta was introduced due to its higher disease-resistance, tolerance for temperature and humidity, higher bean productivity, and quicker fruit maturing (Agricultural Research Development Agency) compared to Arabica. However, Robusta has lately been delivering lower bean productivity than Arabica.

2) Hypotheses

This study proposes that the shrinking area planted in Robusta coffee in Chomphon Province has several causes. First, this region has been producing Robusta coffee for 20–30 years. Public statistical figures (Office of Agricultural Economics, Agricultural Statistics Yearbook) provide evidence that coffee productivity has declined 1.30% annually in the last decade. Productivity declines as trees age, and after 20–25 years of production, the time has come to replace the coffee trees. Second, the labor shortage constraint has become more binding. Coffee farmers in this region have depended on seasonal immigrant labor from the north-eastern part of Thailand for their harvesting work; however, they have recently faced difficulties in hiring harvesting labor. Of course, farmers’ decision to abandon coffee production is not independent from the characteristics of alternative crops in Chumphon Province, such as palm oil, rubber, coconut, and fruits, especially durian.

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labor, and depend on labor from outside. Furthermore, coffee farmers in Chumphon Province are typically farmers who moved from north-eastern Thailand, and their social ties can be utilized to hire seasonal immigrant labor from that region. However, as the succession issues of the agricultural population are also found in the north-eastern region, keeping seasonal harvesting labor becomes more difficult.

Besides the coffee tree aging problem and harvest labor constraint, price is also important for crop profitability. Actually, commodity prices have moved drastically since the 2000s. The farmer’s crop choice decision could be contingent on the prices in our study area. Figure 2 shows the price movements of the four crops since the 1990s. The average price has been around 60 Baht/kg for coffee and rubber, 30 Baht/kg for durian, and 4 Baht/kg for palm since the late 2000s. However, recent prices have fluctuated significantly: prices of palm, rubber, and coffee hiked during the mid-2000s, but have decreased since. On the other hand, the price of durian has drastically increased in recent years, more than ever before. Some coffee cooperatives actively work, as they produce their own brand of instant coffee. However, handling by cooperatives is a small part of total production. The farmers who produce crops of coffee, palm, rubber, and durian can refer well the local market prices because they have channels to sell to local merchant or buyers.

3. Choice Experiment

1) The advantage in the present research

This research aims to examine what factors affect farmers’ decisions to abandon coffee production. As previously discussed, the study region has experienced constraints, including the tree aging problem, resulting in a significant reduction of productivity, and the difficulties in finding/hiring seasonal immigrant labor at the appropriate harvesting time. The successor issues in farming have also been a common constraint in this region (Kwanmuang, 2015), and the effects of these constraints should be examined. To identify the effects, we implemented a choice experiment approach. This approach has an important advantage for examining our research question, since by constructing hypothetical scenarios, we can ask the farmers to make choices among crops (coffee, palm, rubber and durian) with prices as attributes, and with or without the concerning constraints of labor shortages or tree aging problem. This helps disentangle the effects of the individual constraints on crop choice.

However, it is important to consider the validity of this stated preference approach. The choice experiment has been applied to estimate individual preferences in consumption behavior. However, as we discuss in the next section, this approach has also been applied to many studies examining farmers’ preferences for adoption of agricultural practices, variety, technology, and choices of production related contracts, insurance services, and policies.2 The logic that is commonly introduced for technology adoption

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Figure 2. Farm gate prices for coffee, rubber, oil palm, and durian in Chumphon Province

Source: Agricultural Statistics of Thailand, Office of Agricultural Economics.

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2) Aizaki (2009) surveyed the studies that used the multi-attribute stated preference approach on farm management practices in Japan before the mid-2000s.
studies in the context of selection bias correction on revealed data (for example, Shiferaw et al., 2014) or the stated preference approach (Qaim and de Janvry, 2003) is concerned with that a farmer’s (random) utility from introducing a variety or practice is better than that derived from not introducing or from adopting other alternatives. This random utility theory is also applied to the choice of variety or practice with several traits or characteristics (Baidu-Forsom et al., 1997, Sy et al., 1997). Some studies (Jaeck and Lifran, 2014, Ward et al., 2014) discuss the validity of applying choice experiments to farmers’ adoption problems. The arguments are based on the so-called production-consumption non-separability, which means that a farm household makes joint consumption and production decisions in imperfect markets. Edmeades and Smale (2006) and Useche et al. (2013) theoretically discuss the introduction of a farmer’s indirect utility with technology traits.

On the other hand, how to capture a farmer’s heterogeneity in technological adoption has also been empirically investigated, as farmers’ perceptions of a technology could be diversified. For example, panel data gives us the opportunity to treat the farmer’s individual effects in estimating technology adoption behavior (for example, Besley and Case, 1993; Gleewe and Jacoby, 2000). The recent empirical procedures in the choice experiment approach allow estimation of the parameters of attributes or traits with individual preference heterogeneity. This study adopted this approach.

However, we should also justify the choice experiment approach for the present research problem in comparison with alternative approaches. The present study asked about farmers’ choices under hypothetical scenarios. The stated preference approach has several advantages for considering preferences about hypothetical services/goods, even though these do not actually exist. Therefore, this approach is often applied in ex-ante evaluation situations. On the other hand, technology adoption studies have relied on revealed preference data, that is, the farmer’s actual adoption of crops, varieties, and technologies. This ex-post approach on data reflects a farmer’s actual behavior; however, it sometimes presents estimation difficulties. First, actual behavioral variables are simultaneously derived from a farmer’s decision making (Feder et al., 1985), which creates an endogeneity problem in estimation. To deal with this problem, a deliberated survey design is required to collect information to instrument the endogeneity. The field experiments approach is increasingly introduced to cope with this problem (Behrman and Oliver, 2000). The approach in the present study is one type of field experiment study, and could complement the revealed preference approach. In addition, this approach provides an important advantage for examining this study’s research questions. The tree aging problem, the difficulty of hiring harvesting labor, and price effects constitute our hypothesis for explaining crop choice in our study region. However, these phenomena have clearly existed since the mid-2000s, as described in the previous section. Of course, the cropping history and demand or need for harvesting labor may differ among households, but this implies that a number of instrumental variables must be collected through recall because some farmers are no longer engaged in coffee production. Of course, this discussion requires that we can appropriately identify the instrumental variables. Because we could not identify the quasi-experimental situation in the present study area, the revealed data approach is required to cope with endogeneity, as well as multicollinearity (Useche et al., 2013) among the concerning variables of our hypothesis. In addition, the actual cropping pattern is complex because of several types of mixed crop forms, as seen in the next section. This makes it difficult to establish the rigid estimation framework by area share function because estimation procedures must cope with multivariate censored cropping areas (when we suppose a farmer chooses to crop coffee only, this implies we must assign zero to areas of many other cropping types). We should identify appropriate approaches on revealed data, but, our choice experiment approach includes controls for several of the difficulties mentioned above by introducing hypothetical scenarios.

2) Literature survey of choice experiment studies on farmers’ decisions

As the previous section discussed, the choice experiment approach has also been applied to farmer’s technology adoption studies. In the past several years, there have been an increasing number of studies capturing farmers’ heterogeneous preferences on traits of technology in the areas of agricultural economics, development economics, and environmental economics. In these studies, the random parameter logit model is often introduced to consider the heterogeneity of farmers’ preferences. Furthermore, recent farmers’ choice experiment studies are more concerned with their risk attitude or risk tolerance capacity regarding technology adoption. These studies are summarized below.

