Doctoral Dissertation

Rural Households' Behaviors towards Sustainable Rural Development in Vietnam

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Abstract

Sustainable rural development (SRD) is considered a fundamental initiative to achieve the first and second goals of Sustainable Development Goals (SDGs) due to two reasons. First, more than 78% of the poor lives in the rural area. They have limited access to infrastructure facilities and economic elements such as transportation, schools, hospitals, and markets. Second, the majority of the poor engages in agricultural activities that have recently become a major contributor to soil degradation and water deterioration.

Despite the implementation of several programs/policies to achieve SRD, their impacts on rural households' behaviors still remain ambiguous because of self-selection bias. To suggest further implications for policymakers, rigorous causal evidence of these programs/policies need to be investigated. Using both experimental data and observed data, this dissertation examines the impacts of SRD programs/policies related to agricultural sustainability and poverty alleviation through case studies of Vietnam. In detail, three sub-objectives are discussed as follows:

(1) Objective 1: Evaluating impacts of understanding land tenure security (LTS) on agricultural investments (Chapter 2)

(2) Objective 2: Evaluating impacts of information and subsidy treatments on farmers' adoption of organic fertilizer (Chapter 3)

(3) Objective 3: Evaluating impacts of microcredits on welfare of ethnic minorities (Chapter 4)

Vietnam provides a compelling case study to attain these objectives due to three main reasons. First, according to the new law passed in November 2013, usage duration of annual cropland and aquaculture land in Vietnam increased from 20 years to 50 years. This allows me to examine whether understanding the increase in the duration of agricultural land use raises farmers' investments in agriculture such as soil/water conservation and organic fertilizer adoption *(Objective 1)*. Second, Vietnam has been facing serious agricultural pollution due to the overuse of agro-chemicals. Since 2010,

the Vietnamese government has emphasized on the sustainability of agriculture; however, organic farming only accounts for 0.5% of total agricultural land. Thus, I aim to examine whether subsidy treatment and information treatment improve the adoption of organic fertilizer, especially for green tea-cultivating in Vietnam *(Objective 2)*. Third, although Vietnam has achieved significant improvements regarding poverty reduction, there still remains a considerable gap between the ethnic majority (Kinh ethnic) and the ethnic minorities. For example, the poverty rate among ethnic minorities was 44.6% in 2016 while the poverty rate among ethnic majority was only 3.1%. Therefore, it is necessary to investigate whether microcredits improve the welfare of ethnic minorities *(Objective 3)*.

Regarding the first objective (chapter 2), this dissertation contributes to current research by showing the rigorous causal effect of understanding the increase in the duration of agricultural land use on agricultural investments. Although previous studies have shown the importance of knowledge on LTS, to date, only few quantitative evidence regarding the effects of understanding LTS exists *(Research gap 1)*. Due to unobserved covariates, those quantitative studies might fail to provide causal evidence. Using panel data from Viet Nam Access to Resources Household Survey (VARHS) in 2010, 2012, 2014 and 2016, collected before and after the 2013 new land law, this dissertation can control for both unobserved and observed time-variant variables as well as test the parallel trend assumption. Balanced panel data includes 1834 households. Difference-in-difference with fixed effect (DID-FE) is employed to estimate the causal impacts. I find that understanding the increase in the duration of agricultural land use increases investments in irrigation/soil/water conservation and the adoption of organic fertilizer.

To attain the second objective (chapter 3), I conduct a randomized controlled trial (RCT) on 1287 tea-cultivating households in Thai Nguyen province, Vietnam to examine whether subsidy and information treatments improve the adoption of organic fertilizer. The former is given as a 50% price subsidy, while the latter shares the experience of farmers who have adopted organic fertilizer on their farms. Although previous literature highlights the significant roles of economic incentive and information access on organic fertilizer adoption, the causal impacts still remain unclear because of endogeneity bias

(Research gap 2). In this study, I implement an RCT, which can eliminate selection bias and produce precise causal estimates. In addition, my experimental design allows me to compare the effects of two different interventions, the subsidy and information provision, which provides crucial evidence for policy implementation. I find that both the subsidy and information treatments have significant impacts on the adoption of organic fertilizer. Moreover, the effect of the information treatment via farmers who share a group identity with target farmers is approximately one-third that of the 50% price subsidy. This finding demonstrates the potential of the former to partially substitute for the latter. I also find substantial impacts of the information treatment in the context of farmers who belong to certification groups (VietGAP group).

The third and last objective (chapter 4) contributes to poverty alleviation literature by providing evidence on the impacts of microcredits on household welfare of ethnic minorities. Although a large number of studies have investigated the impacts of microfinance on rural households, their effects on ethnic minorities, who are among the left-behind groups, have not been evaluated *(Research gap 3)*. In this chapter, I examine whether microcredits provided by the Vietnam Bank for Social Policies (VBSP) improves the household welfare of ethnic minorities living in the northern mountainous regions of Vietnam. A stratified random sampling technique is applied to a sample of 289 households in Bac Kan province, Vietnam. Propensity score matching (PSM) is employed to mitigate bias caused by the self-selection of the VBSP borrowers. Coarsened exact matching (CEM) is employed to verify the consistency of the PSM estimates. The results show positive and consistent impacts of microfinance loans on total expenditure per capita and educational expenditure per student, which supports the welfare effects of microfinance loans on ethnic minorities in northern mountainous areas of Vietnam.

Based on the findings of the three analysis chapters, the dissertation discusses further implications for achieving SRD in Vietnam. Regarding sustainable agriculture, it is necessary to raise farmers' awareness about the LTS to encourage sustainable agricultural investments such as soil/water conservation and organic fertilizer adoption. In addition, providing information about the experience of peer farmers or providing monetary incentives can be used to promoting the adoption of environmentally friendly behaviors, for

example, organic fertilizer adoption. Besides, to end poverty in all its forms, it is crucial to improve the welfare of poor ethnic minorities, one of the most left-behind group. The results highlight the importance of maintaining and developing microcredit programs for ethnic minorities, especially educational microcredit programs. In short, this dissertation examines rigorously causal effects of SRD programs/policies in Vietnam with regard to agricultural sustainability and poverty alleviation. My findings can support policymakers when making future policies to enhance rural households' behaviors towards SRD.

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Lastly, to my husband and my family, for all their unconditional love and supports, I could not be more grateful.

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Abbreviations

ATE	**A**verage **T**reatment **E**ffect
ATET	**A**verage **T**reatment **E**ffect on the **T**reated
CEM	**C**oarsened **E**xact **M**atching
PSM	**P**ropensity **S**core **M**atching
RCT	**R**andomized **C**ontrolled **T**rial
DID	**D**ifferent-in-different
FE	**F**ixed **E**ffect
LTS	**L**and **T**enure **S**ecurity
VBSP	**V**ietnam **B**ank for **S**ocial and **P**olicies
VARHS	**V**ietnam **A**ccess to **R**esources **H**ousehold **S**urvey

Chapter 1

Introduction

1.1 Background

The first goal of Sustainable Development Goals (SDGs) is to end poverty in all its forms (Nations, 2015). The second goal of SDGs is to end hunger, achieve food security and promote sustainable agriculture (Nations, 2015). To achieve these missions, sustainable rural development (SRD) is considered as a fundamental initiative for two reasons (FAO, 2017). First, more than 78% of the poor lives in the rural area (World Bank, 2013). They have limited assess in infrastructure facilities and economic elements such as transportation, schools, hospitals, and markets. If this trend continues, global poverty can become overwhelmingly an issue of rural area. Second, over 63% of the poor engage in agricultural activities (World Bank, 2013). The agricultural activities have recently become a major contributor to soil degradation and water deterioration (Javier et al., 2017).

Many programs/policies have been implemented to achieve SRD; however, their impacts remain unclear due to self-selection bias from rural households. To suggest further implications, it is necessary to examine the effects of these programs/policies rigorously with a causal approach. In this dissertation, I focus on investigating the impacts of SRD programs/policies related to agricultural sustainability and poverty alleviation using rural household data. Findings from my study can provide causal evidence for policymakers to adopt future policies enhancing SRD. In detail, I conduct analysis based on three sub-objectives as follows:

(1) Objective 1: Evaluating impacts of understanding land tenure security (LTS) on agricultural investments (Chapter 2).

(2) Objective 2: Evaluating impacts of information and subsidy treatments on the adoption of organic fertilizer (Chapter 3).

(3) Objective 3: Evaluating impacts of microcredits on household welfare of ethnic minorities (Chapter 4).

1.2 Sustainable rural development policies in Vietnam

Vietnam provides a compelling case study for this research due to the following reasons. In Vietnam, 65% of the population lives in rural area[1]. Regarding poverty reduction, Vietnam has achieved remarkable achievement, for example, the poverty rate reduced from 58.1% in 1993 to 9.8% in 2016 (World Bank, 2018). However, there remains a significant gap between rural and urban areas, as well as between ethnic minorities and ethnic majorities. With regard to agricultural activities, Vietnam moved from a food deficit country after World War II to a world's third-largest rice exporter (FAO, 2018). Although the intensification of crops and the adoption of agrochemicals improved crop productivity, Vietnam has recently faced serious agricultural pollution because of the overuse of chemical fertilizer and chemical pesticides (T. H. Nguyen, 2017).

To evaluates the SRD programs/policies in Vietnam, in this section, I focus on three main programs/policies, which are agricultural land policy, policy related to agricultural production and poverty alleviation programs.

1.2.1 Agricultural land policy in Vietnam

Agricultural land policy in Vietnam was illustrated in Table 1.1.

Table 1.1: Agricultural land policy

Time	Agricultural land policy
1998	- The transfer of agricultural land use rights from collectives to individual households
1993	- Issuance of systematic land titling - Landholders: trade, transfer, rent, bequeath, and mortgage their land-use rights. - Duration of land use: + Annual crop, Aquaculture: 20 years + Perennial crop: 50 years - Agricultural land: cultivation, husbandry, aquaculture or research
2003	- Agricultural land: annual crops, perennial crops, forest land, aquaculture and salt making
November, 2013	- Duration of agricultural land use: 50 years

(Source: author's summary from land law 1993, 2003, and 2013)

There have been considerable changes in agricultural land policy in Vietnam since "Doi Moi" reform, an innovation policy reform. In 1988, agricultural lands were reallocated from collectives to individual households to alleviate inequality and encourage farmers' investments in their lands (Q. Do and Iyer, 2008). However, farmers were reluctant to

[1]see https://www.gso.gov.vn/default.aspx?tabid=714

make long-term investments. Because their lands were not tradable which made them insecure about their plots (Menon et al., 2014). To incentivize investments in farmland, a new land law, passed in 1993, allowed landowners to trade, transfer, rent, bequeath, and mortgage their land-use rights. A systematic land titling, known in Vietnam as Land-Use Certificates (LUCs), was initiated since 1993. In addition, the government also set up the duration of agricultural land use. Annual cropland and aquaculture land could be used for 20 years while perennial cropland could be used for 50 years. What to do upon the expiry of land-use rights, as would occur with many annual croplands and aquaculture lands in 2013, became a big concern for not only farmers but also policymakers. It is common that the shorter the duration of agricultural land use is, the less confident the farmers are when investing in their plots (World Bank, 2012a). To enhance further long-term investments, a new land law regarding the duration of agricultural land use was passed in November 2013. According to the new law, usage duration of all agricultural lands was 50 years, which indicated an increase in the duration of annual cropland use and aquaculture land use from 20 years to 50 years.

While there was some literature studying for impacts of the land titling in 1993 land law (Q. Do and Iyer, 2008; Kemper et al., 2015), there was no study researching on impacts of the change in the duration of agricultural land-use rights in 2013 land law. Understanding the increase in the duration usage of agricultural land could reduce the uncertainty and encourage farmers to make long-term investments. Thus, the first objective of this dissertation is to investigate whether understanding the increase in duration of agricultural land use in 2013 land law improved agricultural investments of farmers in Vietnam.

1.2.2 Policy related to agricultural production in Vietnam

Policy related to agricultural production in Vietnam was illustrated in Figure 1.2.

There have been four distinct stages regarding the development of the agricultural sector and crop production system in Vietnam since 1980 (T. H. Nguyen, 2017). The first stage, occurred during the 1980s, saw a movement from a food deficit country to a rice exporter of Vietnam. This resulted from the "Doi Moi" reform and Green Revolution promoting the adoption of agrochemicals and high-yielding varieties, the improvement of irrigation, and the diversification of crop varieties. From 1990 to 2000 (second stage), there was a considerable investment in irrigation systems and rural infrastructure. In addition, crop production was intensified and specialized. These changes boosted agricultural productivity, for example, rice harvesting increased from two to three times per year in several places. Beside the positive impacts on economics, agricultural pollution also increased.

Table 1.2: Policy related to agricultural production

Time	Policy related to agricultural production
1980s	- Green revolution: agrochemicals, high-yielding varieties, irrigation - "Doi Moi" reform: diversification of crop varieties
1990-2000s	- Significant investments in irrigation systems and rural infrastructure - Intensification and specialization in crop production => Increasing pollution
2001-2010	- High intensification of crops => Serious pollution impacts on soil and water environments
2010- now	- Emphasizing on sustainability of agriculture + Agricultural Restructuring Plan (ARP) + Good Agricultural Practice (GAP) standards and climate-smart agriculture + Markets for organic foods and food safety products

(Source: adapted from (T. H. Nguyen, 2017))

The main feature of the third stage (from 2001 to 2010) was the high intensification of crops. This made Vietnam become the top third-largest rice exporter in the world. However, the cost of high agricultural intensification was serious soil and water pollution due to the overuse of agrochemicals such as chemical fertilizer and chemical pesticides. Realizing those environmental impacts, the government moved to promote the sustainability of agriculture since 2010 (fourth stage). Several policies have been introduced, for instance, Agricultural Restructuring Plan (ARP), Good agricultural practice (GAP) standards, climate-smart agriculture, and creating the markets for organic foods and food safety products (T. H. Nguyen, 2017).

Despite the implementation of many programs focusing on sustainable agriculture, organic farming in Vietnam only accounted for 0.5% of total agricultural land (Willer and Julia, 2019). Besides, due to the limited awareness of farmers, they often adopted fertilizers more than the recommended level. For example, coffee farmers adopted Nitrogen (N), Diphosphorus pentoxide (P_2O_5), and Potassium oxide (K_2O) more than the advised levels by 50%, 210% and 30% respectively (T. H. Nguyen, 2017). Therefore, how farmers can be encouraged to use environmentally friendly inputs become a crucial question. This also reflects the second objective of this dissertation that investigates the impacts of information and subsidy treatments on farmers' adoption of organic fertilizer.

1.2.3 Poverty alleviation programs in Vietnam

Vietnam has implemented several poverty alleviation programs as follows.

- P-135 and P30a: These programs focused on improving the living conditions of ethnic minorities.

- P-132 and P-134: These programs emphasized on increasing access to land and improving housing conditions of Central Highlands areas.
- Hunger and Poverty Eradication Program (HEPR): This program aimed at eliminating hunger and reducing the national poverty rate.
- NTP-PR: This program provided health insurance for the poor households.
- Microcredits: Microcredits were mainly implemented through Vietnam Bank for Social and Policies (VBSP)

Thanks to those programs, Vietnam has seen remarkable achievements in poverty reduction, for example, the poverty rate reduced from 58.1% in 1993 to 9.8% in 2016 (World Bank, 2018). However, there remains a substantial poverty gap between the ethnic majority and ethnic minorities (see Figure 1.1).

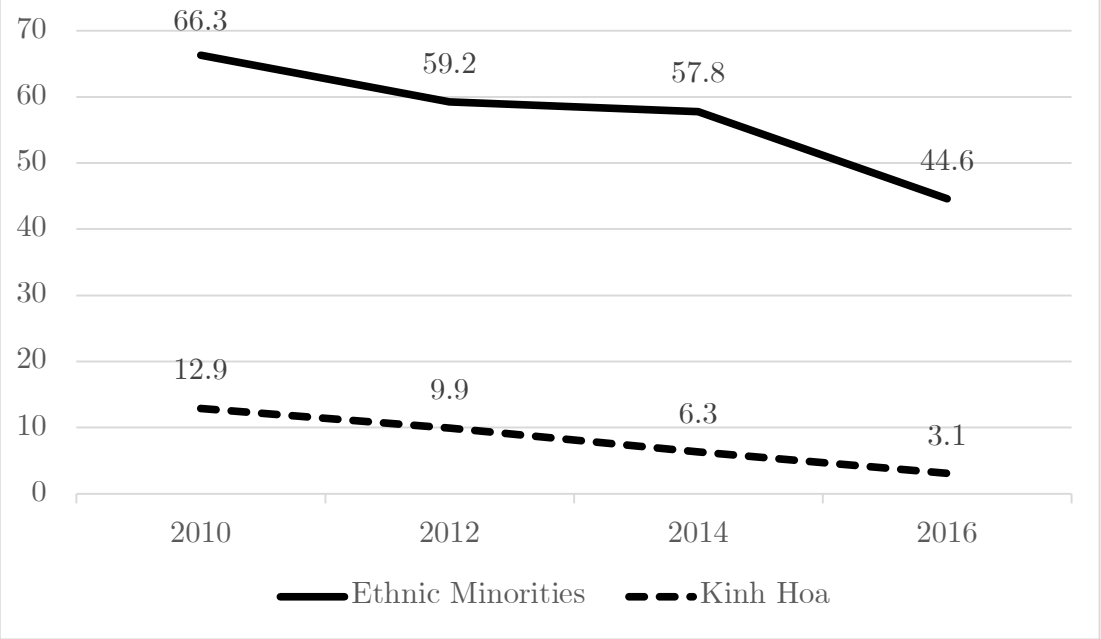

FIGURE 1.1: Poverty rates by ethnicity

(Source: World Bank, 2018)

The poverty rate of the ethnic majority in 2016 was only 3.1% while the poverty rate of the ethnic minority was only 44.6% (World Bank, 2018). If this trend continues, poverty can be overwhelming an issue of ethnicity. Thus, the third objective of my dissertation is to examine whether microcredits improve household welfare of ethnic minorities.

1.3 Dissertation structure

This dissertation consists of 5 chapters with the structure presented in Figure 1.2.

Chapter 1 has so far provided background information on why investments in the rural area are needed to achieve SDGs. In addition, it justifies the selection of Vietnam as a compelling case study of this dissertation. In doing so, I describe three intriguing policies of the Vietnamese government which are agricultural land policy, policy related to agricultural production and poverty alleviation programs.

Chapters 2, 3 and 4 are core contents of the dissertation, which presents data analysis to attain the three mentioned research objectives. Specifically, chapter 2 attains the first research objective using data from Vietnam Access to Resources Household Survey (VARHS) collected in four periods (2010, 2012, 2014, and 2016). This chapter examines whether understanding the increase in the duration of agricultural land use increase environmentally friendly land-related investments and crop productivity of farmers in Vietnam. I apply different-in-different (DID) and fixed effect (FE) methods for impact evaluation. Chapter 3 attains the second research objective using a randomized controlled trial (RCT) conducted in Thai Nguyen province, Vietnam. This chapter focuses on the causal impacts of information treatment and subsidy treatment on farmers' adoption of organic fertilizer. Chapter 4 achieves the third research objective using primary data collected in Bac Kan province, Vietnam. This chapter examines whether microcredits improve household welfare of ethnic minorities by applying propensity score matching (PSM) method.