Asrat et al. (2010) studied Ethiopian farmers’ preferences for the variety traits of sorghum and teff. They estimated farmers’ heterogeneous preferences for several traits of varieties, such as crop productivity,
yield stability, and environmental adaptability, defined as tolerance for environmental stress like poor soil, poor rainfall, or frost. They found that farmers’ preferences were heterogeneous regarding the attributes of each crop. Their estimation of the marginal willingness to pay for these attributes without/with an individual farmer’s characteristics derived several important implications. Farmers with larger land or a higher value of livestock, who were likely to be less risk-averse, valued productivity attributes more than environmental tolerance or yield stability attributes.

Blazy et al. (2011) examined the heterogeneity of farmers’ preferences for alternative innovative farming methods, like intercropping with a legume crop, introducing pest tolerant variety, and improving the fallow period to reduce the use of pesticides for banana production in the French West Indies. They applied a random coefficient estimation with a binary choice for the specialization of banana production, as tolerance for environmental stress like poor soil, yield stability, and environmental adaptability, defined as farmers’ risk attitudes, reflected in the specialization of banana production, are related to the decision of introducing innovations. Highly specialized farmers, who seem to be risk averse in their interpretation, have a significantly negative attitude towards innovation adaptation.

In Ward et al. (2014), attributes of rice varieties, such as yields in normal rainfall, moderate drought, and extreme drought, are included in the choice set of their farmers’ choice experiment for drought tolerant rice varieties in Bihar, an eastern state of India. Their experiment design has the advantage that the estimation of a random parameter logit can derive farmers’ positive, but heterogeneous, preferences for higher yields in the context of the first, second, and third stochastic dominance. Furthermore, their estimation, under a utility function consistent with prospect theory, suggests that risk-averse and loss-averse farmers significantly preferred the hypothetical drought tolerant rice varieties to the common variety that they actually produced.

Our study, which aims at capturing the effects of the coffee tree aging problem and hiring labor shortage constraint on crop choice among coffee and other commodities, is also concerned with the risk aspects of commodities. These commodities suffer price fluctuations and are characterized by a difference in the frequency of income generated within one year. Our choice experiment is designed for coping with these aspects of commodities, as discussed in the next subsection.

3) Random parameter logit model

The cropping pattern in the study area is diversified, as discussed later, and this reveals the heterogeneity of farmers’ preferences for crop choice. Furthermore, their decision is taken on other attributes of crops, like profitability, which depend on prices and requirements of various inputs. The economic evaluation of this input requirement is contingent on farmers’ individual characteristics, such as resource endowments. In order to examine the farmers’ crop choice taking their heterogeneous preference for crops into account, this study adopted a random parameter logit (RPL) model, maximizing the mixed logit probability.3)

When $V_{ij}(\beta)$ is denoted as the deterministic part of random utility of individual $i$, with his/her preference parameter vector, $\beta$, for choosing alternative $j$ in the choice opportunity $s$, the RPL estimator is derived by maximization of the mixed logit probability below:

$$
P_{ij}=\prod_{s} \left[ \frac{\exp \left[ V_{ij}(\beta) \right]}{\sum_{j} \exp \left[ V_{ij}(\beta) \right]} \right]^{y_{is}} f(\beta) d\beta, \quad (1)
$$

where $y_{is}=1$ when individual $i$ chooses alternative $j$ in the choice opportunity $s$, and 0 otherwise, and $f(\cdot)$ is the density function of the preference parameter $\beta$. It is known that this approach has the important advantage that the irrelevance of the independent alternative (IIA) property is not required, and a flexible substitution between alternatives is permitted (Train, 2009).

In the present study, we examined the farmers’ crop choice under several scenarios. The detailed specification of the random utility function, and choice set design for each scenario, are introduced in the next subsection.

4) Choice experiment design

The present study designed two types of farmers’ crop choice experiments. First, farmers were asked to suppose that they had a plain land of one plot, which had eight rai, as an average size in the study region, and then to choose one crop among (A) coffee, (B) oil palm, (C) para rubber, and (D) durian, or (E) to keep this land plain. In this scenario, the RPL model was estimated considering their experience with

3) Choice experiment studies which estimate a random parameter logit model or a generalized mixed logit model without individual effects of risk attitudes are also increasingly seen; for example, on adoption of crop practices with legumes in Malawi (Ortega et al., 2016), adoption of drought tolerance maize in Zimbabwe (Kassie et al., 2017), adoption of pigeon peas as a nitrogen-fixing legume in Malawi (Waldman et al., 2017), and choosing index-insurance in Ethiopia (Tadesse et al., 2017).

4) See Train (2009) for a detailed discussion of the RPL model.
the problem of hiring labor in order to test the effect of the labor shortage constraint. In the second scenario, farmers were asked to suppose they had one plot of a given age coffee tree, and then to choose among a mixed crop of (A) new coffee, (B) new palm, or (C) new durian with (old) coffee trees, or (D) to keep all (old) coffee trees. In this scenario, two different constraints were imposed on the crop choice experiments, as two separate sub-scenarios. First, we introduced a constraint on hiring labor. Second, we considered the problem of coffee tree aging. These two experiments were conducted independently for the two separate groups, and we tested how the labor constraint and tree aging problem affected farmers’ choices by conducting this experiment first without constraints, and then imposing a constraint on the choice experiment.

(1) The first choice experiment scenario

For the sake of clarity, an example of the choice set for the first scenario is presented in Table 2

We assume a deterministic utility, $V_i$, over the attributes of a crop and its price levels, and an independent and identically distributed (i.i.d.) error term of a Gumbel distribution, $\varepsilon_{it}$, and that these elements constitute the random utility, $U_{it}$, of individual $i$ from choosing option $j$. However, a clear understanding of the price level in the future at the choice moment is not realistic; therefore, the prices of each commodity at three instances in the past (last year, 3 years ago, the last 5–6 years) are introduced in the experiment. We assume the deterministic utility on alternative $j$ for individual $i$ at choice opportunity $s$, as

$$V_i = ASC_j + h_j \cdot (\text{Price}_{s, t-1} - \text{Price}_{s, t-2} - \text{Price}_{s, t-3})$$

where $ASC_j$ is the alternative specific constant for crop $j$ and parameter $\beta_j$, whose distribution describes the heterogeneity among farmers. An attribute, $\text{Price}$, includes four levels (0.75, 1, 1.25, 1.5) for each commodity at each timing. In order to show the actual prices for respondents, benchmark prices (for price index level 1) are fixed at 60 Baht/kg for coffee, 4 Baht/kg for palm, 60 Baht/kg for rubber, and 32 Baht/kg for durian, respectively. That is, the levels of prices (Baht/kg) at the past three timings are, for coffee, 45, 60, 75, 90; for palm, 3, 4, 5, 6; for rubber, 45, 60, 75, 90, and for durian, 24, 32, 40, 48. We introduced these price levels based on the information on past prices and on farmers’ responses at our pre-survey.5 The choice set is built on the labeled type of orthogonal array.6 We adopted the DoE.base package (Groemping, 2015) of the statistical software R (R Core Team, 2016). A total of 48 choice sets are randomly divided into six blocks; then, each farmer faces eight choice sets for the first scenario. The utility from the option to keep the land without cropping is set as zero, but this is just the reservation level of the latent utility. Farmers can actually consider several benefits from holding plain/clean land. For example, they can consider the gain from selling the land in the future. This implies that the sign of parameter $\beta$ on the ASC could be either positive or negative. For example, it would be negative if a farmer prefers keeping the land plain due to the large cost for cropping compared to the future benefit from selling the land. This evaluation depends on the resource endowments of the farmer. This parameter could be positive if a farmer values more the relative benefit from production, or enjoys farming out of personal motivation.