Chapter 5 concludes the findings from the three core chapters. Based on the findings, this chapter discusses policy implications related to sustainable agriculture and poverty alleviation. Lastly, chapter 5 also acknowledges the limitations of the dissertation and give suggestions for future study.

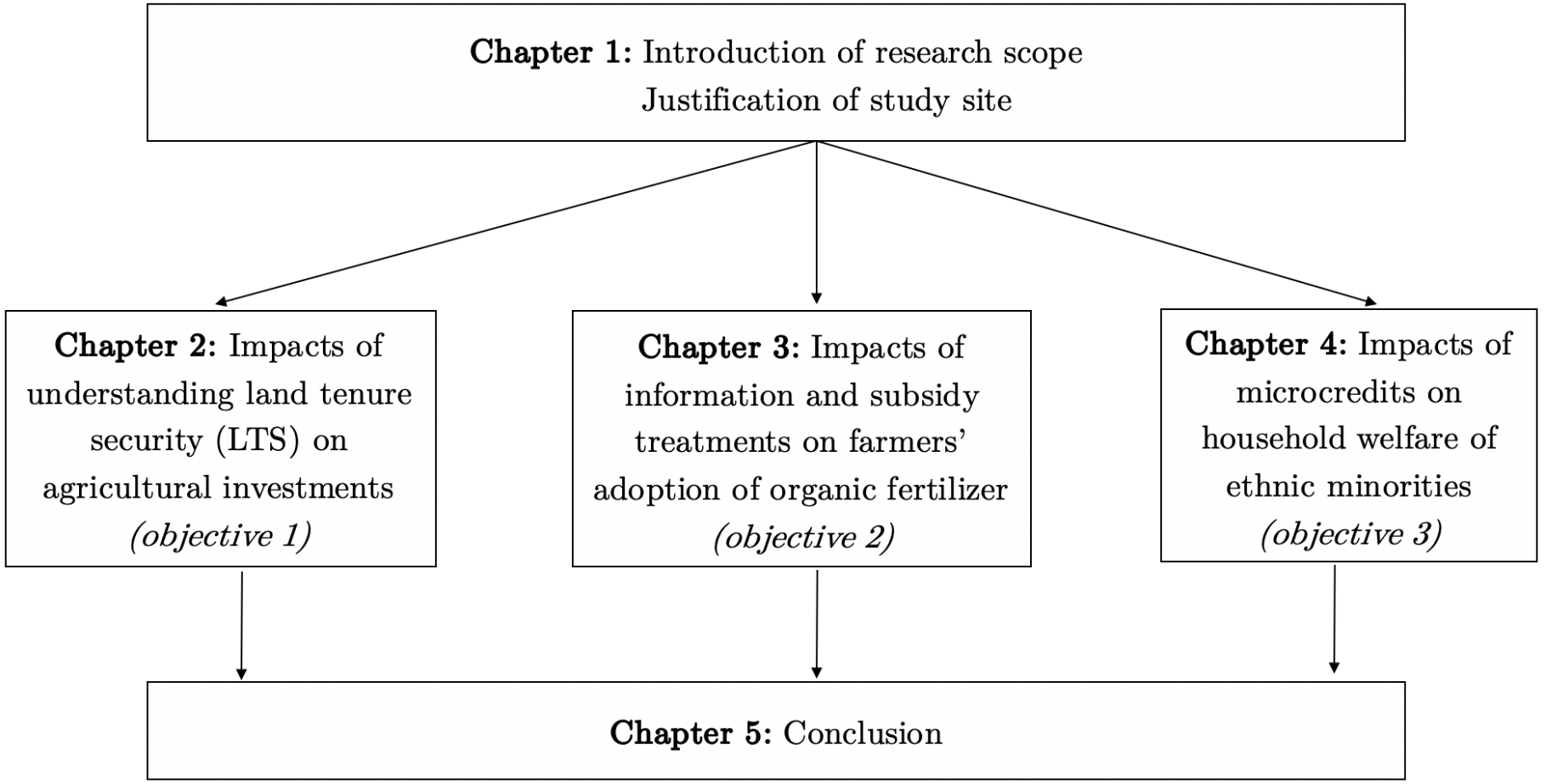

FIGURE 1.2: Dissertation structure

Chapter 2

Impacts of understanding land tenure security (LTS) on agricultural investments

2.1 Introduction

Agricultural land tenure security (LTS) plays a crucial role in reducing poverty and achieving rural development (Higgins et al., 2018; T. T. Nguyen, 2012). LTS is defined as a degree of certainty that "a person's rights to land will be recognized by others and protected in cases of specific challenges" (FAO, 2002). According to a report by World Bank (2013), 63% of the poor have engaged in agricultural activities. Thus, agricultural land property rights are considered key factors to improve the livelihood of the poor by enhancing agricultural productivity and income from agriculture (Lawry et al., 2017).

Increased agricultural LTS is believed to incentivize farmers to invest more in agriculture, which will induce higher productivity and income from agricultural activities (Feder and Nishio, 1998; Besley, 1995). However, current empirical studies on the impacts of LTS interventions have shown mixed results. Santos et al. (2014) found significant effects of land allocation and registration programs on the adoption of fertilizers and improved seeds in West Bengal, India. Paltasingh (2018) also showed positive impacts of LTS on the adoption of modern rice technology in Odisha, Eastern India. In contrast, insignificant impacts on the adoption of fertilizers, manure or pesticides were found in Malawi (Mendola and Simtowe, 2015) and Fiji (Kumari and Nakano, 2016).

Several qualitative studies have pointed out that a lack of understanding LTS amongst beneficiaries of LTS interventions constrained the impacts of such interventions (Yami

and Snyder, 2016; Leeuwen, 2017; Mazhawidza et al., 2011). Lack of knowledge on LTS is especially relevant in the context of developing countries that have often introduced new land laws without a sufficient focus on disseminating information and explanations about them (Deininger et al., 2008). In a review paper about the impacts of rural LTS, Higgins et al. (2018) emphasized the need for quantitative evidence about the impacts of knowledge on LTS, as most quantitative studies begin with the assumption that the respondents recognize LTS and move directly to evaluating the impacts of LTS interventions.

Despite the importance of understanding LTS that has been highlighted in the previous literature, to date, there have been only a few quantitative studies regarding the effects of understanding LTS. To the best of our knowledge, Deininger et al. (2008) was the main exception. Using cross-sectional data from Uganda, they found that legal knowledge, including awareness of land rights, restrictions on land use and recognition of women's land rights, increased land-related investments (tree plantation and soil conservation) and land productivity. In addition to the main finding mentioned above, they found interesting associations between rights to transfer land, length of occupancy and land-related investments. Rights to transfer land were positively correlated with visible investment, such as investment in tree plantations, which was expected to affect land value. However, length of occupancy was positively associated with invisible investments, such as soil conservation, which improved soil fertility in a sustainable manner. To control for unobserved household characteristics, such as mental agility and interest in community affairs, which could affect both levels of legal knowledge and land-related investments, Deininger et al. (2008) applied an instrumental approach. The instrumental variables included three sets of retrospective variables: radio ownership and parents' educational attainment, previous land conflicts, and previous land sales market participation. However, these instrumental variables might not satisfy the exogeneity condition and exclusion restriction assumptions. To suggest further policy implications, it is necessary to rigorously investigate the causal effects of legal knowledge.

In this study, I used DID-FE with panel household data to examine whether understanding the increase in the duration of agricultural land use increased the agricultural investments of farmers. Because of the significant changes in the usage duration of agricultural land, Vietnam provides a compelling case study for testing this hypothesis. Under the new law passed in November 2013, the usage duration of annual cropland and aquaculture land in Vietnam increased from 20 years to 50 years. This study used panel data from the Viet Nam Access to Resources Household Survey (VARHS) collected

in 2010, 2012, 2014 and 2016, before and after the 2013 new land law[1]. The balanced panel data included 1834 households. I found that farmers' understanding the increase in the duration of agricultural land use increased their investments in irrigation/soil conservation/water conservation and adoption of organic fertilizer.

This study contributes to the current research regarding the impacts of knowledge on LTS on agricultural investments in two ways. First, I provide quantitative evidence on the impact of understanding LTS on agricultural investments, which has received little attention in the previous literature. Our findings highlight the positive impacts of understanding LTS on farmers' investments in soil fertility, such as the adoption of organic fertilizer and spending more money and labor on irrigation/soil conservation/water conservation. Second, I use balanced panel data collected before and after the new land law, which allows me to control for both unobserved and observed time-variant variables. In addition, I check the parallel trend assumption. Thus, I can estimate the causal impacts of understanding LTS on agricultural investments.

The remainder of this paper is organized as follows: Section 2 provides background on the duration of agricultural land tenure in Vietnam. Section 3 presents the data descriptions, and Section 4 presents the methodology. The results and discussion are provided in Section 5. Section 6 concludes by offering recommendations and policy implications.

2.2 Background: Changes in agricultural land tenure in Vietnam

Since the introduction of "Doi Moi", a set of innovation reforms, in 1986, Vietnam has seen significant changes in the agricultural sector. Considerable reform regarding the duration of agricultural land-use rights was emphasized in land laws passed in 1998, 1993, and 2013.

The 1988 land law granted the transfer of land-use rights from collectives to individual households.Agricultural investment decisions and the usage of output were also privatized to farm households (Kemper et al., 2015; Menon et al., 2014). This liberalization played an important role in encouraging farmers to put effort into their lands, which contributed to the growth of Vietnam's agricultural output (Pingali and Vo-Tong, 1992). However, as the land-use rights were not tradable, many farmers felt insecure and reluctant to make long-term investments (Menon et al., 2014).

[1]The 2014 VARHS data were used only to identify the balanced panel household data. They are not included in the main analysis because the outcome variables (household investments) in the 2014 data contained investments both before and after 2013 new land law.

To strengthen property rights over land, the government passed a new land law in 1993 that allowed landowners to trade, transfer, rent, bequeath, and mortgage their land-use rights. The law also regulated the duration of land allocation and issued land-use certificates. Annual cropland and aquaculture land could be used for 20 years, whereas perennial cropland could be used for 50 years. These reforms were expected to increase farmers' investments in agriculture, especially durable investments. However, it was common for farmers to gradually decrease their investments according to the expiration time of their agricultural land tenure. In 2000, the share of agricultural investments in the total investment of the whole country was 13.2%; however, this percentage decreased by half in 2009 (World Bank, 2012a).

To inspire the long-term investments of farmers, the 2013 land law was approved. A notable regulation in the new law was the considerable increase in the usage duration of annual cropland and aquaculture land from 20 years to 50 years. Understanding the increase in the duration of agricultural land use has the potential to reduce uncertainty and incentivize farmers to make long-term investments for two reasons. First, the longer usage term reduces the likelihood that the government will expropriate the land-use rights from the farmers and their offspring, which makes them confident in making long-term investments (Q. Do and Iyer, 2008). In addition, farmers have more time to enjoy the fruits of their investments. Second, it is easier to obtain loans with stronger land-use rights because of their value as collateral in the credit market (Menon et al., 2014). Thus, farmers can invest in improvements with high initial costs, such as irrigation.

There have been several studies evaluating the impacts on land titling of the 1993 land law in Vietnam (Q. Do and Iyer, 2008; Kemper et al., 2015; Menon et al., 2014). However, the impacts of understanding the increase in the duration of agricultural land use of the 2013 land law have not yet been examined. This topic is especially important in Vietnam and other developing countries where new land laws have often been introduced with limited effort to implement them or disseminate information about them. In the 2016 VARHS data, only 24.6% of the respondents understood the change in the duration of agricultural land use mentioned in the 2013 land law (within approximately three years). Thus, it is necessary to investigate the effects of understanding the increase in the duration of agricultural land use on farmers' investments.

2.3 Data and key variables measurement

2.3.1 Data

To attain our objective, I used panel data from four rounds of the VARHS collected in 2010, 2012, 2014 and 2016, before and after the 2013 new land law. The VARHS surveys rural households in 12 different provinces from North, Central, and South Vietnam[2]. Data were collected between June and August in each survey year. The sample sizes for the 2010, 2012, 2014 and 2016 rounds were 3202, 3704, 3648, and 2669 households, respectively. The balanced panel data for the four rounds covered 1992 households. I excluded 158 households that had no agricultural land in all four rounds. Therefore, the final balanced panel data for analysis included 1834 households.

The VARHS was designed to complement the Vietnam Household Living Standards Survey (VHLSS), a national survey collected biennially by the General Statistics Office (GSO). While the VHLSS focuses mainly on reflecting consumption poverty rates, the VARHS provides detailed information on land use, labor, and credit access. Many households were surveyed in both the VARHS and VHLSS because the VARHS re-interviewed rural households selected for the VHLSS in 2002 and 2004. Tarp (2017) indicated the similarity between VARHS households and VHLSS households as well as the population census. Thus, the findings from the VARHS data can be generalized to the Vietnamese population (Tarp, 2017).

2.3.2 Key variables measurement

I estimated the impacts of understanding the increase in the duration of agricultural land use on investments in aquaculture, irrigation/soil conservation/water conservation, and the adoption of organic fertilizer.

The VARHS included some questions designed to identify whether a household understood the increase in the usage duration of agricultural land in the 2013 new land law (Table A.1). I selected 2 questions to categorize a household in a treated group or a control group (Table 2.1). The first question was whether the household had heard about the 2013 new land law. The second question was about the duration of agricultural land use rights under the new land law. A total of 452 households that answered "yes" to the first question and "50 years" to the second question were classified in the treated group. A total of 776 households that answered "no" to the first question and not "50 years"

[2]The sampled provinces include Ha Tay, Lao Cai, Phu Tho, Lai Chau, Dien Bien, Nghe An, Quang Nam, Khanh Hoa, Dak Lak, Dak Nong, Lam Dong, and Long An. In 2008, Ha Tay was subsumed into Hanoi, the capital of Vietnam.

to the second question were classified in control group 1. To check the sensitivity of the results, I also compared the treated group with control group 2, which contained the 1382 remaining households after the treated households were excluded from the data. The descriptive statistics of the treated group, control group 1, and control group 2 are provided in table A.2. Table A.3 further reports the differences in the means of the selected covariates between the treated group and control group 1 and between the treated group and control group 2. In general, the treated group outperformed both control group 1 and control group 2 in terms of education of household head, dependent ratio, dummy of poor household, dummy of government officer, and expenditure on New Year.

TABLE 2.1: Treatment identification

Treatment identification		Have you heard about the new land law of 2013?	
		Yes	No
What is the duration of land use rights to agricultural land?	50 years	452 households	249 households
	Not 50 years	357 households	776 households

The outcome variables included cash (thousand VND) and labour (number of days) spent on aquaculture and cash (thousand VND) and labor (number of days) spent on irrigation/soil conservation/water conservation within the previous two years[3]. Another outcome variable was cash spent on organic fertilizer (thousand VND) within the previous 12 months. All monetary values were adjusted for inflation in Vietnam. Specific descriptions of each outcome variable are provided in table A.4. Table 2.1 shows the descriptive statistics of the outcome variables in the four rounds: 2010, 2012, 2014, and 2016. In general, cash spent on irrigation/soil conservation/water conservation and the adoption of organic fertilizer increased from 2010 to 2016, while cash spent on aquaculture fluctuated during this period.

The covariates in this study were divided into two groups: household head features and household characteristics. The household head features included age and education (years of education) of the household head. Household characteristics included family size (number of family members), expenditure on the "Tet" holiday (Vietnamese New Year holiday) (thousand VND), a dummy of government officers, a dummy of poor household, and dependent ratio. Specific descriptions of each covariate are provided in table A.5. The descriptive statistics of these variables from 2010-2016 are presented in table 2.2. The average age and the average years of education of the household head in 2016 were 57.23 years old and 7.62 years, respectively. On average, a household had four members and spent 4.7 million VND during the Tet holiday in 2016. The 2016 VARHS data showed that 15% of the households were poor households.

[3]1 USD is equal to approximately 23,000 VND

TABLE 2.2: Descriptive statistics of outcome variables by year

Outcomes	2016			2014			2012			2010		
	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
Cash spent on irrigation/soil conservation/ water conservation (1,000 VND)	1,834	423.61	4512.09	1,834	340.69	4062.69	1,834	199.35	1920.20	1,834	286.94	2202.74
Labour spending on irrigation/soil conservation/water conservation (days)	1,834	1.09	3.84	1,834	1.03	5.26	1,834	2.73	11.95	1,834	6.62	17.07
Cash spent on aquaculture (1,000 VND)	1,834	258.20	3782.21	1,834	444.82	9563.89	1,834	245.54	2250.53	1,834	689.59	6592.19
Labour spent on aquaculture (days)	1,834	0.64	16.50	1,834	0.32	3.98	1,834	0.65	4.47	1,834	1.29	14.78
Organic fertilizer adoption (1,000VND)	1,834	1417.03	5414.60	1,834	1057.64	5948.45	1,834	891.98	3483.77	1,834	734.87	1996.43

TABLE 2.3: Descriptive statistics of covariates by year

Variable	2016			2014			2012			2010		
	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
Age of household head	1,834	57.23	12.88	1,834	55.82	12.91	1,834	54.25	12.96	1,834	52.75	13.08
Education of household head (years of education)	1,834	7.62	3.53	1,834	7.10	3.66	1,834	6.83	3.53	1,834	6.75	3.57
Family size	1,834	4.11	1.81	1,834	4.22	1.78	1,834	4.32	1.76	1,834	4.40	1.70
Dependent ratio	1,834	0.26	0.32	1,834	0.23	0.30	1,834	0.21	0.29	1,834	0.19	0.27
Dummy of poor household	1,815	0.15	0.36	1,831	0.12	0.33	1,834	0.17	0.38	1,834	0.13	0.34
Dummy of government officer	1,834	0.06	0.24	1,834	0.06	0.23	1,834	0.04	0.20	1,834	0.06	0.23
Expenditure on Tet holiday (1,000 VND)	1,829	4660.99	4315.62	1,834	4130.04	3280.87	1,834	4142.79	3004.09	1,834	3537.91	2889.19

2.4 Methods

To evaluate the effects on agricultural investments of understanding the increase in the duration of agricultural land use in the 2013 new land law , I employed difference-in-difference with fixed effects (DID-FE) regression with two time periods: 2012 and 2016. The 2010 data were used to check the parallel trend assumption. The 2014 data were not included in the main analysis because the household investments (our outcome variables) in the data contained investments both before and after the 2013 new land law[4].

The following model is estimated:

$$Y_{it} = \beta_0 + \beta_1 time_t + \beta_2 household_i + \beta_3 time_t \cdot treated_i + \beta_4 X_{it} + \epsilon_{it} \quad (2.1)$$

where Y_{it} represents the outcome variables investments in aquaculture, irrigation/soil conservation/water conservation, and organic fertilizer adoption. $time_t$ is the dummy of periods after 2013 (after policy intervention). $time_t = 1$ indicates 2016, while $time_t = 0$ indicates 2012. $household_i$ denotes the time-invariant household-level unmeasured variable. $treated_i$ indicates the dummy of the treated group (whether the household understood the duration of agricultural land change). X_{it} includes time-variant household characteristics that can affect both treatment status and outcome variables (for example, family size, dummy of poor household, education of household head, age of household head and expenditure on Vietnamese New Year). The coefficient of interest β_3 shows the impacts of understanding the increase in the duration of agricultural land use on the outcome variable Y_{it}. In the basic DID model, the dummy of treatment status $treated_i$ was included. However, this variable was absorbed by $household_i$ because household fixed effects were controlled in our model.