Next, how their evaluation of past prices of these commodities is formulated must be discussed. In particular, we need to specify the function $h_j(\cdot)$ in equation (2) for commodity $j$’s prices. For example, we can suppose a very naïve functional form, like a linear function of past prices.7 However, the present study assumes that this function can reflect the farmer’s evaluation of price movements. More concretely, we specify this function to capture the farmer’s evaluations of the level, trend, and variation of prices. We define the price growth rate between periods as

$$g_n, -1 = \log(\text{price}_{n, t-1}) - \log(\text{price}_{n, t-2}),$$

$$g_n, -2 = \log(\text{price}_{n, t-2}) - \log(\text{price}_{n, t-3}).$$

These price growth rates are independent from the level of

Table 2. An example of choice set for the first scenario

| (A) | (B) | (C) | (D) | (E) |
|------|------|------|------|------|
| Price (Baht/kg) | Coffee | Palm | Rubber | Durian | Neither |
| Last year | 60 | 3 | 90 | 40 | Keeping (plain land) |
| 3 years ago | 75 | 6 | 45 | 32 | |
| 5-6 years ago | 90 | 5 | 60 | 24 | |

5 The authors conducted the pre-survey interviews with village leaders and some farmers to understand the production situation in the study area, design the questionnaire, and check the validity of farm gate prices fixed as attributes.
6 We referred to Aizaki (2015) for the labeled type design.
7 We estimate RPL under this naïve form also, and we discuss this result briefly in footnote 10.
the first to the second period, price fluctuates, for instance, the price increased from 60 to 75, i.e., 25 Baht/kg, and then decreased from the second period to the last year (g_{p,t}= g_{p,t-1} \times g_{p,t-2})<0). This term is negative. If a farmer does not accept the fluctuation of prices, \( \gamma_a \) could be negative. However, a farmer can accept the continuous growth of prices, and this would lead this term to be positive. In other words, this term is strictly related to the farmer’s attitude towards price risk.

(2) The second choice experiment scenario

As introduced in the previous sections, our study region has been devoted to coffee production for around 20–30 years, and the time has come to replace the old trees with new coffee trees or other crops. At the same time, this region has experienced some difficulties in finding and hiring labor from the villages and from the north-eastern regions. Both reasons could affect the decision to abandon coffee production; however, these two constraints could have different effects on the type of crop that is introduced. In order to examine how the crop choice differs under the tree aging problem and hiring labor constraint, the choice experiment in the second scenario was designed as follows. The farmers were requested to suppose that they could crop one among: (A) a mixed crop of old trees with new coffee trees, (B) a mixed crop with palm, (C) a mixed crop with durian, or (D) keep all presently grown (old) coffee trees. The choice set is also designed in the labeled/crop-type, and prices at previous timings are included as attributes with the same levels of the first scenario. An example of the choice set is shown in Table 3.

We should note several features of this choice experiment setting. First, the mixed crop between two commodities is very common in the study region, as shown in the summary statistics in the next section. The option of a mixed crop with coffee and rubber is not included in the choice set design because of the limited area size shown in the summary statistics. Second, alternatives of mixed crops are introduced for mitigating the cost evaluation of crop change for farmers. Actually, removing all grown trees and introducing new trees can be very costly, not only due to direct costs, but also because production is paused for several years. The evaluation of these costs varies across farmers due to the differences in their risk attitudes and time preferences, and their resource endowments or wealth. However, by introducing a mixed crop option, we attempt to reduce the impact of large costs in crop choices, farmers’ risk attitudes, time preferences, and wealth.

In order to test how farmers’ crop choice decisions are contingent on the binding of the constraints for the tree aging problem or hiring labor problem, they are asked to face four choice sets, under two hypothetical situations, without and with a constraint. For mitigating their weariness, we separated them into two groups in each study village; the tree aging constraint choice experiment was assigned to one group, and the labor constraint design to the other group. The next section provides an explanation of the hypothetical situations they were requested to consider.

### Table 3. An example of choice set for the second scenario

| (A)          | (B)             | (C)           | (D)        |
|--------------|-----------------|---------------|------------|
| Mixed crop with new coffee trees | Mixed crop with palm | Mixed crop with durian | Neither (Keeping all presently grown coffee trees) |
| Price (Baht/kg) | Coffee | Palm | Durian | Price (Baht/kg) |
| Last year | 45 | 6 | 40 | Last year |
| 3 years ago | 60 | 3 | 48 | 3 years ago |
| 5-6 years ago | 75 | 4 | 32 | 5-6 years ago |

The option of a mixed crop with coffee and rubber is not included in the choice set design because of the limited area size shown in the summary statistics.
coffee trees. You do not face any difficulties in hiring labor. Which option would you choose: (A) a mixed crop with new coffee trees, (B) a mixed crop with new palm trees, (C) a mixed crop with new durian trees, or (D) keep all (old, now grown) coffee trees?

Next, farmers were asked to reply to a second four-choice set under the following hypothetical situation, (T-2).

(T-2) You have one plot with 20- to 25-year-old coffee trees. You do not face any difficulties in hiring labor. Which option would you choose one among (A) to (D)?

Hiring labor constraint scenario

For another group, the choice decision for the labor constraint problem was examined. We asked farmers to choose one among (A) to (D) for the first four-choice set under situation (L-1), described below.

(L-1) You have one plot with 15-year-old coffee trees. You do not face any difficulties in hiring labor.

After that, we asked farmers to reply to another four-choice set under the following hypothetical situation, (L-2).

(L-2) You have one plot with 15-year-old coffee trees. You face difficulties in hiring labor.

The labor constraint problem is hypothetically controlled for when testing the tree aging constraint, and the tree aging problem is not imposed in the labor constraint examination. As before, the labeled-type choice set is constructed based on the orthogonal array, and a total of 32 choice sets are randomly blocked into four. However, because we need to avoid the ordered effect in which the first (second) four-choice set is fixed for the unconstrained (constrained) situation in each block, we constructed sub-blocks replacing the first four-choice set with the second in each block. That is, a total of eight blocks was constructed for the second scenario.

Farmer \( i \)’s deterministic utility from alternative \( j \) in these scenarios is described as:

\[
V_{ij} = \begin{cases} 
\beta_e \cdot \text{ASC}_i + \gamma_{em}p_h + \gamma_{ed}d_h + \gamma_{et}t_h : \text{mix with new coffee;} \\
\beta_o \cdot \text{ASC}_i + \gamma_{om}p_h + \gamma_{od}d_h + \gamma_{ot}t_h : \text{mix with new palm;} \\
\beta_d \cdot \text{ASC}_i + \gamma_{dm}p_h + \gamma_{dd}d_h + \gamma_{dt}t_h : \text{mix with new durian;} \\
\gamma_{em}p_h + \gamma_{ed}d_h + \gamma_{et}t_h : \text{keep (grown) coffee trees.} 
\end{cases}
\]

Here, we should note that the fourth alternative, “keeping all grown (old) coffee trees,” introduces a benefit contingent on coffee price. Therefore, the evaluation of the price attributes of coffee is included in this fourth option.

4. Data

1) Our survey

The choice experiment was conducted in our original survey as follows. A multistage sampling approach was applied to identify sub-districts, villages, and households. In the first stage, we selected two active Robusta production sub-districts, which account for 45% and 25% of coffee households of Chumphon Province, respectively. In the second stage, two villages from each sub-district were selected. These villages have almost the same total number of farming households. Fifty households in each village were randomly drawn from the farmers list of the Subdistrict Administrative Organization (SAO). A total of 200 farmers were selected as candidate respondents and invited to our experiment by the cooperators of each village. The choice experiment was conducted in September 2015, before the coffee harvesting season. Because participation in our experiment was voluntary, and some missing or inconsistent replies in the choice experiments were found, we ended up with 150 respondents for the first scenario experiment, and 155 for the second experiment. We used their farming profiles such as land size, conditions of hiring labor, and status of debt holding, as individual effects in the estimation. Moreover, we surveyed the respondents’ risk attitudes and their time preferences. The details of their profiles are introduced in the next section.

2) Farmers’ profiles and summary statistics

The farmers’ profiles included in the estimation of the first scenario are summarized in Table 4. The cropping of coffee, palm, rubber, and durian comprise almost their whole production capacity. The mixing of these crops is common in their crop management. Most of the farmers manage both some single crop plots and mixed crop plots. Table 5 summarizes the distribution of respondents by the types of plots they manage. Six respondent households crop coffee only, eight crop palm only, twenty crop rubber only and seven crop durian only, and around 72 percent of the respondents managed multiple commodities in 2015. Coffee still has a significant place in the study areas, as 85 out of 149 respondents manage coffee production in either the single and/or mixed crop form.

Individual farmers’ characteristics used in the estimations are attitudes towards risk, time preferences, total cropped area, their experience with difficulties in hiring labor, and their holding of debt.

We measured their attitude toward risk by asking farmers their willingness to pay for a hypothetical lottery. Farmers were asked how much they would pay for the following three types of simple lotteries:
(lottery 1) choosing one number between 1 and 2. The prize is 4,000 Baht, with a 50% probability of winning; (lottery 2) choosing one number among 1, 2, or 3. The prize is 3,000 Baht, with a 33% = 1/3 probability of winning; and (lottery 3) choosing two numbers among 1, 2, or 3. The prize is 6,000 Baht, with a 66% = 2/3 probability of winning. We prepared the price lists for each lottery, and asked the respondents to choose one.\textsuperscript{8} In the estimation of the RPL model, we adopted two measures of risk aversion. The first is the coefficient of absolute risk aversion. The second is a simpler measure of their risk acceptance: we identified farmers who show a zero price for any lottery (lottery 1) – (lottery 3) as strict risk averters (SRA). Therefore, the non-strict risk averters (NSRA) are those farmers who reveal positive prices for the hypothetical lotteries.

Some studies are concerned about the time preferences of farmers for technology adoption (Khanna et al., 2017). The respondent’s time preferences for technology adoption.

\begin{table}
\centering
\caption{Respondent land use profiles}
\begin{tabular}{lccc}
\hline
\textbf{Variable} & \textbf{Mean} & \textbf{S.D.} & \textbf{Size} \\
\hline
\text{Area in 2015 (unit: rai)} & & & \\
Total & 22.88 & 19.01 & 149 \\
\text{Plot type} & & & \\
Coffee only & 2.89 & 6.58 & 150 \\
Palm only & 3.65 & 10.18 & 150 \\
Rubber only & 5.45 & 8.16 & 150 \\
Durian only & 1.94 & 4.76 & 150 \\
Mixed Crop of Coffee and Palm & 1.15 & 4.33 & 150 \\
Mixed Crop of Coffee and Rubber & 0.53 & 2.59 & 150 \\
Mixed Crop of Coffee and Durian & 4.83 & 9.16 & 150 \\
Mixed Crop of Palm and Rubber & 0.04 & 0.49 & 150 \\
Mixed Crop of Palm and Durian & 0.83 & 2.98 & 150 \\
Mixed Crop of Rubber and Durian & 0.99 & 3.73 & 149 \\
Mixed Crop of Coffee, Palm and Durian & 0.25 & 1.86 & 150 \\
Mixed Crop of Coffee, Rubber and Durian & 0.07 & 0.82 & 150 \\
Other & 0.11 & 0.81 & 150 \\
\hline
\text{Debt holding (yes = 1, no = 0)} & 0.67 & 0.47 & 150 \\
Experience of difficulty of hiring labor (yes = 1, no = 0) & 0.37 & 0.48 & 146 \\
Time discount annual interest rate (%) & 31.64 & 54.13 & 149 \\
Coefficient of absolute risk aversion for lottery 3 (ARA_L3) & 0.0008 & 0.00023 & 149 \\
Non strict risk averter (non-zero WTP for all lotteries = 1, otherwise = 0) & 0.78 & 0.42 & 150 \\
\hline
\end{tabular}
\end{table}

Source: Authors’ survey.

Note: The profiles of respondents in the estimation for the first scenario are reported.

\begin{table}
\centering
\caption{No. of respondent household by managing plot types}
\begin{tabular}{lcccc}
\hline
 & \text{Mixed crop plot} & & & \\
 & \text{w/ coffee} & \text{w/o coffee} & \text{No mixed crop plot} & \text{Total} \\
\hline
\text{Single crop plot} & & & & \\
Coffee single plot only & 6 & 0 & 6 & 12 \\
Coffee and other single plots & 10 & 2 & 11 & 23 \\
Palm single plot only & 4 & 2 & 8 & 14 \\
Rubber single plot only & 12 & 2 & 20 & 34 \\
Durian single plot only & 3 & 0 & 7 & 10 \\
No coffee single plot & 3 & 0 & 12 & 15 \\
\hline
\text{No single crop plot} & 30 & 11 & & 41 \\
\hline
\text{Total} & 68 & 17 & 64 & 149 \\
\hline
\end{tabular}
\end{table}

Source: Authors’ survey.

Note: Available respondent’s data for first scenario estimation.
preference discount rate is identified using a similar setting of a questionnaire with multiple price lists, as in Coller and Williams (1999) or Ikeda et al. (2010). We asked the respondents to choose their willingness to receive a monetary value nine days later compared to receiving 10,000 Baht two days later. We asked similar questions with two other time settings: their willingness to receive a value 37 days later compared to 10,000 Baht in 30 days, and the willingness to receive a value 30 days later against 10,000 Baht in 2 days. The time discount is derived as an annual interest rate.

We consider a farmer’s debt holding status in the crop choice decision. It is common for farmers to borrow money for several purposes; for instance, to buy production assets in the study region. We construct a dummy variable which takes value of one if farmers have a not completely repaid debt at the time of the survey, and zero otherwise. In order to capture the effect of the labor constraint on crop choice, we asked farmers whether they experienced difficulties in hiring or finding labor for their crops at any time of the last year, five years, and ten years. We then, introduced a dummy variable, which takes value of one in case they experienced such difficulties in the past, and zero otherwise.

5. Results

To estimate the RPL model for our choice sets, we utilized the “gmnl” package (Sarrias and Daziano, 2015) in the statistical software R (R Core Team, 2016).9 We set 500 Halton draws and assumed a normal distribution for the alternative specific constant (ASC). Our estimation does not take into account the correlation of the ASC between alternatives.