The strength of our model is that both observed and unobserved time-invariant household characteristics influencing the treatment and outcome variables were controlled. In addition, I controlled for some time-variant household characteristics that could affect both outcomes and treatment status, for instance, age and education of household head, family size, expenditure on Vietnamese New Year, and dependent ratio. Thus, the potential self-selection bias was largely addressed.

DID estimates require the parallel trend assumption, which requests constant differences over time between the outcome variables of the treated group and the outcome variables of the control group in the absence of treatment (Lechner, 2010). In other words,

[4]In the questionnaire, the respondents were asked about their investments in irrigation/soil conservation/water conservation and their investments in aquaculture in the previous 2 years. They were also asked about cash spent on organic fertilizer adoption in the previous year.

unobserved time-variant characteristics cannot affect the treatment status and outcome variables. Although this assumption could not be tested directly, I checked the trend with some periods of data that were collected before the treatment implementation. In this study, the 2010 data and 2012 data, collected before the 2013 new land law, were used to examine the parallel trend assumption.

To confirm the consistency of the DID-FE estimates, I employed DID-FE with the propensity score matching (PSM) method. PSM estimates the propensity score, which is the probability that a household will understand the change in the duration of agricultural land use in the 2013 new land law given a set of covariates that cannot be affected by the understanding of the change. I used the same covariates for both DID-FE and DID-FE with PSM. The households that were outside the common support were excluded from the analysis. Thus, if the treated and control households were very different, they were eliminated from the data analysis.

2.5 Results and discussion

Table 2.3 shows the average treatment effect (ATE) results between the treated group and control group 1. Outcome variables included cash spent on irrigation/soil conservation/water conservation (thousand VND), labour spent on irrigation/soil conservation/water conservation (days), cash spent on aquaculture (thousand VND), labour spent on aquaculture (days), and cash spent on the adoption of organic fertilizer (thousand VND). All outcome variables were measured within two years after the data collection in 2016, except cash spent on adoption of organic fertilizer, which was measured within a year. Monetary outcomes were adjusted for inflation in Vietnam.

Model 1, model 2, and model 3 of table 2.3 report the results from DID-FE without controlling for covariates, DID-FE controlling for covariates, and DID-FE with PSM, respectively. Nine households lying outside the common support were excluded from the DID-FE with PSM estimation. As mentioned earlier, I controlled for the same covariates for DID-FE and DID-FE with PSM. The controlled covariates included age and education of household head, family size, dependent ratio, dummy of poor household, dummy of government officer, and expenditure on Vietnamese New Year.

TABLE 2.4: ATE results for comparison between treated group and control group 1

Outcome variables	DID-FE	DID-FE	DID-FE with PSM
	Model 1	Model 2	Model 3
Cash spent on irrigation/soil conservation/water conservation (1,000 VND)	601.94***	565.04***	564.78***
	(198.70)	(201.74)	(202.01)
Labour spent on irrigation/soil conservation/water conservation (days)	1.33*	1.53*	1.54*
	(0.78)	(0.80)	(0.80)
Cash spent on aquaculture (1,000 VND)	251.88	235.16	234.96
	(233.42)	(240.50)	(240.83)
Labour spent on aquaculture (days)	1.26	1.28	1.29
	(1.22)	(1.26)	(1.26)
Organic fertilizer adoption (1,000VND)	568.04**	544.96**	545.56**
	(264.14)	(270.57)	(270.93)
Controlling for household characteristics	No	Yes	Yes
Number of observations (balanced panel households)	1228	1228	1219

Note: Standard errors are reported in parentheses.
* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

TABLE 2.5: Checking parallel trend assumption for comparison between treated group and control group 1

Outcome variables	DID-FE	DID-FE
	Model 1	Model 2
Cash spent on irrigation/soil conservation/water conservation (1,000 VND)	-106.2	-105.95
	(163.58)	(165.82)
Labour spent on irrigation/soil conservation/water conservation (days)	-0.54	-0.71
	(1.28)	(1.27)
Cash spent on aquaculture (1,000 VND)	-187.9	-185.99
	(370.33)	(374.8)
Labour spent on aquaculture (days)	-0.43	-0.49
	(0.47)	(0.48)
Organic fertilizer adoption (1,000VND)	56.57	42.85
	(183.62)	(185.93)
Controlling for household characteristics	No	Yes
Number of observations (balanced panel households)	1228	1228

Note: Standard errors are reported in parentheses.

Regarding investments in irrigation/soil conservation/water conservation, I found robust, positive and significant impacts in all three models. Households that understood the increase in the duration of agricultural land use increased their cash spent on irrigation/soil conservation/water conservation by 565,040 VND compared with households that did not understand the increase in the duration of agricultural land use. The results from DID-FE without controlling for covariates (model 1) and DID-FE with PSM (model 3) also showed increases of 601,940 VND and 564,780 VND, respectively. All estimates were significant at 1%. In addition, I found an increase in labour spent on irrigation/soil conservation/water conservation by 1.33 days, 1.53 days, and 1.54 days for model 1, model 2, and model 3, respectively. All estimates were significant at 10%.

In addition, I found robust, positive and significant impacts on organic fertilizer adoption. This finding indicated that the increase in the duration of agricultural land use increased the cash spent on the adoption of organic fertilizer by 568,040 VND in model 1, 544,960 VND in model 2, and 545,560 VND in model 3. In other words, households that understood the increase in the usage duration of agricultural land spent approximately 544,960 VND more on organic fertilizer adoption than households that did not understand the change. All results were significant at the 5% level.

Our findings were consistent with those of Deininger et al. (2008). Using cross-sectional data from Uganda, they found positive impacts on soil conservation and number of trees planted for 5 years of legal knowledge which included awareness of land rights and restrictions on land use as well of recognition of women's land rights. Besley (1995) theoretically and empirically proved the relationship between greater LTS and incentives for long-term investments and sustainable land management. In this study, the usage duration of annual cropland and aquaculture land increased significantly from 20 years to 50 years. The longer usage term decreased the probability that the land-use rights would be expropriated by the government, which made the farmers feel secure and confident in making long-term investments (Q. Do and Iyer, 2008). In addition, farmers have more time to enjoy the fruits of their labor, which might encourage them to maintain and improve soil fertility for longer cultivation periods. As a result, positive significant impacts were found regarding sustainable agricultural investments such as cash spent on irrigation/soil conservation/water conservation, labour spent on irrigation/soil conservation/water conservation, and cash spent on the adoption of organic fertilizer.

To check the sensitivity of our results, I also compared the treatment group and control group 2. The results are shown in appendix table A.6. In general, the findings were consistent with those from the previous comparison between treatment group and control group 1. I observed increases of 515,930 VND and 1.30 days in cash and labour spent on irrigation/soil conservation/water conservation, respectively. The estimates

were significant at 10% in all models. Although there was an increase in cash spent on the adoption of organic fertilizer, the impact was insignificant. In addition, the results from the comparison between treatment group and control group 2 had lower coefficients than those from the comparison between treatment group and control group 1. This difference could be interpreted as follows. Control group 2 included households that said that they did not know about the 2013 land law, but they gave a correct answer to the question about the duration of agricultural land use, which might constrain the impacts of knowledge on the increase in the duration of agricultural land use. The respondents might know a little about the law but might not be confident in their knowledge; thus, they might have answered that they had not heard about the changes in the 2013 land law. In addition, control group 2 included households that answered "yes" to the first question and "100 years" to the second question. Those households might know of the increase in the duration of agricultural land use, but they did not know the exact extent of the new duration. Therefore, the inclusion of those households in control group 2 might underestimate the impacts of their understanding of the increase in the duration of agricultural land use.

The parallel trend is the most critical assumption of DID. I tested this assumption using the 2010 and 2012 data, collected before the 2013 new land law. Table 2.4 shows the test for comparison between the treatment group and control group 1. The results indicated that the parallel trend assumption was satisfied. There were no statistically significant differences in any outcome variables between 2012 and 2010.

2.6 Conclusions and policy implications

This study aimed to examine the impacts of understanding the increase in the usage duration of agricultural land on sustainable investments in irrigation/soil conservation/water conservation and the adoption of organic fertilizer. I used VARHS panel household data collected in 2010, 2012, 2014 and 2016, before and after the implementation of the 2013 new land law. DID-FE was employed to estimate the causal impact of understanding the change in the duration of agricultural land use. To check the sensitivity of the DID-FE estimates, I applied DID-FE with PSM. The parallel trend assumption was also examined using the 2010 and 2012 VARHS data. I found that households that understood the increase in the usage duration of agricultural land spent more money and labour input on irrigation/soil conservation/water conservation than households that did not understand the change in the duration of agricultural land use. In addition, the former spent more cash on organic fertilizer adoption than the latter.

Our findings provide causal evidence to support the impacts of LTS knowledge on agricultural investments, which have remained unclear in the previous literature. However, in our data, only 24.6% of households understood the increase in the duration of agricultural land use within approximately three years (from November 2013 to the data collection period in 2016). Thus, policymakers should pay more attention to improving farmers' knowledge of LTS. This implication is especially significant for developing countries that have introduced new land laws without paying attention to implementing them. Improving farmers' knowledge about LTS could increase their investments in sustainable agriculture, which contributes to the second aim of sustainable development goals (SDGs), which focus on ending hunger and promoting agricultural sustainability.

The external validity of this study might be limited to the 12 provinces surveyed in the VARHS. However, as discussed in section 3, the VARHS data showed similarities with the VHLSS data and population census. Therefore, I can extrapolate the findings from the VARHS data to the Vietnamese population (Tarp, 2017).

Due to the limitations of the questionnaire survey, I could not distinguish when the household had heard of and understood the change in the duration of agricultural land use between November 2013 and the data collection period in 2016. Thus, the treated households might have learned of and understand the increase in the usage duration of agricultural land at different times, which could constrain the impacts. However, I conducted several approaches to guarantee the consistency and reliability of our findings. I compared the treated group with control group 1 and control group 2. DID-FE with PSM was also applied to verify the sensitivity of the DID-FE estimates. Additionally, I carefully checked the parallel trend assumption. In general, the assumption was satisfied, and the results were consistent.

Chapter 3

Impacts of information and subsidy treatments on adoption of organic fertilizer

3.1 Introduction

Asia consumes more fertilizer than any other continent, accounting for more than 50% of global fertilizer consumption (FAO, 2015). Many Asian countries such as China, India, Bangladesh, the Philippines, and Vietnam have witnessed the overuse and inefficient utilization of chemical fertilizer (FAO, 2006). In Vietnam, farmers have excessively used chemical fertilizer (WB, 2004; Thuy et al., 2018; Hong et al., 2016) and have rarely employed organic fertilizer (T. H. Nguyen, 2017). In coffee farming, for example, Nitrogen (N), Diphosphorus pentoxide (P_2O_5), and Potassium oxide (K_2O) were recorded as having been applied at excessive rates of 50%, 210% and 30% of the recommended levels, respectively (T. H. Nguyen, 2017). T. H. Nguyen (2017) also showed that maize farmers in the Mekong Delta region did not use organic fertilizer in conjunction with chemical fertilizer. They employed 140% N, 165% P_2O_5, and 71% K_2O more than the advised levels. The excessive use of chemical fertilizer leads to environmental damage such as soil deterioration, water contamination, and biodiversity loss (Tilman et al., 2001; Mozumder and Berrens, 2007; Sierra et al., 2015). The environmental impacts of chemical fertilizer can be mitigated by applying a combination of organic fertilizer and chemical fertilizer (Duan et al., 2016; Ji et al., 2018). Therefore, how to discourage the overuse of chemical fertilizer and encourage the adoption of organic fertilizer is a crucial question.

Scholars have been increasingly interested in investigating the determinants of farmers' adoption of pro-environmental production, particularly the adoption of organic farming (Mzoughi, 2011; Hattam et al., 2012; Kondylis et al., 2016; Zeweld et al., 2017; Zeweld et al., 2018; Wang et al., 2018b). Some studies report evidence of the importance of economic incentives (e.g., subsidies) to a farmer's decision (Tur-Cardona et al., 2018; Wang et al., 2018a; Wang et al., 2018b). Moreover, a growing number of studies highlight the substantial effects of information access, particularly the role of informal information networks such as neighbors and fellow farmers (Genius et al., 2006; Läpple and Kelley, 2013; Wollni and Andersson, 2014). However, such findings are mostly based on observational data, stated preference data or behavioral intentions. To understand the precise causal impacts of economic incentive and information treatments on the adoption of pro-environmental production, experimental data are needed.

Previous experimental studies on the effects of information provision have focused primarily on the pro-environmental behaviors of consumers in developed countries[1]. The findings from such studies can hardly be applied to the context of the pro-environmental production behaviors of farmers in Vietnam or other developing countries for two reasons. First, compared with citizens of developed countries, rural farmers in developing countries typically have much lower education levels and environmental awareness, which might constrain the impacts of information-related interventions (Farrow et al., 2017). Second, the impoverished status of the farmers negatively affects their patience, which makes them favor production decisions offering quick economic returns (Tanaka et al., 2010). Because the impacts of sustainable practices on crops are not immediately visible, there is further difficulty in changing farmers' behaviors with simple information provision. Thus, it is necessary to examine the effectiveness of information treatments in influencing farmers' pro-environmental production behaviors.

In this study, I conducted a randomized controlled trial (RCT) to examine whether subsidy and information treatments improve the adoption of organic fertilizer in Vietnam. The former is given as 50% price subsidy, while the latter shares the experience of farmers who have adopted organic fertilizer on their farms. The findings of Duflo et al. (2011), Mobarak and Rosenzweig (2012), and Karlan et al. (2014) revealed that farmers were price sensitive, which affected the adoption of new agricultural technologies such as rainfall index insurance and chemical fertilizer. Thus, providing a 50% price subsidy might improve the up-take of organic fertilizer. The potential of my information treatment is supported by Theory of Planned Behavior (TPB), which describes the influence of "important referents" on the adoption of a certain behavior (Ajzen, 1991). The results

[1] see Allcott (2011), Costa and Kahn (2013), and Handgraaf et al. (2013) for energy saving behaviors; Ferraro et al. (2011) and Ferraro and Price (2013) for water conservation; and Schultz et al. (2008), Bohner and Schlüter (2014), and Reese et al. (2014) for hotel towel reuse.

from an experimental study conducted by BenYishay and Mobarak (2018) emphasized that peer farmers who had similar agricultural conditions to the target farmers were significant referents to transfer new technologies in rural communities. Therefore, sharing the experience of peer farmers applying organic fertilizer has the potential to affect other farmers' behavior in adopting organic fertilizer.

I find that both the subsidy and information treatments have significant impacts on the adoption of organic fertilizer. Moreover, the effect of the information treatment via farmers who share a group identity with target farmers is approximately one-third that of the 50% price subsidy. This finding demonstrates the potential of the former to partially substitute for the latter. I also find substantial impacts of the information treatment in the context of farmers who belong to certification groups (VietGAP groups[2]).

This study contributes to the current research on the impacts of subsidy and information treatments on pro-environmental behaviors in three ways. First, I implement an RCT, which can eliminate selection bias and produce precise causal estimates. In my experiment, a 50% price subsidy and an information treatment are randomly assigned to 1287 farmers in Vietnam. Second, this study targets pro-environmental production of farmers in Vietnam, while previous experimental studies have focused on the pro-environmental behaviors of consumers in developed countries. Third, my experimental design allows me to compare the effects of two different interventions, the subsidy and information provision, which provides crucial evidence for policy implementation. Subsidies are costly and impose a burden on increasingly limited public funds, especially for developing countries facing high budget deficits. Moreover, the design of the optimum subsidy to improve the use of organic fertilizer requires the estimation of a full price response function, which is difficult. Therefore, it is worth studying information interventions that can substitute for subsidies.

The remainder of this chapter is organized as follows: Section 2 provides background information on fertilizer use in Vietnam and the study site. Section 3 describes the sampling method, and Section 4 presents the experimental design. Results and discussions are provided in Section 5. Section 6 concludes by offering recommendations and policy implications.

[2]VietGAP is a domestic set of standards, which encourages farmers to produce clean and safe agricultural products.

3.2 Background on fertilizer use in Vietnam and study site

3.2.1 Fertilizer adoption: Tea farming as a case in point

Vietnam ranks 17th in the world in fertilizer consumption (FAO, 2015). The excessive use of chemical fertilizer causes agricultural pollution in Vietnam such as water contamination, soil acidification and soil fertility loss (T. H. Nguyen, 2017). There are two main reasons for the overuse of chemical fertilizer. The primary reason is farmers' limited understanding of input adoption. Most farmers in Vietnam hold the mistaken view that higher inputs result in higher crop yields. T. H. Nguyen (2017) showed that rice farmers in the Mekong Delta, the largest rice-producing region in Vietnam, employed between 20% and 30% more chemical fertilizer than the advised levels. The availability of cheap chemical fertilizers in local markets also led to their improper use. Vietnam used to promote the use of agro-chemicals to improve agricultural production. The price of chemical fertilizers declined by 50% due to the removal of import restrictions in 1991 (T. H. Nguyen, 2017). Moreover, fertilizer retailers have been extremely common at the district, commune and village levels[3]. Numerous advertising campaigns and sponsorships of public activities in rural areas by agro-chemical companies have persuaded farmers to try their products.

Tea production in Vietnam plays an important role in the country's economic development; however, tea cultivation has considerable environmental impacts due to the excessive use of chemical fertilizer. Vietnam is one of the world's largest tea producers, ranked 6th in tea production and 5th in the volume of tea exports (FAOSTAT, 2016). Approximately 400,000 households cultivate tea, and over 1.5 million jobs have been created by the Vietnamese tea industry (Wal, 2008). Tea is a perennial crop harvested for young shoots and leaves; thus, nutrient requirements (especially N) for tea production are particularly high. As a result, heavy synthetic N fertilization is applied in tea farming, which can lead to nitrate pollution of water and soil acidification (Oh et al., 2006; Yang et al., 2018). Hong et al. (2016) reported that chemical fertilizers were overused in tea farming in Vietnam. Previous studies have emphasized the benefits of organic fertilizer in tea cultivation (see Nghia (2008) for reducing chemical residues in the soil, water and tea products; see Ji et al. (2018) on improving soil bacterial diversity and tea yield).

Given this background information, tea production in Vietnam provides a compelling case study for motivating farmers to use organic fertilizer.

[3]The commune is the local administrative unit, which is between the district and village levels.