1) RPL estimation results for the first scenario

The estimation results for crop choice on plain land (first scenario) are reported in Table 6.

Estimation (1-1) does not take into account any farmer’s individual effects on the crop alternative specific constant. Our estimation shows that farmers significantly evaluate the commodity’s average price and positive price trend in the past of each crop. The evaluation parameter for price fluctuations, $\gamma_r$, is positive and significant only for durian. This may reflect the recent rapid growth of durian prices, which made this crop profitable.10

The alternative specific constants, ASCs, for the considered crops have significant standard deviations, meaning that farmers have heterogeneous preferences over crops. The mean ASC, which reveals the farmers’ average evaluation of a commodity compared with keeping the land plain, is positive and significant for coffee, and is significant and negative for palm.

This term could take any sign, as discussed before; however, an interesting interpretation of this term can be derived from estimations (1-2) to (1-4) including farmers’ individual effects.

The acceptance of risk induces cropping, as shown by the significant and negative parameter for the interaction term between ASC and the coefficients of absolute risk aversion for lottery 3, as shown in estimation (1-2). This implies that cropping these commodities with price fluctuations or yield risks are preferred by the less risk-averse farmers than keeping land plain,11 because this coefficient has a small value for the lower risk averter or risk lover. The estimation result with the dummy variable for non-strict risk aversion, NSRA (estimation (1-3)), shows consistency with the estimation results that include the

---

8) We asked respondents to choose a willingness to pay among the price list (0, 200, 400, 600, 800, 1,000, 1,200, 1,400, 1,600, 1,800, 2,000, 2,400, 2,800, 3,200, 3,600, 4,000 Baht) for lottery 1, (0, 100, 200, 300, 400, 500, 600, 700, 800, 900, 1,000, 1,400, 1,800, 2,200, 2,600, 3,000 Baht) for lottery 2, and (0, 400, 800, 1,200, 1,600, 2,000, 2,400, 2,800, 3,200, 3,600, 4,000, 4,400, 4,800, 5,200, 5,600, 6,000 Baht) for lottery 3. Here, to fix the prices of each lottery shown to farmers, we introduced the following approximation of risk premium equation (see. Newbery and Stiglitz, 1981: pp.72–73)

\[
\text{risk premium} (\mu - \text{CE}) = \frac{\sigma^2}{2} \times R_A
\]

where, CE: certainty equivalent, that is, willingness to pay (price) of a lottery, $\mu$: mean value of lottery price, $\sigma^2$: variance of lottery prize, $R_A$: coefficient of absolute risk aversion. These price lists are fixed from the values of the coefficient of absolute risk aversion (0.001, 0.0009, 0.0008, 0.0007, 0.0006, 0.0005, 0.0004, 0.0003, 0.0002, 0.0001, 0, −0.0002, −0.0004, −0.0006, −0.0008, −0.001).

9) Estimation through the gmnl package depends on the packages mlogit (Croissant, 2013) and maxLik (Henningsen and Toomet, 2011).

10) We also estimate this model with a naïve price function formula where the price levels in attributes of choice profiles are directly included. The result shows the last year prices for all commodities are positive and significant, but other past price variables (other than palm price for 2-3 years before) are not significant. Goodness of fit measures (AIC and BIC) are similar values with (only slightly better than) the estimation result of (1-1). We can conclude equation formula (4) is more informative.
Table 6. Estimation results (First scenario)

| Price | ASC X Risk aversion measure | (1-1) Coef. | (1-2) S.E. | (1-3) Coef. | (1-4) S.E. | (1-5) Coef. | (1-6) S.E. |
|-------|-------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|
| γ_m   |                               | 0.034 ***   | 0.007       | 0.030 ***   | 0.007       | 0.030 ***   | 0.007       |
| γ_r   | Coffee                        | 3.500 ***   | 0.524       | 3.253 ***   | 0.520       | 3.236 ***   | 0.521       |
| γ_c   |                               | 0.525       | 0.691       | 0.671       | 0.691       | 0.667       | 0.692       |
| γ_m   |                               | 0.689 ***   | 0.189       | 0.633 ***   | 0.191       | 0.624 ***   | 0.191       |
| γ_r   | Palm                          | 2.870 ***   | 0.864       | 2.617 ***   | 0.877       | 2.615 ***   | 0.879       |
| γ_c   |                               | -0.734      | 1.135       | -0.762      | 1.153       | -0.852      | 1.158       |
| γ_m   |                               | 0.031 ***   | 0.009       | 0.030 ***   | 0.009       | 0.030 ***   | 0.009       |
| γ_r   | Rubber                        | 1.846 ***   | 0.620       | 1.811 ***   | 0.611       | 1.784 ***   | 0.608       |
| γ_c   |                               | 0.018       | 0.841       | -0.058      | 0.829       | -0.067      | 0.827       |
| γ_m   |                               | 0.088 ***   | 0.016       | 0.085 ***   | 0.016       | 0.085 ***   | 0.016       |
| γ_r   | Durian                        | 3.228 ***   | 0.584       | 2.986 ***   | 0.583       | 2.958 ***   | 0.584       |
| γ_c   |                               | 1.367 *     | 0.785       | 1.105       | 0.792       | 1.140       | 0.791       |
| Mean  | Coffee                        | 1.440 **    | 0.606       | 19.777 ***  | 6.657       | -0.682      | 1.399       |
|       | Palm                          | -3.381 ***  | 1.083       | 14.829 **   | 6.871       | -5.236 ***  | 1.753       |
|       | Rubber                        | 0.190       | 0.765       | 17.832 ***  | 6.749       | -0.965      | 1.506       |
|       | Durian                        | -0.256      | 0.675       | 17.257 ***  | 6.666       | -2.381 *    | 1.358       |
| S.D.  | Coffee                        | 2.414 **    | 0.282       | 2.049 **    | 0.286       | 2.083 ***   | 0.296       |
|       | Palm                          | 3.605 ***   | 0.556       | 3.386 ***   | 0.521       | 3.207 ***   | 0.555       |
|       | Rubber                        | 3.468 ***   | 0.510       | 2.686 ***   | 0.341       | 2.587 ***   | 0.355       |
|       | Durian                        | 2.189 ***   | 0.320       | 1.984 ***   | 0.321       | 1.929 ***   | 0.335       |

Individual effects

| Total area | Coffee | 0.001 | 0.021 | -0.011 | 0.022 | -0.001 | 0.023 |
|           | Palm   | 0.031 | 0.025 | 0.023  | 0.027 | 0.034  | 0.028 |
|           | Rubber | -0.017 | 0.026 | -0.024 | 0.025 | -0.016 | 0.025 |
|           | Durian | 0.013 | 0.021 | 0.005  | 0.021 | 0.007  | 0.021 |

| Debt holding | Coffee | 0.389 | 0.878 | 1.604 * | 0.932 | 1.499 * | 0.887 |
|              | Palm   | 0.947 | 1.073 | 2.134 * | 1.112 | 1.271 * | 1.116 |
|              | Rubber | 1.663 * | 0.964 | 2.712 *** | 1.015 | 2.054 * | 1.004 |
|              | Durian | 0.985 | 0.864 | 2.016 * | 0.906 | 1.775 * | 0.914 |

| Experience of difficulty in hiring labor | Coffee | -3.232 *** | 1.197 | -3.605 *** | 1.240 | -4.665 *** | 1.496 |
|                                          | Palm   | -2.816 **  | 1.384 | -2.742 *   | 1.407 | -18.262   | 63.299 |
|                                          | Rubber | -4.834 ***  | 1.313 | -5.391 ***  | 1.358 | -4.928 *** | 1.614 |
|                                          | Durian | -2.822 **  | 1.178 | -3.289 ***  | 1.232 | -5.391 *** | 1.453 |

| Risk aversion | Coffee | -19.097 *** | 6.779 | 5.122 ***  | 1.118 |
|              | Palm   | -20.016 *** | 6.908 | 3.302 **  | 1.373 |
|              | Rubber | -18.580 *** | 6.856 | 3.534 ***  | 1.255 |
|              | Durian | -19.340 *** | 6.784 | 3.880 ***  | 1.093 |

When Lead农民 to Abandon Coffee Production?