3.2.2 Study site

The site selected for this study was Thai Nguyen Province, Vietnam[4]. I chose this site for two reasons. First, Thai Nguyen is the largest green tea-cultivating region in Vietnam with a harvest area of 17,380 ha (GSO, 2016). The total fresh yield was 194,200 tons in 2016 (GSO, 2016). Besides, Thai Nguyen green tea is the most famous green tea brand in domestic markets. Findings from Hong et al. (2016) showed that tea farmers in Thai Nguyen overused chemical fertilizers. Second, Thai Nguyen has the largest number of groups of tea farmers certified in good agricultural practices (GAP), and 39 of the country's 67 domestic certified groups (VietGAP groups) were based in this province as of June 2018 (VietGAP, 2018)[5]. VietGAP is a domestic set of standards implemented in 2008 by the Ministry of Agriculture and Rural Development to encourage farmers to produce clean and safe agricultural products. VietGAP follows the GAP standards announced by ASEAN in 2006. Because both VietGAP and my treatments are intended to encourage farmers to adopt organic fertilizer, I aim to investigate whether my treatments perform well in the context of VietGAP members, who attend multiple trainings on agricultural sustainability.

Dai Tu District is the largest tea region in Thai Nguyen Province, accounting for 30% of the province's tea area[6]. In 2017, this district implemented a program to subsidize the certification fees of new VietGAP groups; as a result, 16 new VietGAP groups in 10 communes were established in December 2017. In total, Dai Tu has 20 VietGAP groups, the largest number of VietGAP groups of any region in Thai Nguyen. Therefore, I selected Dai Tu district to conduct my field experiment.

In tea cultivation, although organic fertilizer is recommended for both basal fertilizing and top-dressing fertilizing[7], few farmers in the study area have adopted it. Before planting, organic fertilizer should be mixed into the soil (basal fertilizing). After planting, organic fertilizer should be additionally applied in the second year. When the tea is more than three years old, farmers should apply organic fertilizer every year, especially after cutting the tea (usually from January to March). However, only 49.27% of farmers in my sample reported that they had experience using organic fertilizer. Of these, only 26.33% reported that they had applied organic fertilizer at least once in the previous season (from January to April, 2018) even though it would have been the ideal time to apply

[4]Thai Nguyen is located in northern Vietnam, the center of which is 80km from Hanoi, the Vietnamese capital. The total provincial area is 3533.1 km2, and the total provincial population was 1.17 million people in 2014. Thai Nguyen Province consists of one city and 8 districts. See http://english.thainguyen.gov.vn/-/natural-conditions.

[5]See Tran and Goto (2018) for further details on VietGAP programs in Vietnam and Thai Nguyen.

[6]See http://daitu.thainguyen.gov.vn/-/le-hoi-tra-ai-tu-nang-cao-gia-tri-cho-san-pham-tra-phat-trien

[7]see http://tuaf.edu.vn/khoanonghoc/bai-viet/quy-trinh-ky-thuat-trong-tham-canh-che-an-toan-1837.html

organic fertilizer. When I asked those farmers who had no experience in using organic fertilizer why the had not used it, 90% said that it was because of a lack of information. Paul et al. (2017) also noted that a lack of information, the cost and laboriousness were major reasons for the low usage of compost among Caribbean farmers. Thus, providing information about organic fertilizer has potential to improve its adoption.

3.3 Design of the randomized controlled experiment

3.3.1 Sampling method

A two-step sampling procedure was employed: village sampling and household sampling.

In the first step, I purposively selected communes and sampled the villages in these communes. I had intended to choose the 10 communes that had established new VietGAP groups in December 2017[8]. However, I only obtained permission to conduct my research in 9 communes: Binh Thuan, Tien Hoi, Khoi Ky, Phu Xuyen, Van Yen, My Yen, Phu Cuong, Hoang Nong and La Bang. In each commune, I chose all villages with active VietGAP groups and their neighboring villages without active VietGAP groups[9]. In total, 30 villages were selected, including 4 villages used in a pilot survey and 26 villages used in my main survey.

After the sample villages were chosen, I used the power calculation to determine my sample size. According to previous experimental studies on chemical fertilizer usage (e.g., Duflo et al., 2011; Carter et al., 2014), I selected a standard deviation of 0.49 and an expected average treatment effect (ATE) of 0.1. I selected a power of 80% with a significance level of 5%. I also selected treatment and control groups of equal sample size. I considered two pairwise comparisons: subsidy treatment versus control and information treatment versus control. Based on these settings, the power calculation suggested that each group should have 378 tea-cultivating households; thus, the total sample size of my experiment should be at least 1134 tea-cultivating households.

In the second step, tea-cultivating households were randomly sampled for the experiment and face-to-face interviews. Member lists of VietGAP groups and tea-cultivating household lists in the selected villages were provided by communal officers and village leaders. The tea-cultivating household lists included households that had a tea farm and produced tea in 2017. I sampled 45 households in every village during the main survey

[8]This is because one of the objectives of my overall project is to evaluate the impact of VietGAP certification on tea farmers. Considering new VietGAP groups allows me to collect information before and after the implementation of VietGAP.

[9]In Hoang Nong Commune, I conducted my research only in villages with certified tea groups following a request from the local government.

and 36 households in every village during the pilot survey[10]. In villages without an active VietGAP group, 45 households were randomly chosen from the list of tea-cultivating households. In villages with an active VietGAP group, I selected all members from the member list of the VietGAP group due to the relatively small number of VietGAP members. The remaining households were randomly selected from the list of tea-cultivating households in the village after excluding households on the member list.

To avoid leaking treatment information, the experiment and survey in each village were completed within a day. I divided investigators into two teams, with each team including six investigators and one manager. Two teams conducted the experiment and household survey in two neighboring villages simultaneously on a single day (each team visited one village). Investigators and managers received the list of selected households and list of alternative households[11]. During the visit, if a selected household was not at home for the entire day, an alternative household was chosen, moving from the top to the bottom of the list. In some villages, some selected households returned home after I visited the alternative households; thus, I re-visited these selected households.

3.3.2 Treatment design

3.3.2.1 Mechanism of subsidy treatment effects

In this study, the subsidy treatment was a 50% price subsidy. A reduction in the price of organic fertilizer can induce an increase in quantity demanded because price is a component of the demand function of a normal good. The results from experimental studies conducted by Karlan et al. (2014) and Mobarak and Rosenzweig (2012) showed that price was a consistent driver of demand for rainfall index insurance. They found that 11%-15% of farmers purchased at the market price, 38%-42% of farmers purchased at a 50% discount, and 60%-67% of farmers purchased at a 75% discount. Using observational data from China, Wang et al. (2018a) showed that the probability of applying organic fertilizer would increase by 18% if a farmer received subsidized organic fertilizer (136.68 USD/acre). Therefore, the 50% price subsidy could be expected to improve farmers' use of organic fertilizer.

[10]Viet Yen Village in My Yen Commune had only 42 households. Of these, 36 households were tea-cultivating households. Therefore, I could only select 36 households

[11]The lists of alternative households included non-selected tea-cultivating households in the village and were sorted randomly.

3.3.2.2 Mechanism of information treatment effects

Exposure to the experiences of farmers who had adopted organic fertilizer is selected as my information treatment. In this section, I discuss how and why the information treatment affects the pro-environmental behavior of farmers through the TPB developed by Ajzen (1991). The TPB has been extensively applied to explain many pro-environmental behaviors such as organic food consumption (Aertsens et al., 2009), the uptake of organic farming (Läpple and Kelley, 2013), waste management (Rulli et al., 2019), and the use of bioenergy (Halder et al., 2013).

According to the TPB, a person's intention to engage in a behavior is the most crucial predictor of performing (or not performing) this behavior. Three factors are used to determine intention: the attitude toward the behavior, subjective norms, and perceived behavioral control Ajzen (1991). The attitude toward the behavior refers to the person's positive or negative evaluation of performing a certain behavior. Subjective norms include influences from "important referents", for example family members, close friends, and colleagues, on performing the behavior. Perceived behavioral control describes someone's capability to facilitate the performance of a certain behavior. When studying the intention to take up organic farming among Irish farmers, Läpple and Kelley (2013) found that subjective norms had the strongest impacts when compared with the attitude toward the behavior and perceived behavioral control. This indicates that a farmer's decision is not solely made by herself/himself; it is significantly influenced by the opinions of others, for instance, family, fellow farmers or information sources (Läpple and Kelley, 2013).

Several previous studies have demonstrated the potential of farmers as an important referents to transfer new agricultural technologies into rural communities. To encourage Malawian farmers to employ pit planting, Beaman et al. (2016) suggested that several farmers with experience with this technology need to be present in rural networks. Nakano et al. (2018) also found the spillover of rice cultivating technology from trained farmers to non-trained farmers in Tanzania. Moreover, BenYishay and Mobarak (2018) found that Malawian farmers were best persuaded to apply pit planting by "peer farmers" facing similar agricultural conditions and constraints to themselves when compared with "lead farmers" or extension workers.

In my information treatment, I selected three tea farmers with a variety of characteristics such as generation (both older and younger generations were included), gender (2 male and 1 female farmers), place of residence (2 farmers from Thai Nguyen city, 1 farmer from Dai Tu district), tea farm size (7,000m^2, 5,000m^2, and 4,000m^2), and usage experience (7 years, 1.5 years, and 6 months) to guarantee that they share a group identity with target

farmers. The selected farmers shared their experience of adopting organic fertilizer in a 3-minute video. They shared their experience on how using organic fertilizer strengthened their tea's health and improved soil structure and how to apply organic fertilizer based on their adopted practice. Because the purpose of the video was not to advertise any fertilizer brand, the tea farmers did not mention any brand names.

3.3.2.3 Design of treatment groups and control group

In this section, I discuss the selection of organic fertilizer used for my experiment and the design of my groups: the control group, information treatment group and subsidy treatment group[12].

I collaborated with Thai Nguyen University of Agriculture and Forestry (TUAF) to use their scientific product, NTT organic fertilizer, in my experiment to avoid the problem of counterfeit fertilizer in Vietnam[13]. NTT organic fertilizer was approved by the Department of Crop Production, Ministry of Agriculture and Rural Development in 2011 and has since been available on the market. Raw materials include peat and pig, chicken, buffalo, and cow manure. Microorganisms are used to break down organic substances[14]. According to the producer's recommendations, this organic fertilizer can be used after each harvest; however, ideally, the fertilizer should be applied in both the spring (February-March) and the rainy season (June-August). NTT organic fertilizer can improve soil structure and benefit the crop's root development, which increases its ability to absorb nutrients and resist difficult conditions such as drought and flood.

My experiment included three groups: the control group, subsidy treatment group and information treatment group. The design of these groups is given in table 3.1.

TABLE 3.1: Design of treatments

Groups	**General information (2-minute video)**	**Free shipping**	**Subsidy treatment (50% price subsidy)**	**Information treatment (3-minute video)**
Control group	x	x		
Subsidy treatment group	x	x	x	
Information treatment group	x	x		x

Basic information on the dangers of excessive chemical fertilizer use and the role of organic fertilizer was shown to all participants in the sample via a 2-minute video (general video). This video was excerpted from the video "Why Soil Matters" published by The

[12]This experiment was registered with the AEA RCT Registry before its interventions began. The RCT ID is AEARCTR-0003084

[13]In 2013, there were 1483 reported violations pertaining to the distribution of low-quality fertilizers and pesticides in Vietnam's southern provinces (Nongnghiep.vn accessed dated July 30th 2014. https://nongnghiep.vn/ngan-chan-phan-bon-thuoc-bvtv-gia-kem-chat-luong-post128850.html).

[14]NTT organic fertilizer has organic content (humus) of 35% and humid acid content of 6-8%. The ratio of N:P:K is 2.5:1:1, and its pH is 6.

Greens-European Free Alliance[15]. The entire sample received free shipping to ensure that all farmers faced identical prices. A 50% price subsidy was given only to farmers in the subsidy treatment group, while a 3-minute video including the experiences of farmers who had applied organic fertilizer was shown only to farmers in the information treatment group. Thus, information treatment group watched 5 minutes of video, including the general video (2 minutes) and information treatment video (3 minutes).

3.3.3 Implementation of the RCT

My experiment was implemented as follows. Assistants from a village (often the village's leaders) took investigators to the selected tea households. After introducing a field investigator to a household's representative, she/he then took other investigators to other selected households. To avoid any noise in the household's decision, the village assistants were not allowed to remain at the household during the visit. Thereafter, the investigator introduced purpose of the visit, and the household was asked to decide whether they would participate in our experiment[16].

My experiment had 2 sessions: an RCT and a questionnaire survey[17]

In the first session (the RCT), the household chose a lottery from a box consisting of 3 lotteries, which were associated with the 3 following groups[18].

Control group: The control group watched a general video (2-minute video) on a tablet and was offered an opportunity to buy NTT organic fertilizer at the regular price but with free shipping[19]. The general video is presented in the supplemental materials (see https://youtu.be/6ppWwrV4d8k).

Subsidy treatment group: The subsidy treatment group also watched the general video on a tablet and was offered the opportunity to buy NTT organic fertilizer at half price (the 50% subsidy) with free shipping.

Information treatment group: The information treatment group watched a 5-minute video on a tablet and was offered the opportunity to buy NTT organic fertilizer

[15]I obtained permission to use the original video from The Greens-European Free Alliance.

[16]Oral informed consent was obtained. Then, the household received an envelope containing 30,000VND (approximately 1.3USD) from the investigator as compensation for participating in my experiment.

[17]This questionnaire survey focused primarily on background information about the households. In addition, 750 selected households from full sample were asked about their stated preferences on participating in a hypothetical VietGAP program.

[18]The lotteries were renewed every 2 days to maintain the quality of randomization

[19]Different agencies provided different prices. Therefore, the regular price in this study was the price the manufacturer offered to farmers if they bought organic fertilizer at the factory in Thai Nguyen City and transported the fertilizer home themselves.

at the regular price but with free shipping. The 5-minute video is given in the supplemental materials (see https://youtu.be/iBjtaXyy5ps).

To avoid the disappointment effect, the contents of the non-selected lotteries were not mentioned to households. Following the result of the lottery, investigators showed the video (2-min video or 5-min video) and then explained the support provided (free shipping or free shipping plus a 50% subsidy) to the household. The package of NTT organic fertilizer was also displayed (see the supplemental materials). The household then had to decide whether to purchase the organic fertilizer at this time[20]. A simple contract was provided to households that wanted to order organic fertilizer (see the supplemental materials). It included the household's information, organic fertilizer information, the quantity ordered and the delivery date. The ordered quantity was specified in terms of bags. One bag weighed 25kg and cost 65,000 VND (approximately 2.8 USD). The maximum purchase quantity through my experiment was 200kg (8 bags) due to budget constraints. Two copies of the contract were signed by the household's representative. The household and the investigator each received one copy. The contract was nontransferable. To guarantee that short-term liquidity constraints did not prevent households from making a decision on the spot, the households would make full payment on the delivery date instead of during the visit.

In the second session (questionnaire survey), the households were asked for background information such as the household members, landholding, tea farm information, experience using organic fertilizer, VietGAP certification, credit and assets. The household information was collected using a smart phone-based questionnaire in Vietnamese[21].

On the delivery date, organic fertilizer was transported to the village center. In each village, two investigators and one village assistant were responsible for distributing the organic fertilizer. I delivered the organic fertilizer on Wednesdays for villages visited on Mondays and Tuesdays[22]. I delivered the organic fertilizer on Sundays for villages visited on Thursdays, Fridays and Saturdays. After showing the contract and making full payment, households claimed their organic fertilizer and signed a list acknowledging receipt.

[20]Investigators explained to the farmers that the study was on the transition to sustainable agriculture. The decision to purchase was freely made, and households' decisions would not affect any future benefits such as agricultural programs offered by the local government and promotions offered by the fertilizer company.

[21]I used ODK Collection, an open Android application for smart phones, to manage and accelerate the interview process and data entry. Not only household information but also images of the respondents and GPS data on the households were collected through this application.

[22]During pilot survey, I conducted the experiment on July 2 (Monday) and July 3 (Tuesday). I distributed organic fertilizer on July 4 (Wednesday) and July 5 (Thursday). During the last week of the main survey, I conducted the experiment on July 23 (Monday), July 24 (Tuesday), and July 25 (Wednesday). Then, I distributed organic fertilizer on July 26 (Thursday).

3.4 Data and estimation approach

3.4.1 Data description

I collected primary data in July 2018. A pilot survey was conducted from July 2 to July 5. The main survey was performed from July 9 to July 26. In total, 1295 tea-cultivating households participated in my experiment, including 136 households in the pilot survey (a response rate of 94.4%) and 1159 households in the main survey (a response rate of 99.3%). However, for 8 households, the owners transferred their tea farms to their children in 2018; thus, I excluded them. The sample size for data analysis was 1287 tea-cultivating households consisting of 412 households in the control group (32.01%), 448 households in the subsidy treatment group (34.81%), and 427 households in the information treatment group (33.18%). The sample sizes of these groups were 9%, 18% and 13% larger, respectively, than those suggested by the power calculation. In my RCT, I followed a set of principles to attain these high response rates. The investigator was introduced to household's representative by a village leader, which induced high credibility for the selected households. Moreover, if a selected household was not at home, the village leader would made a phone call to confirm a time when the household would be available in that day, and the investigator would re-visit this household. As mentioned in the previous session, if a household was not available for whole day, an alternative household was chosen, moving from the top to the bottom of the list.

I examined the impacts of subsidy and information treatments on two outcome variables reported on the delivery date[23]. The first outcome indicated whether a household purchased organic fertilizer through the experiment (hereafter, "purchase dummy"). The second outcome indicated the quantity in kilogram of organic fertilizer purchased by the household (hereafter, "purchase quantity").

During my visit, I collected two types of information: respondent characteristics (age, gender, education, relationship to the household head) and household characteristics (demographic information, experience using organic fertilizer, and some wealth information). In Vietnam, it is common for several generations to live under one roof, and the oldest person is often reported as household's head in the family record book[24]. Thus, the primary decision maker in a family and the household head could be different individuals. I collected information on both of them during my survey; 59% of my respondents

[23]There were 23 households who changed their decisions (They ordered but they did not come to take the organic fertilizers). There were also insignificant differences between these 23 households and the remaining households regarding the baseline characteristics. To confirm the consistency of the results, I reported the estimates from the initial decision made at the end of the RCT session in the appendix (table B.2).

[24]The family record book includes information on each member of a household such as name, birth date, gender, and relationship to the household head.

were household heads, while 71% of our respondents were the primary decision maker in the family.

Summary statistics on both respondent and household characteristics are presented in tables 3.2 and 3.3. Table 3.3 further reports pre-treatment differences between the control group and the treatment groups. In general, the respondent and household characteristics were balanced, except for the gender of the respondent (the difference between the control and subsidy treatment groups was significant at the 10% level). Because the treatments were randomly assigned, any observed difference was attributable to sampling rather than a systematic difference.

Table 3.4 reports descriptive statistics for the outcome variables. The uptake rate of the full sample, control group, subsidy treatment group and information treatment group is 63%, 50%, 79% and 59%, respectively. While the average purchase quantity in those groups is 102.1kg, 74.0kg, 142.2kg and 87.1kg, respectively. Figure 3.1 provides bar charts of the purchase quantity by each group. The white columns, grey columns and black columns represent the control group, subsidy treatment group and information treatment group, respectively. Compared to the control group, the subsidy treatment group was more likely to purchase the maximum quantity (200kg). The number of non-buyers in the subsidy treatment group was much lower than in the control group. Compared to the control group, the information treatment group had more households buying 200kg and 100kg of fertilizer and fewer non-buyers.