Log-likelihood - 1.090.7 - 1.028.5 - 1.026 - 1.029.2
AIC 2.221.4 2.137 2.132 2.138.3
BIC 2.323.2 2.338.7 2.333.9 2.340.3
Sample size 1,200 1,144 1,152 1,152
No. of respondents 150 143 144 144

Source: Authors’ estimation.

Note: ARA stands for coefficient of absolute risk aversion, ***: p < 0.01, **: p < 0.05, *: p < 0.1.
coefficient of absolute risk aversion. Interestingly, the parameter reflecting price fluctuation/continuous growing, \( \gamma \), for durian turns out to be not significant when we include farmers’ risk attitudes in the estimation.

As seen in estimations (1-2) to (1-4), time preference effects are positive for choosing to crop some commodities rather than keeping land plain. This implies that respondents with higher time discount rates are not likely to keep land without any production. This effect is not robust in other estimation formulas,\(^{12}\) and this might reflect the fact that these crops require several periods before the first harvest.

Farmers who presently hold debt prefer to crop rather than keep their land plain. This reflects their evaluation of the future liquidity of production and/or the gain from land assets with plant capital. The size of the crop area does not significantly affect the evaluation of crops.

For discussing the effect of the labor constraint on crop choice, the interaction term between ASC and farmers’ difficulty in hiring labor is considered. This term shows a negative and significant coefficient for coffee, rubber, and durian, but less significant for palm. The fact that coffee and durian are relatively labor intensive in maintenance is reflected in the estimation results. Rubber can be harvested almost every day. If farmers are concerned with the difficulties of finding permanent labor, they are likely to hesitate to introduce rubber. As mentioned before, coffee production traditionally depends on seasonal immigrant labor from the north-eastern region during the harvest season, implying a significant difficulty in securing sufficient labor at the appropriate harvesting time. In order to confirm how experience with labor difficulties affects the preference for commodities between strict risk averter and non-strict risk averter, we imposed the non-strict risk averter dummy on the interaction term between ASC and the labor difficulty experience dummy. Estimation result (1-4) shows that strict risk averse farmers are more hesitant to crop coffee and durian if they experienced difficulties in hiring labor in the past. Because these differences are not confirmed by the estimation using the coefficient of absolute risk aversion, this interpretation requires some reservation. However, it should be noted that these two commodities have a harvesting timing of about once a year. This suggests that the seasonal labor shortage problem increases the uncertainty of coffee crop management.

2) Estimations under labor and tree aging constraint problems

(1) RPL estimation result

Tables 7 and 8 show the results of the RPL estimation for the labor constraint and tree aging problem sub-scenarios in the second scenario, respectively. The parameters of price evaluation, especially on coffee, are less significant than in the first scenario. This can be interpreted as coffee production being sunk under the second scenario. However, as the standard deviations for the ASCs are significant, the estimation that takes into account the heterogeneity of farmers’ preferences for crop choice is still valid in these scenarios.

When we consider the estimation results including individual effects, such as risk attitudes, time preferences, and debt holding status, the information criteria measures are not improved in either sub-scenario. Most parameters related to individual effects are not significant in either sub-scenario. Notably, the parameters related to the coefficient of absolute risk aversion for lottery 3, and time discount rates are not significant; therefore, these are not reported.\(^{13}\) The comparison of the insignificance of the mean ASC for coffee in estimation (2L-1) and negative and significance of it in estimation (2L-2) in the first two estimations in Table 7 shows that the imposition of the hiring labor constraint negatively affects farmers’ preferences for the introduction of new coffee trees. On the other hand, the comparison of the significance of coffee’s ASCs between the first two estimations (2T-1) and (2T-2) in Table 8 implies that the imposition of the tree aging problem seems to make partial replacement of old coffee trees more attractive. However, this willingness to adopt should be tested carefully, taking into account the option to keep all old coffee trees, as discussed in the next subsection.

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11) The estimation results (not reported) with the coefficient of absolute risk aversion for lotteries 1 and 2 do not robustly show the significance of these parameters; therefore, this interpretation requires some reservations. However, it should be noted that lottery 3 is the first-order stochastic dominant to lottery 1 or 2.

12) This estimation uses the annual time discount rate from the question for a four-week difference. The other estimation results are not reported because of space. Estimations with time discount rates from the shorter time difference settings (nine days later against two days later, and 37 days later against 30 days later) do not robustly show the significance of these effects.

13) Only the parameters of interaction terms between time discount (derived from the four-week difference settings) and the ASCs of coffee and durian in the estimation without the tree aging problem show significance at the 10% level.
### Table 7. Estimation results (Second scenario: Labor constraint)

|                     | No individual effects | Incl. individual effects |
|---------------------|-----------------------|--------------------------|
|                     | No | Yes | No | Yes |
| **Estimation No.**  | (2L-1) | (2L-2) | (2L-3) | (2L-4) |
| \( \gamma_w \) Coffee | 0.012 | 0.060 * | 0.012 | 0.061 * |
|                     | (0.018) | (0.031) | (0.018) | (0.032) |
| \( \gamma_r \) Palm | 0.038 | 7.231 *** | 0.094 | 7.943 *** |
|                     | (1.261) | (2.417) | (1.271) | (2.715) |
| \( \gamma_r \) Coffee | 1.449 | 5.334 * | 1.506 | 5.361 * |
|                     | (1.876) | (2.899) | (1.900) | (2.956) |
| **Price**           |            |              |          |          |
| \( \gamma_w \) Palm | 0.967 ** | 1.801 *** | 0.979 ** | 1.705 *** |
|                     | (0.420) | (0.617) | (0.427) | (0.616) |
| \( \gamma_r \) Durian | -0.035 | 1.607 | 0.119 | 1.283 |
|                     | (1.962) | (2.394) | (2.001) | (2.435) |
| \( \gamma_r \) Durian | -4.070 | -7.870 ** | -3.839 | -8.092 ** |
|                     | (2.868) | (3.206) | (2.965) | (3.340) |
| **ASC**             |            |              |          |          |
| Coffee              | -1.616 | -4.352 * | -1.856 | -2.451 |
|                     | (1.137) | (2.257) | (2.698) | (4.299) |
| Palm                | -5.376 ** | -8.030 ** | -4.298 | -4.313 |
|                     | (2.427) | (4.052) | (2.885) | (4.674) |
| Durian              | 0.630 | 3.876 | -0.356 | 7.565 |
|                     | (1.945) | (3.101) | (2.896) | (5.170) |
| **S.D.**            |            |              |          |          |
| Coffee              | 5.845 *** | 6.263 *** | 5.523 *** | 6.201 *** |
|                     | (1.296) | (1.926) | (1.269) | (1.612) |
| Palm                | 2.941 *** | 8.295 *** | 3.040 *** | 6.397 *** |
|                     | (0.815) | (2.079) | (0.968) | (1.715) |
| Durian              | 5.514 *** | 8.622 *** | 5.676 *** | 8.696 *** |
|                     | (1.096) | (1.971) | (1.244) | (2.514) |
| **Debt holding**    |            |              |          |          |
| Coffee              | 0.129 | 1.596 |
|                     | (1.796) | (2.369) |
| Palm                | -0.223 | 7.303 ** |
|                     | (1.312) | (2.869) |
| Durian              | 1.847 | 5.039 ** |
|                     | (1.699) | (2.276) |
| **ASC X**           |            |              |          |          |
| Coffee              | 0.350 | -2.524 |
|                     | (2.623) | (4.102) |
| NSRA Palm           | -1.166 | -7.951 ** |
|                     | (1.752) | (3.600) |
| Durian              | -0.709 | -7.996 * |
|                     | (2.166) | (4.189) |
| **Log-likelihood**  | -262.3 | -211.1 | -261.1 | -203.9 |
| AIC                 | 554.5 | 452.3 | 564.2 | 449.8 |
| BIC                 | 611.6 | 509.3 | 644.2 | 529.8 |
| Sample size         | 332 | 332 | 332 | 332 |
| No. of respondents  | 83 | 83 | 83 | 83 |

Source: Authors' estimation.
Note: Standard error in parenthesis. ***: \( p < 0.01 \), **: \( p < 0.05 \), *: \( p < 0.1 \).
Table 8. Estimation Results (Second scenario: Tree aging problem)

| Estimation No. | No (2T-1) | Yes (2T-2) | No (2T-3) | Yes (2T-4) |
|----------------|-----------|------------|-----------|------------|
| $\gamma_w$ Coffee | 0.041 ** | 0.023 | 0.041 * | 0.021 |
| | (0.022) | (0.018) | (0.023) | (0.018) |
| $\gamma_r$ Coffee | 5.296 *** | 2.660 ** | 5.644 *** | 2.686 ** |
| | (1.587) | (1.172) | (1.599) | (1.176) |
| $\gamma_r$ | 3.800 | 0.416 | 4.191 * | 0.499 |
| | (2.386) | (1.807) | (2.455) | (1.803) |

| Price | No (2T-1) | Yes (2T-2) | No (2T-3) | Yes (2T-4) |
|-------|-----------|------------|-----------|------------|
| $\gamma_w$ Palm | 0.969 * | 0.891 ** | 1.128 * | 0.844 ** |
| | (0.588) | (0.353) | (0.610) | (0.351) |
| $\gamma_r$ Palm | 5.109 ** | 2.941 ** | 5.401 ** | 2.663 * |
| | (2.404) | (1.466) | (2.414) | (1.467) |
| $\gamma_r$ | -1.118 | 0.637 | -0.995 | 0.357 |
| | (4.033) | (2.255) | (4.081) | (2.232) |

| Mean | No (2T-1) | Yes (2T-2) | No (2T-3) | Yes (2T-4) |
|------|-----------|------------|-----------|------------|
| $\gamma_w$ Durian | 0.119 *** | 0.056 * | 0.125 *** | 0.056 * |
| | (0.042) | (0.031) | (0.042) | (0.031) |
| $\gamma_r$ Durian | 3.248 * | 0.066 | 3.281 ** | 0.091 |
| | (1.664) | (1.208) | (1.656) | (1.206) |
| $\gamma_r$ | 0.300 | 2.257 | 0.500 | 2.199 |
| | (2.269) | (1.807) | (2.262) | (1.801) |

| ASC | No (2T-1) | Yes (2T-2) | No (2T-3) | Yes (2T-4) |
|-----|-----------|------------|-----------|------------|
| Coffee | -0.630 | 1.526 *** | -2.720 | -0.175 |
| | (0.879) | (0.524) | (1.883) | (1.316) |
| Palm | -4.912 | -1.233 | -8.932 * | -1.328 |
| | (3.464) | (2.088) | (4.652) | (2.379) |
| Durian | 0.498 | 3.191 * | -5.078 * | 1.377 |
| | (2.172) | (1.652) | (2.953) | (1.801) |

| S.D. | No (2T-1) | Yes (2T-2) | No (2T-3) | Yes (2T-4) |
|------|-----------|------------|-----------|------------|
| Coffee | 4.098 *** | 1.970 *** | 3.938 *** | 2.013 *** |
| | (1.094) | (0.633) | (1.011) | (0.689) |
| Palm | 5.069 *** | 2.443 *** | 4.928 *** | 2.281 *** |
| | (1.878) | (0.736) | (1.621) | (0.718) |
| Durian | 5.427 *** | 2.693 *** | 5.065 *** | 2.639 *** |
| | (1.767) | (0.657) | (1.277) | (0.631) |

| ASC X | No (2T-1) | Yes (2T-2) | No (2T-3) | Yes (2T-4) |
|-------|-----------|------------|-----------|------------|
| Coffee | -0.040 | 1.237 | 1.445 | 1.355 |
| | (1.518) | (1.144) | (2.197) | (1.182) |
| Durian | 2.288 | 1.826 | 2.288 | 1.827 |
| | (1.827) | (1.212) | (1.827) | (1.212) |

| Log-likelihood | No (2T-1) | Yes (2T-2) | No (2T-3) | Yes (2T-4) |
|----------------|-----------|------------|-----------|------------|
| Coffee | -233.8 | -247.2 | -225.8 | -243.9 |
| | (1.784) | (1.274) | (1.216) | (1.243) |
| NSRA Palm | 3.566 * | -0.495 | | |
| | (2.161) | (1.243) | | |
| Durian | 5.779 *** | 1.218 | | |
| | (1.972) | (1.273) | | |

| AIC | No (2T-1) | Yes (2T-2) | No (2T-3) | Yes (2T-4) |
|-----|-----------|------------|-----------|------------|
| Coffee | 497.7 | 524.4 | 493.6 | 529.9 |
| | (552.6) | (579.4) | (570.5) | (606.8) |
| BIC | 552.6 | 579.4 | 570.5 | 606.8 |
| | | | | |
| Sample size | 288 | 288 | 288 | 288 |
| | | | | |
| No. of respondents | 72 | 72 | 72 | 72 |

Source: Authors’ estimation.
Note: Standard error in parenthesis. ***: $p < 0.01$, **: $p < 0.05$, *: $p < 0.1$. 

(2) Simulating choice probability

In order to discuss how these problems may affect crop choices differently, we estimated the choice probabilities on alternatives for each sub-scenario. In this way, we tried to overcome the limitations to the direct comparison of the ASC’s parameters between estimations, without and with the imposition of constraints. However, the fitted probabilities of each alternative from the RPL model estimation are not appropriate for this comparison, as they are derived from different levels of attributes, that is, different price levels among choice sets. Therefore, we derived the mixed logit choice probabilities on four alternatives (keeping all old coffee trees, or a mixed crop with new coffee, palm, or durian), controlling for the price levels. We fixed the price level at the benchmark level for each crop at each past timing, that is, 60 Baht/kg for coffee, 4 Baht/kg for palm, and 32 Baht/kg for durian. We assumed the average commodity price as a benchmark and neglected any growth and variation in prices.