TABLE 3.2: Descriptive statistics of baseline characteristics

Variables	Full sample (n=1287)		Control group (n=412)		Subsidy treatment group (n=448)		Information treatment group (n=427)	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Household demographics								
Market distance (km)	1.90	1.18	1.92	1.17	1.83	1.07	1.95	1.29
Family size	3.86	1.34	3.87	1.33	3.88	1.30	3.83	1.40
VietGAP dummy	0.26	0.44	0.25	0.43	0.28	0.45	0.26	0.44
Credit dummy	0.34	0.47	0.33	0.47	0.32	0.47	0.36	0.48
Experience with bio-compost								
NTT organic fertilizer knowledge dummy	0.05	0.22	0.05	0.23	0.06	0.23	0.04	0.19
Organic fertilizer usage dummy	0.49	0.50	0.51	0.50	0.47	0.50	0.50	0.50
Dummy of organic fertilizer usage Jan-Apr 2018	0.26	0.44	0.25	0.43	0.27	0.44	0.28	0.45
Quantity of organic fertilizer usage Jan-Apr 2018 (kg)	159.97	420.26	147.44	392.41	174.83	488.58	156.46	365.69
Land area (ha)								
Tea farm	0.32	0.23	0.32	0.22	0.32	0.19	0.33	0.28
Forest land	0.22	0.48	0.23	0.54	0.22	0.46	0.21	0.45
Annual crop land	0.09	0.10	0.09	0.10	0.09	0.10	0.09	0.11
Perennial crop land	0.35	0.26	0.34	0.23	0.35	0.23	0.35	0.30
Number of assets 6/2018								
Motorbike	1.77	0.85	1.75	0.81	1.79	0.86	1.76	0.89
TV	1.04	0.30	1.04	0.28	1.04	0.30	1.05	0.33
Fridge	1.01	0.28	1.00	0.22	1.01	0.33	1.01	0.29
PC	0.11	0.35	0.10	0.34	0.10	0.32	0.14	0.38
Air conditioner	0.06	0.26	0.05	0.26	0.07	0.27	0.06	0.26
Interviewee characteristics								
Age	47.20	10.98	46.71	11.04	47.48	11.08	47.31	10.63
Education (years)	7.42	2.30	7.45	2.24	7.53	2.36	7.27	2.29
Female dummy	0.46	0.50	0.49	0.50	0.43	0.50	0.47	0.50
Household head dummy	0.59	0.49	0.57	0.50	0.59	0.49	0.60	0.49
Primary decision maker dummy	0.71	0.45	0.70	0.46	0.71	0.46	0.72	0.45

TABLE 3.3: Baseline comparisons among groups

Variables	Subsidy treatment vs. Control			Information treatment vs. Control			Information treatment vs. Subsidy treatment		
	Diff	**S.E**	**t-value**	**Diff**	**S.E**	**t-value**	**Diff**	**S.E**	**t-value**
Household demographics									
Market distance(km)	-0.092	0.076	-1.206	0.023	0.085	0.274	0.115	0.080	1.445
Family size	0.008	0.090	0.093	-0.035	0.094	-0.373	-0.044	0.091	-0.478
VietGAP dummy	0.031	0.030	1.035	0.008	0.030	0.253	-0.024	0.030	-0.787
Credit dummy	-0.011	0.032	-0.352	0.023	0.033	0.710	0.035	0.032	1.081
Experience with bio-compost									
NTT organic fertilizer knowledge dummy	0.002	0.016	0.155	-0.016	0.014	-1.109	-0.018	0.014	-1.282
Organic fertilizer usage dummy	-0.034	0.034	-0.998	-0.011	0.035	-0.312	0.023	0.034	0.688
Dummy for organic fertilizer usage Jan-Apr 2018	0.018	0.030	0.596	0.026	0.030	0.866	0.008	0.030	0.282
Quantity of organic fertilizer usage Jan-Apr 2018 (kg)	27.393	30.383	0.902	9.024	26.176	0.345	-18.369	29.284	-0.627
Land area (ha)									
Tea farm	0.002	0.014	0.130	0.007	0.017	0.394	0.005	0.016	0.314
Forest land	-0.009	0.034	-0.276	-0.022	0.034	-0.653	-0.013	0.031	-0.420
Annual crop land	0.003	0.007	0.406	-0.001	0.007	-0.141	-0.004	0.007	-0.538
Perennial crop land	0.012	0.016	0.750	0.010	0.019	0.552	-0.002	0.018	-0.089
Number of assets 6/2018									
Motorbike	0.045	0.057	0.782	0.006	0.059	0.110	-0.038	0.059	-0.646
TV	-0.001	0.020	-0.054	0.006	0.021	0.266	0.007	0.021	0.313
Fridge	0.002	0.019	0.095	0.007	0.018	0.388	0.005	0.021	0.239
PC	-0.002	0.022	-0.076	0.031	0.025	1.265	0.033	0.024	1.398
Air conditioner	0.016	0.018	0.887	0.005	0.018	0.292	-0.011	0.018	-0.604
Characteristics of interviewee									
Age	0.764	0.755	1.012	0.600	0.748	0.802	-0.164	0.735	-0.223
Education (years)	0.080	0.157	0.510	-0.175	0.156	-1.118	-0.255	0.157	-1.624
Female dummy	-0.059*	0.034	-1.750	-0.024	0.035	-0.702	0.035	0.034	1.047
Household head dummy	0.021	0.034	0.622	0.029	0.034	0.854	0.008	0.033	0.245
Primary decision maker dummy	0.004	0.031	0.119	0.015	0.031	0.482	0.011	0.031	0.372

* Significant at 10%.
** Significant at the 5% level.
*** Significant at the 1% level.

TABLE 3.4: Descriptive statistics of outcome variables

Outcomes	Full sample (n=1287)		Control group (n=412)		Subsidy treatment group (n=448)		Information treatment group (n=427)	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Purchase dummy	0.63	0.48	0.50	0.50	0.79	0.41	0.59	0.49
Purchase quantity (kg)	102.08	89.03	74.03	83.70	142.19	83.08	87.06	85.14

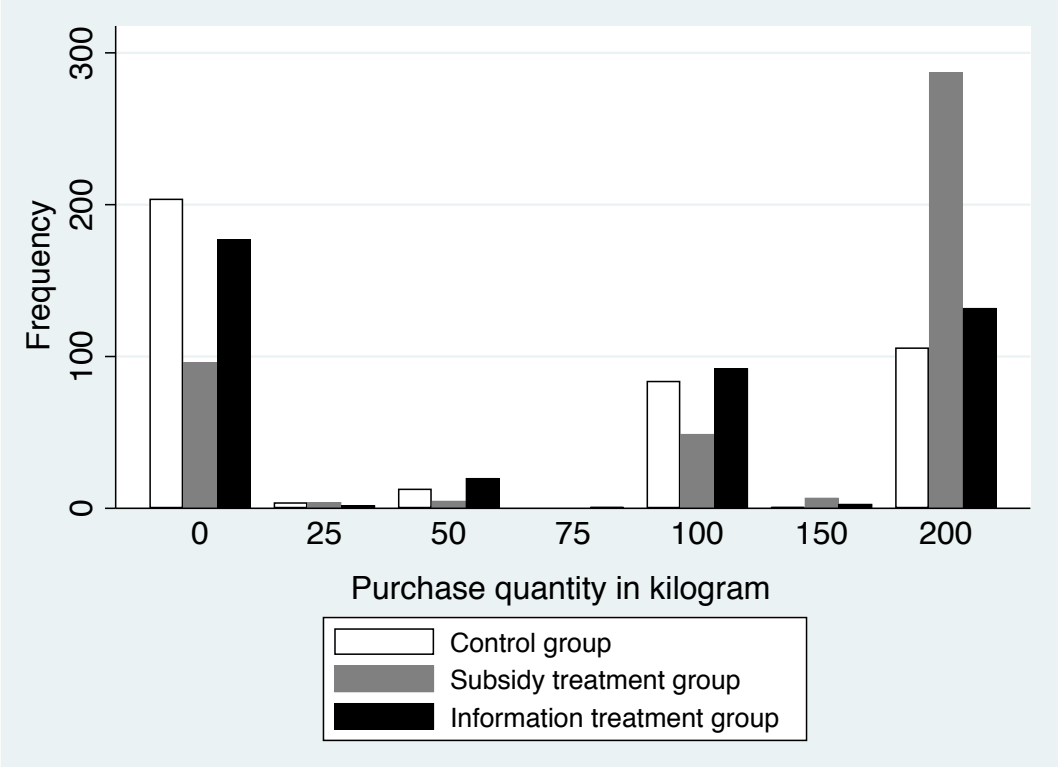

FIGURE 3.1: Purchase quantity (kg) by each group

3.4.2 Estimation approach

My main objective was to evaluate the causal effect of the information treatment and subsidy treatment on farmer behavior. I did so by estimating the average treatment effects (ATEs) of these two treatments relative to the control group.

Because the farmers were assigned randomly to the treatment and control groups, a simple comparison of the means of the outcomes yields unbiased estimates of the ATEs.

I followed Neyman et al. (1935) and Athey and G. Imbens (2017) in estimating ATEs as follows[25]:

[25]In the implementation, I used OLS regression to estimate τ. I also provide estimates obtained after controlling for a number of characteristics at baseline in table 3.6.

$$\hat{\tau} = \bar{Y}_t^{\text{obs}} - \bar{Y}_c^{\text{obs}} = \frac{1}{N_t} \sum_{i:W_i=1} Y_i^{\text{obs}} - \frac{1}{N_c} \sum_{i:W_i=0} Y_i^{\text{obs}} \tag{3.1}$$

where N_t and N_c are the sample sizes of the treatment group (subsidy treatment group or information treatment group) and control group, respectively. (Y_i^{obs}) is the outcome (purchase dummy or purchase quantity) of tea-cultivating household i. W_i indicates the treatment status of household i.

$$W_i = \begin{cases} 0, & \text{if household } i \text{ belongs to the control group} \\ 1, & \text{otherwise} \end{cases}$$

3.5 Results and discussion

3.5.1 Average treatment effects

The ATEs are reported in table 3.5. Table 3.6 reports the estimates after controlling for a number of characteristics at baseline. The effects on the purchase dummy and purchase quantity are shown in the first and second columns, respectively. In general, the interventions had substantial impacts on both the purchase dummy and purchase quantity for farmers who received them. The effects were consistent and statistically significant regardless of controlling for baseline characteristics.

Subsidy treatment

The 50% price subsidy had considerable and consistent impacts on both outcomes. The subsidy led to a 28.1% increase in the organic fertilizer purchase dummy and a 68.2kg increase in the quantity of organic fertilizer purchased. Both outcomes were significant at the 1% level. Given a take-up rate of 52.0% and take-up quantity of 78.3kg among control farmers, these effects represented a 54.0% and 87.1% increase relative to the control group, respectively. I ran the same estimates while controlling for several baseline characteristics including household characteristics (distance to nearest market, number of family members, dummy for certification (VietGAP), credit dummy, NTT organic fertilizer knowledge dummy, organic fertilizer usage dummy, tea farm size, forest land area, annual crop land area, and number of assets such as motorbike, TV, fridge, PC, and air conditioner) and respondent characteristics (age, education, and female dummy). Table 3.6 shows that the estimates were consistent.

My findings echo those of other studies that showed significant impacts of price subsidies on technology adoption. Karlan et al. (2014) indicated that the take-up of rainfall index insurance in Ghana rose by 31% due to a 50% price subsidy. In a similar setting to that of Karlan et al. (2014), (Mobarak and Rosenzweig, 2012) showed that a 50% price subsidy induced an increase in uptake rate by 23%. The substantial impact of 50% price subsidy can be explained by the fact that farmers are price sensitive to the adoption of agricultural technologies. Price is a component of the demand function; thus, a reduction in the price of a normal good can induce an increase in the quantity demanded.

Regarding the usage of organic fertilizer, Wang et al. (2018a) found that a subsidy (136.68 USD/acre) positively influenced farmers' decision to adopt organic fertilizer instead of chemical fertilizer using observational data from China. In term of farmers' stated preference on accepting bio-based fertilizers, Tur-Cardona et al. (2018) found that farmers preferred bio-based fertilizers if their nitrogen content was similar to that of mineral fertilizers but had a price approximately 65% of that of chemical fertilizer. In this study, I extended the previous literature on the adoption of organic fertilizer by using experimental data, which can eliminate the endogeneity problem, thus producing rigorous estimates.

Information treatment

I found substantial and consistent effects for farmers receiving the information treatment. The information treatment induced an 8.1% increase in the purchase dummy and a 13.0kg increase in purchase quantity, both of which are significant at the 5% level. The control farmers showed a take-up rate of 52% and a take-up quantity of 78.3kg; thus, these effects represent a 15.6% and 16.6% increase relative to the control group, respectively. The results remained consistent after controlling for baseline characteristics; the purchase dummy increased by 7.9%, and the quantity purchased increased by 12.7kg.

TABLE 3.5: ATE on purchase dummy and purchase quantity

	Purchase dummy	**Purchase quantity (kg)**
Subsidy treatment	0.281***	68.158***
	(0.032)	(5.731)
Information treatment	0.081**	13.032**
	(0.032)	(5.799)
Observations	1287	1287

Note: Standard errors are reported in parentheses.
* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

TABLE 3.6: ATE on purchase dummy and purchase quantity after controlling for baseline characteristics

	Purchase dummy	**Purchase quantity (kg)**
Subsidy treatment	0.281***	68.674***
	(0.032)	(5.675)
Information treatment	0.079**	12.706**
	(0.032)	(5.736)
Characteristics of household	Yes	Yes
Characteristics of respondent	Yes	Yes
Observations	1287	1287

Note: Standard errors are reported in parentheses.

Household characteristics include market distance, family size, VietGAP dummy, credit dummy, NTT organic fertilizer knowledge dummy, organic fertilizer usage dummy, tea farm, forest land, annual crop land, motorbike, TV, fridge, PC, and air conditioner.

Interviewee characteristics include age, education, and female dummy.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

The substantial positive impacts of the information treatment on farmers' adoption of organic fertilizer can be interpreted as follows. Farmers were convinced by the testimony of other farmers on their experience in my information treatment. my findings can be supported by the TBP, which emphasizes the influence of "important referents", for example family members, close friends, and colleagues, on the adoption of a certain behavior (Ajzen, 1991). In my experiment, farmers who share a group identity with the target farmer were important referents, and their experience had a strong impact on other farmers' behavior. The following experimental studies also reported that peer farmers were significant referents in the diffusion of new agricultural technologies. Examining the adoption of pit planting in Malawi, BenYishay and Mobarak (2018) found that farmers were better persuaded by peer farmers facing agricultural conditions and constraints similar to their own than they were by other communicators. Moreover, Beaman et al. (2016) suggested the need for several "seed" farmers who have experience with a new technology when diffusing this technology within rural networks in Malawi. Another possible reason for my results is that farmers might have expected similar returns to the three farmers in the treatment information when they decided to purchase organic fertilizer in the experiment. In a review paper on pro-environmental behavior, Farrow et al. (2017) concluded that social information can affect an individual's behavior because people take the behavior of others as evidence of what is most effective.

Information treatments are increasingly applied to induce pro-environmental behaviors (see Delmas et al. (2013) and Farrow et al. (2017) for a review; see Osbaldiston and Schott (2012) for a meta-analysis). However, the main targets of previous experimental studies were pro-environmental behaviors of consumers in developed countries. This study contributes to the literature on how information treatments can affect pro-environmental production behavior of farmers in developing countries. I experimentally investigated the impacts of an information treatment on farmer's adoption of organic fertilizer in Vietnam.

My findings suggest that both the subsidy treatment and information treatment had substantial, significant and consistent impacts on the behavior of tea farmers. Although the 50% subsidy had remarkable impacts, it was an extremely costly intervention. Showing videos of the experience of farmers who had adopted organic fertilizer, an economical information treatment, had an effect on purchase dummy equal to approximately one-third of that of the 50% price subsidy. Policy makers seeking to influence farmers' behavior can regard such an information treatment via farmers who had similar agricultural conditions and constraints as a substitute for subsidies.

3.5.2 Subgroup treatment effects

Policy makers are increasingly interested in subgroup treatment effects to determine the groups for which treatment performs best. In this study, I designed two treatments, subsidy and information, to encourage farmers to adopt organic fertilizer and promote sustainable agriculture, which is also the purpose of VietGAP. Members of VietGAP groups had to participate in several training programs on the adoption of pesticides and fertilizers to produce clean and safe agricultural products. Thus, I examine the conditional average treatment effect (CATE) with respect to VietGAP membership, in other words, whether my treatments worked well in the context of VietGAP membership[26]. The results are presented in table 3.7.

I found substantial and statistically significant impacts of the subsidy and information treatments on both the purchase dummy and purchase quantity, regardless of whether I controlled for baseline characteristics. The CATE point estimates for VietGAP members were much higher than the corresponding ATE values, especially for the information treatment (See figure B.2 and figure B.3 in the appendix). For the purchase dummy, the effect of the information treatment was 2.5 times higher for VietGAP members than for the full sample. The CATE was 21.7%, while the ATE was 8.1%. Moreover, the CATE of my information treatment on the purchase dummy was equal to nearly two-thirds that of the 50% price subsidy. For purchase quantity, the CATE of the information treatment for VietGAP members was approximately three times higher than the corresponding ATE. The CATE was 40.6kg, whereas the ATE was 13.0kg.

This finding is consistent with Ibanez and Blackman (2016), who showed that certification increased the use of organic fertilizer among coffee farmers in Colombia. Due to the non-randomness of VietGAP membership, the substantial CATE could be interpreted as VietGAP membership or other covariates driving self-selection into VietGAP groups. My data showed that VietGAP members outperformed non-members in terms of education of household head, distance to the nearest market, experience with using organic fertilizer, tea farm size, and household assets (see appendix table B.3). These factors might affect the effectiveness of my information in the context of VietGAP membership. For example, due to their higher education level, VietGAP households might be more responsive to updated information. Further research is necessary to precisely determine the reasons for the remarkable CATE of the information treatment for VietGAP members.

[26]Because VietGAP was an endogenous variable, I could not directly compare the impacts of my treatments between VietGAP members and non-members.

TABLE 3.7: CATE for VietGAP membership

	Purchase dummy	**Purchase quantity (kg)**	**Purchase dummy**	**Purchase quantity (kg)**
Subsidy treatment	0.347***	81.842***	0.341***	82.244***
	(0.061)	(11.173)	(0.060)	(10.922)
Information treatment	0.217***	40.587***	0.192***	36.133***
	(0.063)	(11.533)	(0.063)	(11.459)
Characteristics of household	No	No	Yes	Yes
Characteristics of respondent	No	No	Yes	Yes
Observations	339	339	339	339

Note: Standard errors are reported in parentheses.

Household characteristics include market distance, family size, VietGAP dummy, credit dummy, NTT organic fertilizer knowledge dummy, organic fertilizer usage dummy, tea farm, forest land, annual crop land, motorbike, TV, fridge, PC, and air conditioner.

Interviewee characteristics include age, education, and female dummy.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

I also examined the interaction effects between the treatments and other variables such as gender, age, education level of the respondents, family size, household assets and tea farm size. However, the results were statistically insignificant, except for number of motorbikes and the quantity of organic fertilizer usage from January to April 2018[27].

3.6 Conclusions and policy implications

Encouraging pro-environmental production behaviors has played a significant role in enhancing agricultural sustainability. Using observational and stated preference data, a considerable literature has emphasized the significant roles of subsidies and information treatments in determining farmers' behaviors. The aim of my study was to contribute to this growing area of research by exploring the effects of a 50% price subsidy and an information treatment on farmers' adoption of organic fertilizer using original experimental data. The information treatment refers to the sharing of other farmer's experience using organic fertilizer; these farmers have similar agricultural conditions and constraints as the target farmers.

I conducted a randomized controlled trial on 1287 tea-cultivating farmers in Thai Nguyen province in Vietnam. I found substantial and consistent impacts on both my purchase dummy and purchase quantity when farmers received my interventions. Moreover, the effect of the information treatment, a non-pecuniary intervention, on the purchase dummy was equal to approximately one-third of that of the 50% subsidy, a costly pecuniary intervention. With regard to subgroup treatment effects, the CATE results indicated that the information treatment worked very well in the context of farmers who were members of a VietGAP group. The effect of the information treatment was 2.5 times and 3 times higher for VietGAP members than for the full sample in term of the purchase dummy and purchase quantity, respectively.

The findings of this study have important implications for future practice regarding sustainable agriculture. In general, both the information and 50% price subsidy treatments represented feasible and effective policy tools to enhance farmers' pro-environmental behavior. However, the subsidy treatment is costly, which can impose a burden on public budgets, particularly for developing countries. Thus, developing low-cost interventions would provide policy makers with viable and sustainable tools. The considerable impacts of information treatment compared to 50% price subsidy suggested the potential of the former being a substitute for the latter. This implication was especially significant for

[27]Specifically, I found a positive and significant association between the subsidy treatment and the number of motorbikes. I also found a positive association between the information treatment and the quantity of organic fertilizer usage from January to April 2018.

certificated farmers, for whom the impacts of the information treatment were nearly 3 times higher than those for the full sample.

The external validity of my study may be limited to tea farmers in Vietnam. However, not only the tea sector but also other crop sectors such as coffee, rice, and maize have experienced the overuse of chemical fertilizers (T. H. Nguyen, 2017). Additionally, many Asian countries have seen the excessive use of chemical fertilizer (FAO, 2006). Thus, my findings could offer a reference for enhancing environmentally friendly behavior by crop farmers in Asian countries, specifically the adoption of organic fertilizer.

One notable limitation of this chapter is that my findings primarily reflect the short-run impacts of the subsidy and information treatments on farmers' pro-environmental behavior. Further research is needed to examine the persistent impacts of both treatments in the long run.

Chapter 4

Impacts of microcredits on household welfare of ethnic minorities

4.1 Introduction

The pledge "to leave no one behind" and "endeavor to reach the furthest behind first" is acknowledged by 193 United Nations Member States in the 2030 Agenda for Sustainable Development (UNDP, 2018). This indicates that specific actions are needed to eliminate extreme poverty, curb inequalities, and confront discrimination for the most left-behind people[1]. Poor ethnic minorities are considered one of the most left-behind groups because they have limited access to fundamental economic elements, especially education and health care (Lenhardt and Samman, 2015; UNDP, 2018)

Inspired by the success of Grameen Bank in Bangladesh, many developing countries have promoted microfinance as a credit channel for the low-income class to improve their livelihoods. Although a substantial body of literature has examined the impacts of microcredit on poverty alleviation in the context of rural households (Al-mamun et al., 2014; Al-shami et al., 2018; Augsburg et al., 2015; Banerjee et al., 2015; Chowdhury et al., 2005; Imai et al., 2010; Rafi Khan and Rafi Khan, 2016), its effects on poor ethnic

[1]Left-behind people lack opportunities to take part in and benefit from development progress. Beside low socio-economic status, there are another four factors used to assess whether a person is being left behind: these are discrimination (exclusion or mistreatment due to any aspect of their identity), geographically isolated residence, disadvantaged governance (due to ineffective, unjust, or unresponsive national or sub-national institutions) and vulnerability to shocks and fragility (UNDP, 2018).

minorities have not been evaluated. In addition, the impact of microcredit remains controversial. Some studies have reported that microcredit has failed to reach poor people[2] (Coleman, 2006; V. C. Nguyen, 2008) Therefore, it is crucial to carefully investigate the effects of microcredit on poor ethnic minorities.

Several reasons make Vietnam a compelling case study for evaluating the impacts of microcredit on ethnic minorities. Vietnam is a multi-ethnic country with 54 ethnic groups. The "Kinh" ethnic group is the largest, accounting for 85 percent of the population. Ethnic minorities constitute only 15% of the population but account for nearly 50% of the impoverished population (World Bank, 2012b). Vietnam has not only a high poverty rate for ethnic minorities but also a substantial and widening poverty gap between the ethnic majority and ethnic minorities (World Bank, 2012b). For example, the poverty rate among ethnic minorities exceeded that of the Kinh ethnic majority by a factor of only 1.6 in 1993, but this factor increased to 5.1 in 2010 (World Bank, 2012b). Low levels of education, language barriers, less-productive lands and market access are the main factors causing these issues (H. T. M. Nguyen et al., 2017; Bank, 2009). The Vietnamese government has implemented several microcredit programs for ethnic minorities through loans from Vietnam Bank for Social Policies (VBSP) and Vietnam Bank for Agriculture and Rural Development (VBARD). However, the effect of these microcredit programs on the welfare of ethnic minorities is still questionable.

In Vietnam, there is growing interest in examining the impacts of microcredit on poverty reduction. Several studies have found significant effects of microcredit on rural households via increased income, expenditure, or self-employment profit or mitigation of the effects of health shocks (see X. L. Do and Bauer (2016) and T. T. Pham et al. (2019) for positive impacts on household income and/or household expenditure; see Lensink and T. T. T. Pham (2012) for improved self-employment profit; and see Thanh and Duong (2017) for mitigation of health shocks). Moreover, considerable impacts on poor households in term of self-employment profits or household income and household expenditure have been found (Lensink and T. T. T. Pham, 2012; Phan et al., 2014). By contrast, Duong and Thanh (2014) and V. C. Nguyen (2008) pointed out that microcredit did not effectively reach poor people. For instance, while the effect of microcredit on household income was statistically significant for rural borrowers, it was statistically insignificant for poor rural borrowers (Duong and Thanh, 2014). Duong and Thanh (2014) suggested that this might be due to lack of experience with business investment and/or prioritizing loan use for basic consumption. Ethnic minorities are not just poor rural households. Beside economic disadvantages, ethnic minorities often face discrimination in education and health cares (Lenhardt and Samman, 2015; UNDP, 2018) Further, two

[2]Significant impacts were found for wealthier borrowers, but the impacts were insignificant for less-wealthy or poor borrowers.

outstanding features experienced by ethnic minorities, namely language barriers and geographically isolated residence, mean that they have poor access to input and output markets (H. T. M. Nguyen et al., 2017; Bank, 2009). Thus, they may not be able to make good use of microcredit, and may even receive unwelcome effects from the exposure to microcredit.

In this study, I extend these previous studies in two ways. First, whereas the previous literature mainly focused on rural households, I target ethnic minorities, the left-behind group. I evaluate the impacts of VBSP microcredit on the household welfare of ethnic minorities in Northern mountainous regions of Vietnam. These areas were selected as the study site due to the high density of poor ethnic minorities. Approximately 73% of the ethnic minorities in this region lived under the poverty line in 2010 (Bank, 2009; World Bank, 2012b). Moreover, ethnic minorities in this area have much lower income than those in other areas (H. T. M. Nguyen et al., 2017). Second, by decomposing household expenditure, I investigate the impacts of microcredit on each expenditure's component, such as educational expenditure, health expenditure and food expenditure. My findings indicate that participation in VBSP microcredit improved household welfare among ethnic minorities in the Northern mountainous regions by increasing their educational expenditure and their total expenditure. This finding is especially significant for ethnic minorities, who often have limited access to education (Lenhardt and Samman, 2015; UNDP, 2018).

The chapter is organized as follows. Section 2 provides background information regarding the development of microfinance in Vietnam and VBSP. Section 3 presents the study site and data collection. Section 4 explains the data analysis methods. The results are presented and discussed in section 5, and section 6 concludes the chapter.

4.2 Microfinance development in Vietnam and the Vietnam Bank for Social Policies

The development of microfinance in Vietnam can be summarized in terms of three main stages: a beginning stage, a horizontal development stage, and a vertical development stage (Nguyen, 2014).

In the beginning stage, which started in the late 1980s (before 1990), microfinance was introduced in Vietnam by international organizations, non-governmental organizations (NGOs), and official aid programs for the purpose of alleviating poverty and income

inequality. Initially, microfinance programs merely provided microcredit to poor households to allow improvements in production activities or to start small businesses. Gradually, other services, such as savings, training, and insurance, were supplied to the poor.

During the horizontal development stage (from 1991 to 2005), a number of microfinance institutions (MFIs) were established, and the scale and coverage of these institutions expanded[3]. In August 1995, the Vietnam Bank for the Poor (VBP) was established and operated under the management of the Vietnam Bank for Agriculture and Rural Development (VBARD). Thereafter, VBSP was established based on a restructuring of VBP in 2002 to achieve poverty alleviation targets and separate policy credit from commercial credit. The expansion of the formal banking system was considered the most remarkable achievement of microfinance during this period because this expansion reduced the dependence of the rural poor on informal financial sectors.

In the vertical development stage (from 2005 to the present), a legal framework was developed to formalize and manage MFIs in Vietnam[4]. Although there are currently approximately 50 microfinance organizations in Vietnam, only three organizations in addition to the banking system were licensed as of December 31, 2015. Compared with other MFIs, VBSP has been the largest provider of microfinancing in terms of the number of customers and outstanding microcredit balances (see table 4.1).

In addition, VBSP, with nationwide coverage, has been the most common source of credit for ethnic minorities[5]. (Bank, 2009, p.30-31). In the Northern mountainous region, 32% of ethnic minorities have access to credit; 70% of them have borrowed from VBSP (Xuan Luan and Anh, 2015). VBSP has a dominant role in providing credit to ethnic minorities. Currently, VBSP has 63 provincial branches, 629 district transaction offices, and 11,068 mobile transaction points (VBSP, 2015, p. 9). Therefore, this study mainly focuses on the microcredit programs of VBSP.

Similar to Grameen Bank, VBSP provides microcredit based on a group lending scheme. To obtain credit, a household must participate in a lending group in the local area. A lending group has at least 5 and at most 50 members living in the same village. Each lending group is managed by a local organization in the commune, such as a women's union, a farmers' union, a youth union, or a war veterans' union, because VBSP's lending procedure involves entrusting the decisions to such local organizations. When a member/household desires to borrow money, the member must complete a form

[3]The first MFI, "Capital aid fund for poor laborers create job" (CEP), was established in 1991.

[4]A decree of the Government on the organization and operation of small-scale financial institutions in Vietnam was issued in 2005. According to the Law on Credit Institutions issued in 2010, MFIs were officially admitted as a type of credit institution.

[5]For example, 42%, 45%, and 62% of Tay, Hmong, and Mnong ethnic minority households borrowed from VBSP, respectively. However, only 15%, 19%, and 10% of Tay, Hmong, and Mnong ethnic minority households borrowed from VBARD, respectively (Bank, 2009) .

Table 4.1: Formal microfinance institutions in Vietnam (2005-2013)

Formal microfinance institutions (MFIs)	Number of customers (million people)				Outstanding microcredit balance (million USD)			
	2005*	2010	2012	2013	2005	2010	2012	2013
Vietnam Bank for Social Policies (VBSP)	3.8	7.8	5.76	6.98	1064	4398	4142	5350
Vietnam Bank for Agriculture and Rural Development (VBARD)	2.88	3.2	1.63	1.49	3771	3500	1452	1390
Co-operative of Vietnam/ Central People's Credit Fund (Co-op Bank/CCF)	0.85	0.95	1.07	1.12	700	1006	1051	1294
Other MFIs	0.28	0.6	0.48	0.5	47.4	75	108	113
Total	7.81	12.55	8.94	10.09	5583	8979	6753	8147

*(Source: Nguyen, 2014); * estimated data*

that provides household information and indicates the amount and purpose of the loan desired. The group leader collects the forms from all applicants and arranges a meeting of all group members to determine whether and what amount a household can borrow. Then, a list of qualified applicants is sent to the commune organization that manages the lending group. Once the list is ratified, it is sent to a VBSP branch for final approval.

4.3 Study sites and data collection

4.3.1 Study site

The household survey was conducted in two communes, the Thanh Van commune and the Mai Lap commune of the Cho Moi district in Bac Kan province, in September 2015. Bac Kan province is located in the northern mountainous region of Vietnam, the center of which is 170 km from Hanoi, the Vietnamese capital. The total provincial area is 485,941 ha, and the total provincial population was 308,300 in 2014, including seven

ethnic communities [6]. Ethnic minorities account for more than 80% of the population. The poverty rate in Bac Kan province was 18.5% in 2013, compared with only 9.8% in the entire country. This province consists of 1 city and 7 districts, with a total of 122 communes.

There are two main reasons for selecting the Thanh Van and Mai Lap communes. First, these communes are listed as especially disadvantaged according to Decision 2405/QĐ-TTg, dated 10/12/2013, of the Prime Minister. As a result, all local residents are eligible to participate in the microfinance program of VBSP. With regard to formal microcredit without collateral, households in both communes have mainly borrowed from VBSP through local organizations in their commune, such as a women's union, farmer's union, youth union, and war veterans' union[7]. Second, the two communes have similar demographic and geographic characteristics. Only the poverty rates slightly differ, with a poverty rate in the Thanh Van commune of 33.1% (195 of 589 households are poor or near-poor) and a rate in the Mai Lap commune of 49.2% (210 of 427 households are poor or near-poor)[8].

In both communes, forest lands cover more than 90% of the natural area, with households using a large part of these lands for timber plantations. Regarding agriculture, rice is the main crop, with two harvests per year, while other major crops include corn and cassava. As a result of development projects, banana cultivation has become very popular in both communes. Livestock husbandry is also one of the main income sources in this area. Households often raise pigs, poultry, and buffalo.

Ethnic minorities speak their own languages and comprise more than 90% of the population. Currently, young generations speak both a common language (Kinh language) and their ethnic language, while older generations often speak only in their ethnic language. Most residents in the study sites identify as members of the "Tay" ethnic group. The traditional house in the study sites is a "San" house made of wood and palm leaves. Residents often do not follow any religion and mainly worship their ancestors[9]. The Tet holiday and the ghost festival are the two biggest festivals of the year.

4.3.2 Data collection

In this study, selected households were divided into two groups: a treatment group and a comparison group. The treatment group included households that had borrowed money

[6]See https://www.backan.gov.vn/Pages/tim-hieubac-kan-129/gioi-thieu-chung-137/GIE1BB9AI20THIE1BB-61a524087b26a319.aspx. (in Vietnamese).

[7]The average amount of a VBSP loan in the sample was 22.9 million VND (1 US$ was approximately equal to 21,500 VND in December 2014).

[8]This information was provided by communal officers during the survey period.

[9]They do not have any religion that revolves around a deity or deities.

from the VBSP program; the comparison group included households that had never received a formal loan from VBSP.

A stratified random sampling technique was applied to sample the households. Based on the borrower list[10] provided by branch offices of VBSP, 204 treated households (VBSP borrowers) were randomly selected. Next, 85 control households (VBSP non-borrowers) were randomly chosen from the resident list[11] supplied by commune committee officers. Overall, a total of 289 households participated in face-to-face interviews using structured questionnaires. The household survey was conducted in September 2015 in each selected respondent's house to maintain anonymity. During an interview, only the investigator worked with a household's representatives. The investigators were young teaching staff at the Thai Nguyen University of Agriculture and Forestry (TUAF) who had no ties to VBSP, the local government or the selected respondents. The structured questionnaire included questions related to household characteristics, credit information, household income and expenditures.

4.4 Methodology

Among indicators of household welfare, household income and expenditures are commonly used. However, households are often reluctant to reliably report their income sources. Moreover, it is common for rural incomes to fluctuate substantially from year to year; thus, income does not accurately reflect the long-term economic status of a household[12]. Therefore, this study mainly focuses on the expenditure aspect, which is less sensitive to the above issues. PSM is applied to estimate the impacts (average treatment effects on the treated - ATET) of a microfinance loan on several outcomes: total expenditure per capita, food expenditure per capita, health expenditure per capita, educational expenditure per student, and total cash income per capita[13]. Specific descriptions of each outcome variable are provided in table C1.

PSM is a two-stage estimation method (Rosenbaum and Rubin, 1983). In the first stage, I estimate the propensity score $P(X)$, which is the probability that a household will participate in a VBSP microfinance program given a set of observable covariates that cannot be affected by this program. Then, the treated households and control households are matched based on their propensity scores and the type of matching method used. Because the dependent variable is a binary variable, a probit model or logit model is

[10]This list includes the names of borrowers, the name of the lending group, the maturity date of the loans, the principal debt balances, and the amount of savings in VBSP.

[11]This list contains names of household heads, locations (villages), and the land ownership area.

[12]For example, see Ledgerwood et al. (2013, p. 142 & p. 144).

[13]I also examined the effects on durable assets and production assets of the household. However, the estimates were sensitive to the PSM models.

applicable[14]. This study employs a probit model adapted from the work of Imai et al. (2010) to estimate the propensity score according to the following equation:

$$P(T_i = 1|X_i) = \phi(\beta X_i) \tag{4.1}$$

where T_i denotes a binary variable. $T_i = 1$ if a household borrowed money from VBSP (VBSP borrowers); $T_i = 0$ if a household never received a formal loan from VBSP (VBSP non-borrowers); X_i is a vector of household characteristics[15]; and ϕ is the standard normal cumulative distribution function.

In the second stage, I estimate the ATET of the VBSP microfinance program on outcomes using the nearest-neighbor matching method. The ATET can be defined as follows (Becker and Ichino, 2002):

$$ATET_{PSM} = \frac{1}{N_T}\Big[\sum_{i\in T} Y_i^T - \sum_{i\in T} w_j Y_j^C\Big] \tag{4.2}$$

where T and C are the treatment group and comparison group, respectively, and i and j denote a treated household (VBSP borrower) and a control household (VBSP non-borrower), respectively. Therefore, Y_i^T and Y_j^C are potential outcomes for treated household i and control household j, respectively.

N_T is the number of treated households, and w_j is the weight used to aggregate potential outcomes of the matched control households in the nearest-neighbor matching. w_j is calculated as follows (Becker and Ichino, 2002):

$$w_j = \sum_{i\in T} w_{(i,j)} \tag{4.3}$$

where $w_{(i,j)} = \frac{1}{N_i^C}$ if $j \in C(i)$; otherwise, $w_{(i,j)} = 0$. $C(i)$ and N_i^C are the set of the control households and the number of control households matched to the treated household i, respectively.

PSM offers some important contributions compared with a simple regression. First, PSM compares only treated households and control households with similar propensity scores.