As discussed in the previous subsection, we confirmed that the estimation of the RPL model excluding individual effects is more efficient on the information criteria than the estimation including these effects. Therefore, we derive the choice probabilities from the estimation without any farmers’ specific individual effects (estimations (2L-1) and (2L-2) for the hiring labor constraint problem sub-scenario, and (2T-1) and (2T-2) for the tree aging problem sub-scenario).

Here, the simulated mixed logit probability shown in equation (1) is derived by an \( R \) times random drawing of the RPL parameters from the distribution \( f(\beta) \). We estimate the ASC parameters under a multivariate normal assumption on a mixed crop with new coffee, palm, and durian, as:

\[
\beta \sim MVN(b, W),
\]

where \( b \) and \( W \) are the mean and variance-covariance vectors in the multivariate normal distribution of the RPL parameter \( \beta \). When the \( r \)-th draw is noted as \( \beta_r \), the simulated choice probability for alternative \( j \) under given commodity prices is derived as:

\[
\hat{P}_j = \frac{1}{R} \frac{\exp \left[ V_{ij}(\beta_r, \gamma_m) \right]}{\sum_{l} \exp \left[ V_{il}(\beta_r, \gamma_m) \right]}.
\]

In order to fix the RPL parameters \( b, W, \) and \( \gamma_m \) in the model, we adopt the Krinsky and Robb (1986) approach for drawing from the RPL estimators’ distribution. Our procedure is summarized as follows.

( i ) Random drawing of \( b, W, \) and \( \gamma_m \) from the RPL estimators’ distribution, with estimates (coefficients) and variance-covariance matrix.

( ii ) Random drawing of \( \beta \) for the ASCs’ parameters from a multivariate normal distribution \( MVN(\beta, W) \). This drawing is replicated \( R = 100,000 \) times, and we derive the simulated choice probabilities in equation (6).

Processes (i) and (ii) are replicated 5,000 times to derive the distributions of the simulated choice probabilities. Figures 3 and 4 show the distributions of the simulated choice probability for comparison between situations without/with the labor constraint problem, and situations without/with the tree aging problem, respectively. Table 9 shows the mean and percentiles of the distribution of the simulated probability.

Scenarios (L-1) and (T-1), the hypothetical situations with no imposition of constraints for both sub-scenarios, are almost equivalent for respondents. Interestingly, these sub-scenarios show almost the same choice probability of the option to keep all coffee trees (about 15%) and mixing with new coffee trees (about 22–23%), although the choice probability of mixing with palm (durian) under situation (L-1) is higher (lower) than under situation (T-1).

First, we checked the change in choice probability by imposing the labor constraint (Figure 3).

The labor constraint does not impose significant changes on the choice probability of keeping all coffee trees, but it significantly changes the choice probability of replanting them, amounting to about 85% which is the sum of choice probabilities of mixed crop with new coffee, palm, and durian. Farmers show a strong preference for the option of not replanting new coffee trees, as the mean choice probability decreases from around 22% to 10%. Farmers choose to crop palm (from 8 to 14%) or durian (from 55 to 61%) with higher probability.

On the other hand, imposing the tree aging problem, in the absence of the labor constraint, induces farmers to choose not to keep old coffee trees, as the mean choice probability decreases from 16 to 3%, without significantly affecting the choice probability of replanting new coffee trees (Figure 4). The choice to crop with palm or durian could be feasible alternatives. The mean probabilities increase from 12.5 to 18%, and 48.5 to 58% for crops with palm and durian, respectively.

6. Conclusion

The present study analyzes the recent reduction of coffee production in southern Thailand, with special regard for Chumphon Province. The study region,
which has been devoted to active coffee production for about 20–30 years, has highly depended on immigrant labor from the north-eastern part of Thailand in the harvesting periods of coffee production. However, recent economic developments and changes in the labor market created difficulties in finding and hiring harvesting labor in this region. We asked farmers to join a choice experiment based on different scenarios for testing the effects of the coffee tree aging problem and labor hiring constraint on their crop choice decision. It is found that farmers are not likely to replant fresh coffee trees under the labor constraint, but their probability to keep the present coffee production is not affected by this constraint. On the other hand, the tree aging problem makes farmers stop maintaining present coffee trees, while the probability of introducing new coffee trees is not affected when farmers are not aware of the difficulties of finding labor. It is also found that other products, like durian or palm, could be significant alternatives for replacement of coffee production in our choice experiments.

However, how should we interpret the different effects of the labor constraint and coffee tree aging problem on coffee management? As the estimation that considers farmers’ strict risk averse attitudes in the first scenario implies, the uncertainty in coffee management is contingent on the availability of labor to be hired in the appropriate timing of harvesting. If farmers cannot hire sufficient labor at the appropriate time, coffee production, which generates income only once a year, exposes farmers to more risks. The reason why farmers are not likely to introduce new coffee trees under the labor constraint could be the increased crop uncertainty under this constraint. However, this concern is not only affecting coffee production. Our experiment shows that farmers’ choices also depend on past price trends and levels. Durian has become an attractive crop due to its recent price growth, which is reflected in the estimation by the significant and positive parameter for the perception of continuous price increases. The prices of these cash crops are very volatile, and this could be another source of uncertainty for farmers. On the other hand, the labor shortage constraint can be seen as a more general concern in Thailand. Our results seem to
suggest that in addition to efforts to mitigate vulnerability to risks, technological innovation related to the labor requirements of crop production and its diffusion among these crops is required to achieve sustainable production. At the same time, the above discussion implies the limitations of this study. Our choice experiment asked respondents to suppose that other conditions or technological traits were fixed. Additionally, the setting of attributes in our choice profile was simplified to make it easier for respondents to reply under the different scenarios. However, this setting implicitly requested that the respondent consider other situations or attributes as fixed; for example, we did not introduce any settings about other input prices or food prices. How the changes in these prices affect crop choices should be examined to understand farmers’ consumption and production behaviors. Our choice experiment did not introduce the detailed traits of crops. However, training programs given by government offices or cooperatives for improving productivity or reducing cost are found in the study region. Constructing a choice experiment to capture farmers’ preferences on the traits of the crops ex ante could help identify the needs for development of new practices or varieties.

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**Table 9. Mean and percentiles of choice probabilities**

|                                | Hiring labor const. problem | Tree aging problem |
|--------------------------------|----------------------------|-------------------|
|                                | Mean | 5 percentile lower | upper | Mean | 5 percentile lower | upper |
| Mixed crop with w/o problem    | 0.217 | [0.160, 0.285]     | 0.230 | [0.149, 0.319]     |
| Mixed crop with w/ problem     | 0.102 | [0.062, 0.167]     | 0.208 | [0.143, 0.279]     |
| Mixed crop with w/o problem    | 0.081 | [0.042, 0.128]     | 0.124 | [0.054, 0.205]     |
| Mixed crop with w/ problem     | 0.140 | [0.100, 0.181]     | 0.180 | [0.116, 0.249]     |
| Mixed crop with w/o problem    | 0.552 | [0.463, 0.638]     | 0.485 | [0.356, 0.601]     |
| Mixed crop with w/ problem     | 0.606 | [0.514, 0.694]     | 0.578 | [0.490, 0.663]     |
| Keeping all old coffee trees   | 0.151 | [0.100, 0.209]     | 0.162 | [0.103, 0.230]     |
| w/ problem                     | 0.152 | [0.092, 0.222]     | 0.034 | [0.016, 0.060]     |

Source: Author’s estimation.

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