[14]The probit model and logit model usually produce similar results when estimating a binary outcome (Caliendo and Kopeinig, 2008).

[15]The covariates added in probit model should affect both VBSP membership (the treatment) and outcomes; however, the covariates should not be affected by the treatment. Thus, to satisfy these conditions, covariates should ideally be fixed overtime or selected from the pre-treatment variables. With the absence of pre-treatment covariates in my cross-sectional data, I attempt to select covariates that satisfy these above conditions based on previous studies which also use PSM to evaluate the impact of microcredit programs.

In other words, if a treated household and a control household are very different, they will not be matched. This contrasts with a regression, which will produce results for unmatched households. Additionally, PSM does not impose any particular functional form on the data; thus, both homogeneous and heterogeneous treatment effects on the treated are recorded(Chemin, 2008). In contrast to exact matching, PSM avoids the "curse of dimensionality" because this method incorporates different dimensional characteristics of each observation into a single index, called a propensity score (S. K. Khandker and Samad, 2009)

The PSM method requires two assumptions: common support and conditional independence (Rosenbaum and Rubin, 1983). The common support assumption guarantees that a treatment household has a comparison control household "nearby" in the propensity score distribution (Heckman et al., 1999). The effectiveness of PSM depends on how large and balanced the common support region is. In this study, a graph of the propensity score distribution is provided to examine the common support assumption (see figure 4.1). The conditional independence assumption (CIA) implies that the decision of a household to participate in a VBSP microfinance program depends entirely on observable features, i.e., unobservable features cannot significantly affect the household's decision. For instance, a business idea is usually an unobserved factor in microcredit. Households with clear business ideas are more likely to borrow money, and their business performance is also possibly better than the performance of those with unclear business ideas. Motivation for children's future is also considered an unobserved variable that can affect both probabilities to borrow money and educational expenditure. It is difficult to control these unobserved factors directly. Nonetheless, even when unobserved covariates exist, if I select appropriate observed covariates, the back-door criterion could still be satisfied(Pearl, 1995). Therefore, causal effects could possibly be determined by using PSM[16]. To confirm the consistency of the PSM estimates, I employ the coarsened exact matching (CEM) method[17]. The ATET estimations with different sets of covariates are also presented in the appendix (see table C2).

I cannot control all covariates in the probit model, and ATET results are often sensitive to the set of covariates; therefore, it is necessary to assess the quality of the matching. The basic idea is to check the balance of selected covariates in the probit model by comparing the status of these covariates before and after matching. Follow G. W. Imbens and Rubin

[16]For example, households with a high education level and more members working in the public sector are often interested in their children's education. These households also have more opportunities to access the latest information or training, which leads to specific business ideas. Thus, by controlling for observed factors that are not affected by microcredit status, such as the education of the household head and number of household members working in the public sector, I can mitigate the endogeneity caused by unobserved motivation and unobserved business ideas.

[17]CEM is a type of "monotonic imbalance bounding" (MIB) matching method, which coarsens each variable through recoding. CEM can reduce model dependence and bias and improve efficiency (Iacus et al., 2012).

(2015), I treat these selected covariates as pseudo-outcome variables and estimate pseudo-ATETs on them (see table 4.6). After matching, pseudo-ATETs should be statistically insignificant and near zero, which implies good matching and the plausibility of the conditional independence assumption.

4.5 Results and discussion

4.5.1 Descriptive statistics of the sampled households

The criteria for choosing covariates, which drive household decision of participating in microcredit, was explained in detail in methodology section. The covariates in this study were divided into the following three groups: household head features, household characteristics and geo-economic factors. Household head features included age, gender (male dummy) and education (years of education). Household characteristics included family size (number of family members), land size (ha), dependent ratio, informal credit and number of family members working in the public sector. These variables were considered as important covariates in assessing microcredit (X. L. Do and Bauer, 2016; Duong and Thanh, 2014; Khoi et al., 2013; Li et al., 2011; B. D. Pham and Izumida, 2002; Thanh et al., 2019). Moreover, variables controlling for geographic location and village facilities were used by Li et al. (2011) andPitt and S. R. Khandker (1998). In this study, a location dummy variable was used to capture these factors. The descriptive statistics of these covariates are presented in table 4.2.

The data showed that the average age of household heads was 43 years, and their average educational level was 7 years of schooling. Ninety-four percent of household heads were male. On average, household size was approximately 4 members, and households owned approximately 4.77 ha of forest land and 0.25 ha of crop land. Eleven percent of households had loans from informal sources, such as moneylenders, friends and relatives.

Table 4.2 further reports differences in the means of selected covariates between VBSP borrowers and VBSP non-borrowers. The mean differences were insignificant, with the exception of the location dummy variable and the age of the household head, which indicates similarity and comparability between the treatment and control households. There were significant differences in the age of the household head and the location dummy variable because household heads in the comparison group were older than those in the treatment group and the number of VBSP borrowers in the Mai Lap commune was higher than the number of borrowers in the Thanh Van commune.

TABLE 4.2: Descriptive statistics of covariates

Variables	1	2	3	4
	Total sample (N=289)	VBSP borrowers (N=204)	VBSP non-borrowers (N=85)	(2-3)
	Mean	Mean	Mean	Mean difference
Household head features				
Age (Age of household head)	42.75	41.80	45.01	-3.21**
	(10.35)	(10.48)	(9.73)	
Gender (Gender of household head, 1=Male, 0=female)	0.94	0.94	0.94	0.00
	(0.24)	(0.24)	(0.24)	
Education (Education of household head: years of schooling)	7.16	7.13	7.24	-0.10
	(2.88)	(2.91)	(2.81)	
Household characteristics				
Family size (Number of family members)	4.14	4.08	4.28	-0.20
	(1.26)	(1.16)	(1.48)	
Forestry area (ha)	4.77	4.56	5.30	-0.74
	(4.15)	(3.88)	(4.73)	
Crop area (ha)	0.25	0.24	0.26	-0.02
	(0.28)	(0.30)	(0.21)	
Number of family members working in the public sector	0.22	0.20	0.28	-0.09
	(0.46)	(0.43)	(0.53)	
Informal loans dummy (Whether household has any informal loans: 1=Yes, 0=No)	0.11	0.10	0.15	-0.05
	(0.32)	(0.30)	(0.36)	
Dependent ratio [Ratio of number of dependent people (age <15 or age >60)/Family size)]	0.29	0.30	0.26	0.04
	(0.22)	(0.22)	(0.21)	
Geo-economic factors				
Location dummy (Dummy variable of commune: 1=Thanh Van, 0=Mai Lap)	0.58	0.55	0.66	-0.10*
	(0.49)	(0.50)	(0.48)	

Note: Standard errors are reported in parentheses.
* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

This study evaluated the impacts of VBSP microcredit on several outcomes: total expenditure per capita, food expenditure per capita, health expenditure per capita, educational expenditure per student, and total cash income per capita. Specific definitions of each outcome variable are provided in appendix table C1. The descriptive statistics of the outcomes are shown in table 4.3. On average, total expenditure per capita was 8.41 million VND, and total cash income per capita was 17.10 million VND for whole sample.

TABLE 4.3: Descriptive statistics of outcome variables

Variables	1	2	3
	Total sample (N=289)	VBSP borrowers (N=204)	VBSP non-borrowers (N=85)
	Mean	Mean	Mean
Total cash income per capita	17.10	16.40	18.50
	(14.40)	(14.00)	(15.40)
Total expenditure per capita	8.41	8.59	7.97
	(7.96)	(8.94)	(4.81)
Educational expenditure per student	2.92	3.33	1.89
	(7.15)	(8.02)	(4.14)
Health expenditure per capita	1.08	1.13	0.94
	(2.41)	(2.65)	(1.73)
Food expenditure per capita	3.27	3.10	3.66
	(2.48)	(2.46)	(2.52)

Note: Standard errors are reported in parentheses.

4.5.2 Impact of the microfinance program

Following the procedure discussed in section 4, I first estimated the propensity score of each household using a probit model. The results are provided in table 4.4[18].

The densities of the propensity scores for the treatment and comparison groups are shown in figure 4.1.

The white columns represent the propensity score distribution of the VBSP borrowers, while the gray columns represent the propensity score distribution of the VBSP

[18]The probit model in the first stage of PSM is not a determinants model; obtaining a distribution of participation probabilities is more important than determining participation (Khandker et al., 2009, p. 58-59). Thus, this study does not explain the determinants of access to microcredit in detail.

TABLE 4.4: Results of the Probit model

Covariates	Coefficient	p-value
Constant	1.98	0.00
Household head traits		
Age (age of the head of household)	-0.02**	0.05
Education (years of schooling)	-0.03	0.31
Gender (male dummy)	-0.04	0.90
Household characteristics		
Number of family members working in the public sector	-0.09	0.64
Forest area (ha)	-0.04*	0.08
Geo-economic factor		
Location dummy	-0.42**	0.02

Note:
* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

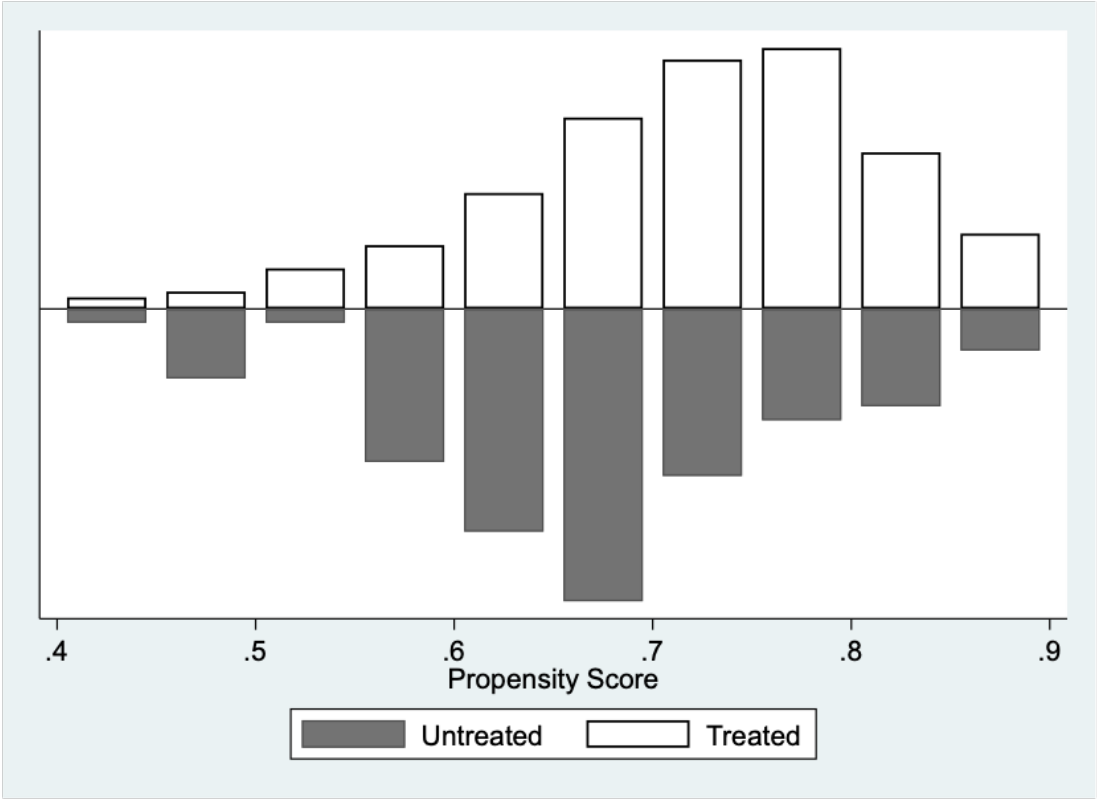

FIGURE 4.1: Propensity score distribution

non-borrowers, which had common support. The propensity score distributions of the treatment and comparison groups largely overlapped, satisfying the requirement of the common support assumption. Figure 4.1 also shows that no observation is outside the common support in my sample.

Table 4.5 reports the ATET results that were obtained using the two alternative estimation techniques, i.e., PSM (nearest-neighbor matching) and CEM. Column 1 presents the ATET estimates based on 1:1 nearest-neighbor matching. The second column presents the CEM results. Both methods used the same covariates.

TABLE 4.5: Average treatment effect on the treated (ATET) results (Million VND)

Outcomes	ATET (Million VND)	
	PSM	CEM
	1:1 nearest-neighbor matching (Base model)	
	1	2
Total cash income per capita	-0.82	2.22
	(0.65)	(0.24)
Total expenditure per capita	1.58*	1.97*
	(0.10)	(0.09)
Educational expenditure per student	1.61**	2.42**
	(0.02)	(0.04)
Health expenditure per capita	-0.03	0.08
	(0.90)	(0.81)
Food expenditure per capita	-0.45	0.08
	(0.19)	(0.82)
	N = 289	N = 210

Note: Standard errors are reported in parentheses.
* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

In general, a consistent and positive ATET estimation regarding education expenditure per student was observed with both estimation methods. In particular, I found that microcredit increases educational expenditure per student by 1.61 million VND using the PSM specification and by 2.42 million VND using the CEM specification. This indicates that VBSP borrowers tend to spend more money on their children's education than VBSP non-borrowers. This result is consistent with the findings of Takahashi et al. (2010) in Indonesia.

The significant impact on educational expenditure in this study might arise from the fact that households borrow money to fund higher education, for example, high school, vocational school, college and university. Because there is no high school nearby, all high school students have to stay in Cho Moi town, which is approximately 35 km from the study site. There is also no university/college located in Bac Kan province, and students must go to another province to study. Educational expenditure in this study includes not only tuition fees, admission fees, books, and stationery but also living costs for high school and university/college/vocational school students who must stay in a different area[19]. According to UNFPA (2011), the rate of completion of high school and higher for ethnic minorities is 2.5 times lower than that of the Kinh ethnic majority (9% versus 22.7%). Thus, the statistically significant effect on educational expenditure is considered a good sign that microcredit can contribute to reducing the gap in educational level between ethnic minorities and the ethnic majority (Kinh ethnicity). Investing in education could be the key to improving the welfare of the next generation and could break the poverty trap in developing countries (Maldonado and González-Vega, 2008).

Because education is one component of total expenditure, an increase in educational expenditure could result in an increase in total expenditure. Indeed, a significant impact on total expenditure per capita was observed in both the PSM and CEM specifications. In detail, the PSM estimate showed an increase of 1.58 million VND, and the CEM estimate showed an increase of 1.97 million VND. Using data from the 2002 and 2004 Vietnam Household Living Standard Survey (VHLSS), Nguyen (2008) also found a positive impact of microcredit from VBSP on total expenditure per capita. Duong and Thanh (2014) found similar results using VHLSS in 2006 and 2008. Compared to previous literature, this study decomposed the household expenditure; thus, I could identify the contribution of each component. The increase in total expenditure mainly came from the increase in educational expenditure. Moreover, the target respondents were ethnic minorities who remain disadvantaged relative to the Kinh majority, and thus my estimations could isolate effects on ethnic minorities.

Regarding the impact of microcredit on cash income per capita, the findings remain ambiguous. One reason is that borrowers might need sufficient time to generate a profit, especially in forestry-related production. In the study site, forest land covers more than 90% of the natural land, and forest plantations are one of the main income sources. Another reason is that households could use their loans for non-productive purposes, such as to pay for children's education, to pay for medical treatment or to purchase furniture. Traditionally, microcredit primarily consisted of loans invested productively in microenterprises. People living in disadvantaged regions, however, often have limited investment opportunities, while their other needs are more urgent (Joanna Ledgerwood

[19]This living cost only includes financial support from household members.

and Nelson, 2013). Using the Vietnam Access Resources Household Survey (VARHS) of 2012, X. L. Do and Bauer (2016) found heterogeneous effects of both formal and informal credit on borrowers' income in northern mountainous areas. A statistically significant effect was found only for the Kinh majority, while a statistically insignificant effect was reported for ethnic minorities. However, this study did not separate microcredit from other credit, and different credit sources might have divergent effects.

ATET results are often sensitive to the set of covariates used in the probit model in the first step of the PSM method. Nevertheless, I could not control for all covariates in the propensity score modeling because over-specification of the model might lead to higher standard errors for the estimated propensity score and in the perfect prediction of participation for many households (the propensity score of households was equal to 1) (S. K. Khandker and Samad, 2009). Caliendo and Kopeinig (2008) noted that the main purpose of propensity score modeling is not to perfectly predict selection into treatment and comparison groups but to balance all selected covariates. Therefore, I report pseudo-ATETs to check the balance of the selected covariates across the treatment group. Table 4.6 shows the balance checking before and after matching. In general, the balance is improved dramatically after matching. Before matching, there are statistically significant differences in location of the household and age of the household head between VBSP-members and VBSP-nonmembers. However, the differences become statistically insignificant after matching. The magnitudes of the differences are also reduced to nearly zero.

Table 4.6: Balance checking: VBSP borrowers and VBSP non-borrowers

Covariates	Before matching			After matching		
	N	Mean	p-value	N	Mean	p-value
Location dummy	289	-0.10*	0.10	289	0.05	0.32
Age of household head	289	-3.21**	0.02	289	0.71	0.32
Education of household head	289	-0.10	0.78	289	-0.26	0.27
Number of family members working in the public sector	289	-0.09	0.15	289	-0.02	0.47
Forest area	289	-0.74	0.17	289	-0.60	0.11
Gender of household head	289	0.00	0.89	289	0.01	0.54

Note:
* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

In addition, I provide the ATET estimates of different sets of covariates in the appendix (table C2). All models show consistent results. I also check the balance of the covariates in these models (table C3).

4.6 Conclusion and policy implications

The main goal of this study was to evaluate the impact of the VBSP microcredit program on the household welfare of ethnic minorities living in the northern mountainous area of Vietnam. A household survey was conducted in 2015 in Bac Kan province, a typical northern mountainous region, where ethnic minorities account for more than 80% of the population. The PSM method was applied to estimate the ATET of VBSP microcredit. The CEM method was employed to verify the consistency of the PSM estimates. I also checked for balance on the covariates after matching and provided different PSM models for checking the sensitivity of the PSM estimates. I found that microcredit from VBSP increased the total expenditure and educational expenditure of ethnic minorities. The impacts on cash income, health expenditure and food expenditure were statistically insignificant.

My findings provide empirical evidence to support the implementation of VBSP microcredit for ethnic minorities. Although ethnic minorities have had limited access to educational opportunities compared with the Kinh ethnic majority (Bank, 2009), a positive significant impact on educational expenditure was still observed. This could be a good sign that extending microcredit to ethnic minorities can contribute to shrinking the educational gap between ethnic minorities and the ethnic majority. Moreover, investing in education could improve the welfare of the next generation, thereby breaking the poverty trap (Maldonado and González-Vega, 2008). As a result, my findings provide support for Vietnamese government's current policy, which has implemented several microcredit programs for ethnic minorities through VBSP. To improve the effect of microcredit policy on reducing the educational gap, further studies are needed to examine the impacts of VBSP microcredit on ethnic minority students' outcomes, for example, enrollment rate and educational performance.

The external validity of this study might be limited to ethnic minorities living in Bac Kan province, a Northern mountainous province in Vietnam. Because 86.5% of my sample were "Tay" ethnic minority, my findings might offer a reference for the potential impacts of microcredits on "Tay" group living in Northern mountainous regions of Vietnam. I also compared my sample statistics with those of some previous literature (See appendix table C4). The means of some basic characteristics of my sample, such as age, years of education of the household head, household size, and number of household members

or relatives working in the public sector appear not very far off from those in previous studies using national data or data of Northern mountainous area (Phung et al., 2016; Xuan Luan and Anh, 2015; Dang, 2012; Fujii, 2018). However, one should be cautious when extrapolating my findings to other study site because the effect of microcredit is very heterogeneous and the 53 ethnic minorities in Vietnam are diversified.

This study has some limitations. One limitation is that ATET estimates could be sensitive to self-selection bias because my matching might not perfectly mitigate bias from unobserved factors. Besides, the data was collected after program implementation. Thus, pre-treatment covariates could not be included in the model, which might raise a concern about reverse causality. For example, within the poor and low-income households who were the target borrowers of VBSP microcredit programs, relatively wealthier households with more spending might have some probabilities to get credit easier. However, I conducted several approaches to guarantee the reliability of my findings. Different specifications of the probit model were given to check the sensitivity of the ATET estimates (appendix table C2). I carefully checked the balance of covariates after the matching to ensure the matching quality (table 4.6). Moreover, the CEM method was applied to check the consistency of the estimates (table 4.5). In general, the results were consistent. Another limitation is that this study could not distinguish the effects on each educational level of students due to the limited sample size. Further research is needed to explore these impacts for fundamental educational levels and higher educational levels.

Chapter 5

Conclusion

5.1 Summary of findings

Although there have been several programs/policies implemented to attain sustainable agriculture and reduce poverty, their impacts on rural households' behaviors are still unclear due to endogeneity bias. Using causal approaches, this dissertation provides rigorously causal evidence on the impacts of such programs/policies through a case study of Vietnam. In detail, this dissertation has three research objectives corresponding with three analytic chapters. Each research objective is addressed one literature gap regarding sustainable agriculture and poverty alleviation.

Chapter 2 investigates the impacts of understanding LTS on agricultural investment. Despite the essential role of LTS knowledge highlighted in several qualitative literature, only few quantitative studies evaluate the effect of understanding LTS. Chapter 2, therefore, contributes to current research on the impacts of LTS knowledge by analyzing a panel data of 1834 households surveyed in four periods 2010, 2012, 2014, and 2016. Both unobserved and observed time-variant variables are controlled by applying DID-FE methods. The parallel trend assumption is also tested. Thus, the causal impact of understanding LTS on agricultural investment is estimated rigorously. I find that understanding the LTS increases sustainable agricultural investments such as investments in irrigation/soil/water conservation and the adoption of organic fertilizer.

To enhance sustainable agriculture, chapter 3 also examines the effects of subsidy and information treatments on organic fertilizer adoption. Previous observational studies emphasize the importance of economic incentives and information access to farmers' decision-making processes; however, due to endogeneity issues, little strong causal evidence is available. This chapter makes an original contribution by experimentally examining the impacts of 50% price subsidy and information treatments on farmers' adoption

of organic fertilizer. Exposure to the experience of farmers who have applied organic fertilizer is selected as information treatment. I analyze data from a randomized controlled trial (RCT) conducted with 1287 small-scale tea farmers in Vietnam. I find significant impacts of both the information and 50% price subsidy treatments. Moreover, the effect of the former is approximately one-third that of the latter. Subgroup treatment analysis also reveals that the information treatment performs well for members of certification groups.

Lastly, chapter 4 contributes to research on poverty alleviation by estimating the impacts of microcredits on household welfare of ethnic minorities. Despite a number of studies examining the impacts of microfinance on rural households, their effects on ethnic minorities, a left-behind group, have not been evaluated. This chapter uses primary data collected in Bac Kan province, a northern mountainous province of Vietnam. Propensity score matching (PSM) is employed to estimate the impacts on 289 ethnic minority households. Coarsened exact matching (CEM) is employed to check the consistency of the PSM estimates. I find positive and consistent impacts on total expenditure and educational expenditure, which supports the welfare effects of microcredits on ethnic minorities in northern mountainous areas of Vietnam.

5.2 Implications

In this section, by combining the findings of three core chapters, I discuss further implications for SRD in Vietnam.

To promote sustainable agriculture, findings from chapter 2 and chapter 3 show the importance of LTS knowledge, a monetary incentive, and information treatment. Chapter 3 highlights the positive significant impacts of understanding LTS on sustainable agricultural investments. However, only 24.6% of households in VARHS data understand the increase in the duration of agricultural land use from November 2013 to June-August 2016. Therefore, it is necessary to raise farmers' knowledge about LTS. This implication is especially important in the context of developing countries which often introduces new land laws without paying enough attention to disseminate and explain them. To encourage farmers' adoption of organic fertilizer, findings from chapter 4 suggests that both information (experience sharing of peer farmers) and 50% price subsidy treatments can be feasible and effective policy tools. Moreover, the impacts of information treatment, a cheap intervention is approximately one-third of that of 50% price subsidy, a costly intervention, which suggests the potential of the former being a substitute for the latter. This implication is especially significant for certificated farmers (VietGAP farmers) because the impact of information treatment for this group is 3 times higher than that for

the full sample. Thus, experience sharing of peer farmers should be included in VietGAP training to encourage VietGAP members to adopt organic fertilizers.

To alleviate poverty in all its forms, it is necessary to focus on the left behind people. Chapter 4 finds the positive significant impacts of microcredits on household welfare of ethnic minorities via increasing total expenditure and educational expenditure. Thus, policymakers should maintain and develop microcredit programs for ethnic minorities, especially educational microcredit programs.

In short, my findings suggest some implications to enhance long-term investments, for example, investments in soil fertility (through using organic fertilizer or soil conservation) and investments in children's education. These long-term investments play a significant role to achieve SRD.

5.3 Limitations

This dissertation has some limitations.

The first limitation comes from the limit of treatment identification in chapter 2. Because of the constrain of the questionnaire, VARHS data doesn't allow me to distinguish when households hear and understand the change in the duration of agricultural land use. Thus, treatment status might not be homogeneous among the treated households, which could constrain its impacts. However, I have made several attempts to assure the reliability of the findings. Beside the main comparison between treated group and control group 1, I compare between treated group and control group 2 including 1382 remaining households after excluding treated households from the data. I also provide different DID-FE models and DID-FE with PSM to check the sensitivity of the estimates.

In chapter 3, only short-term impacts of 50% subsidy and information treatments are examined. It is necessary to investigate the long-term impacts of those treatments on farmers' pro-environmental behavior.

The third limitation comes from the limit of the PSM method used in chapter 4. The PSM procedure might not perfectly mitigate bias from unobserved factors regarding the self-selection into VBSP borrowers. I, therefore, conduct several approaches to assure the reliability of the findings, including sensitivity checking of ATET estimates across different models and different methods (PSM and CEM) and balance checking of covariates after the matching.

Beside the limitations mentioned above, the external validity of the findings of this dissertation needs to be discussed. The findings from three analytic chapters could be

limited to some specific groups in Vietnam. Thus, the extrapolation of the results should be done cautiously.

Appendix A

An appendix for chapter 2

TABLE A.1: VARHS questionnaire related to 2013 new land law

1	Have you heard about the new Land Law from 2013?	1. YES 2. NO>>Q3
2	How much do you know about the new land law?	1. NO KNOWLEDGE AT ALL 2. LITTLE KNOWLEDGE 3. SOME KNOWLEDGE 4. SUBSTANTIAL KNOWLEDGE
3	What is the duration of Land Use Rights to agricultural land? ASK EVEN IF ANSWER TO Q1 IS "NO"	1. 10 YEARS 2. 20 YEARS 3. 50 YEARS 4. 100 YEARS 5. DO NOT KNOW
4	When the government confiscates a plot of land, and there is no other land available for compensation, what compensation is the land user entitled to? CHOOSE ONE ASK EVEN IF ANSWER TO Q1 IS "NO"	1. NO COMPENSATION 2. HALF THE MARKET VALUE OF THE LAND 3. THE MARKET VALUE OF THE LAND 4. ONE AND A HALF TIMES THE MARKET VALUE OF THE LAND 5. COMPENSATION IS ARBITRARILY DECIDED BY LOCAL AUTHORITIES 6. DO NOT KNOW
5	From which sources have you mainly heard about these issues (mentioned in Q3-4)? STATE TWO MOST IMPORTANT	1. HAVE NOT HEARD ABOUT THESE ISSUES 2. TV, RADIO, NEWSPAPER, INTERNET 3. PUBLIC LOUDSPEAKERS 4. FRIENDS AND FAMILY 5. MEETING ARRANGED BY COMMUNE AUTHORITIES TO INFORM ABOUT LAW 6. EXTENSION AGENT/AGRICULTURAL ORGANISATION 7. OTHER GROUPS OR MASS ORGANIZATIONS 8. OTHER

(Source: 2016 VARHS questionnaire)

Table A.2: Descriptive statistics of treated group, control group 1, and control group 2

Variable	Treated group			Control group 1			Control group 2		
	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
Age of household head	452	57.15	11.79	776	57.41	13.74	1,382	57.26	13.22
Education of household head (years of education)	452	8.25	3.22	776	6.64	3.82	1,382	7.42	3.60
Family size	452	4.28	1.73	776	4.07	1.95	1,382	4.05	1.84
Dependent ratio	452	0.23	0.29	776	0.28	0.33	1,382	0.27	0.32
Dummy of poor household	446	0.08	0.27	767	0.24	0.43	1,369	0.18	0.38
Dummy of government officer	452	0.09	0.29	776	0.03	0.17	1,382	0.05	0.22
Expenditure on Vietnamese New Year (thousand VND)	450	5553.89	4211.76	773	3901.23	4818.56	1,379	4369.62	4310.61

TABLE A.3: Covariate comparison among groups

Variable	Treated group vs control group 1		Treated group vs control group 2	
	Mean difference	Std. Err.	Mean difference	Std. Err.
Age of household head	-0.11	0.70	-0.26	0.77
Education of household head (years of education)	0.84***	0.19	1.61***	0.21
Family size	0.23**	0.10	0.20*	0.11
Dependent ratio	-0.04**	0.02	-0.05**	0.02
Dummy of poor household	-0.10***	0.02	-0.16***	0.02
Dummy of government officer	0.04***	0.01	0.06***	0.01
Expenditure on Vietnamese New Year (thousand VND)	1184.27***	232.71	1652.66***	273.04

Table A.4: Description of outcome variables

Outcome variables	Description
Cash spent on irrigation/soil conservation/water conservation (1,000 VND)	Cash spent on irrigation/soil conservation/water conservation show the total cash the households spent on all irrigation and soil and water conservation improvements (for example, rock bunds, soil bunds/grass lines, terraces, brick walls, irrigation systems and other related investments) during the previous 2 years.
Labour spent on irrigation/soil conservation/water conservation (days)	Labour spent on irrigation/soil conservation/water conservation show total days of labor spent by the households on all irrigation and soil and water conservation improvements during the previous 2 years.
Cash spent on aquaculture (1,000 VND)	Cash spent on aquaculture indicate the total cash the households invested in aquaculture (for example, ponds and shrimp farms) during the previous 2 years.
Labour spent on aquaculture (days)	Labour spent on aquaculture indicate total days of labour spent by the households on investments in aquaculture during the previous 2 years.
Organic fertilizer adoption (1,000 VND)	Organic fertilizer adoption show the value of the organic fertilizer used by the households during the previous 12 months.

Table A.5: Description of covariates

Covariates	Description
Household head features	
Age of household head	Age of household head
Education of household head (years of education)	Education of household head (years of education)
Household characteristics	
Family size	Number of family members in the household
Dependent ratio	Ratio of number of dependent people [age <6 or age >60]/Family size
Dummy of poor household	Whether a household is catergorized as a poor household or not
Dummy of government officer	Whether a household has at least a member working in the public sector
Expenditure on Tet holiday (1,000 VND)	Expenditure on Vietnamese New Year (Lunar New Year)

TABLE A.6: ATE results for comparison between treated group and control group 2

Outcome variables	DID-FE	DID-FE	DID-FE with PSM
	Model 1	Model 2	Model 3
Cash spent on irrigation/soil conservation/water conservation (1,000 VND)	543.62**	515.93*	515.15*
	(266.26)	(269.76)	(270.36)
Labour spent on irrigation/soil conservation/water conservation (days)	1.16*	1.3*	1.31*
	(0.69)	(0.70)	(0.70)
Cash spent on aquaculture (1,000 VND)	329.28	283.59	284.06
	(212.54)	(204.87)	(205.33)
Labour spent on aquaculture (days)	1.31	1.34	1.34
	(0.92)	(0.95)	(0.95)
Organic fertilizer adoption (1,000 VND)	435.9	376.69	376.27
	(316.78)	(323.63)	(324.35)
Controlling for household characteristics	No	Yes	Yes
Number of observations (balanced panel households)	1834	1834	1818

Note: Standard errors are reported in parentheses.
* Significant at the 10% level.
** Significant at the 5% level.

TABLE A.7: Checking parallel trend assumption for comparison between treated group and control group 2

Outcome variables	DID-FE	DID-FE
	Model 1	Model 2
Cash spent on irrigation/soil conservation/water conservation (1,000 VND)	-209.79	-207.52
	(156.44)	(158.3)
Labour spent on irrigation/soil conservation/water conservation (days)	-0.45	-0.49
	(1.12)	(1.12)
Cash spent on aquaculture (1,000 VND)	-46.9	-26.87
	(373.06)	(377.3)
Labour spent on aquaculture (days)	0.25	0.26
	(0.83)	(0.84)
Organic fertilizer adoption (1,000VND)	-224.02	-217.79
	(195.37)	(196.97)
Controlling for household characteristics	No	Yes
Number of observations (balanced panel households)	1834	1834

Note: Standard errors are reported in parentheses.

Appendix B

An appendix for chapter 3

Table B.1: Design of treatments

Groups	General information (2-minute video)	Free shipping	Subsidy treatment (50% price subsidy)	Information treatment (3-minute video)
Control group	x	x		
Subsidy treatment group	x	x	x	
Information treatment group	x	x		x

TABLE B.2: Descriptive statistics of baseline characteristics

Variables	Full sample (n=1287)		Control group (n=412)		Subsidy treatment group (n=448)		Information treatment group (n=427)	
	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
Household demographics								
Market distance (km)	1.90	1.18	1.92	1.17	1.83	1.07	1.95	1.29
Family size	3.86	1.34	3.87	1.33	3.88	1.30	3.83	1.40
VietGAP dummy	0.26	0.44	0.25	0.43	0.28	0.45	0.26	0.44
Credit dummy	0.34	0.47	0.33	0.47	0.32	0.47	0.36	0.48
Experience with bio-compost								
NTT organic fertilizer knowledge dummy	0.05	0.22	0.05	0.23	0.06	0.23	0.04	0.19
Organic fertilizer usage dummy	0.49	0.50	0.51	0.50	0.47	0.50	0.50	0.50
Dummy of organic fertilizer usage Jan-Apr 2018	0.26	0.44	0.25	0.43	0.27	0.44	0.28	0.45
Quantity of organic fertilizer usage Jan-Apr 2018 (kg)	159.97	420.26	147.44	392.41	174.83	488.58	156.46	365.69
Land area (ha)								
Tea farm	0.32	0.23	0.32	0.22	0.32	0.19	0.33	0.28
Forest land	0.22	0.48	0.23	0.54	0.22	0.46	0.21	0.45
Annual crop land	0.09	0.10	0.09	0.10	0.09	0.10	0.09	0.11
Perennial crop land	0.35	0.26	0.34	0.23	0.35	0.23	0.35	0.30
Number of assets 6/2018								
Motorbike	1.77	0.85	1.75	0.81	1.79	0.86	1.76	0.89
TV	1.04	0.30	1.04	0.28	1.04	0.30	1.05	0.33
Fridge	1.01	0.28	1.00	0.22	1.01	0.33	1.01	0.29
PC	0.11	0.35	0.10	0.34	0.10	0.32	0.14	0.38
Air conditioner	0.06	0.26	0.05	0.26	0.07	0.27	0.06	0.26
Interviewee characteristics								
Age	47.20	10.98	46.71	11.04	47.48	11.08	47.31	10.63
Education (years)	7.42	2.30	7.45	2.24	7.53	2.36	7.27	2.29
Female dummy	0.46	0.50	0.49	0.50	0.43	0.50	0.47	0.50
Household head dummy	0.59	0.49	0.57	0.50	0.59	0.49	0.60	0.49
Primary decision maker dummy	0.71	0.45	0.70	0.46	0.71	0.46	0.72	0.45

TABLE B.3: Baseline comparisons among groups

Variables	Subsidy treatment vs. Control			Information treatment vs. Control			Information treatment vs. Subsidy treatment		
	Diff	**S.E**	**t-value**	**Diff**	**S.E**	**t-value**	**Diff**	**S.E**	**t-value**
Household demographics									
Market distance(km)	-0.092	0.076	-1.206	0.023	0.085	0.274	0.115	0.080	1.445
Family size	0.008	0.090	0.093	-0.035	0.094	-0.373	-0.044	0.091	-0.478
VietGAP dummy	0.031	0.030	1.035	0.008	0.030	0.253	-0.024	0.030	-0.787
Credit dummy	-0.011	0.032	-0.352	0.023	0.033	0.710	0.035	0.032	1.081
Experience with bio-compost									
NTT organic fertilizer knowledge dummy	0.002	0.016	0.155	-0.016	0.014	-1.109	-0.018	0.014	-1.282
Organic fertilizer usage dummy	-0.034	0.034	-0.998	-0.011	0.035	-0.312	0.023	0.034	0.688
Dummy for organic fertilizer usage Jan-Apr 2018	0.018	0.030	0.596	0.026	0.030	0.866	0.008	0.030	0.282
Quantity of organic fertilizer usage Jan-Apr 2018 (kg)	27.393	30.383	0.902	9.024	26.176	0.345	-18.369	29.284	-0.627
Land area (ha)									
Tea farm	0.002	0.014	0.130	0.007	0.017	0.394	0.005	0.016	0.314
Forest land	-0.009	0.034	-0.276	-0.022	0.034	-0.653	-0.013	0.031	-0.420
Annual crop land	0.003	0.007	0.406	-0.001	0.007	-0.141	-0.004	0.007	-0.538
Perennial crop land	0.012	0.016	0.750	0.010	0.019	0.552	-0.002	0.018	-0.089
Number of assets 6/2018									
Motorbike	0.045	0.057	0.782	0.006	0.059	0.110	-0.038	0.059	-0.646
TV	-0.001	0.020	-0.054	0.006	0.021	0.266	0.007	0.021	0.313
Fridge	0.002	0.019	0.095	0.007	0.018	0.388	0.005	0.021	0.239
PC	-0.002	0.022	-0.076	0.031	0.025	1.265	0.033	0.024	1.398
Air conditioner	0.016	0.018	0.887	0.005	0.018	0.292	-0.011	0.018	-0.604
Characteristics of interviewee									
Age	0.764	0.755	1.012	0.600	0.748	0.802	-0.164	0.735	-0.223
Education (years)	0.080	0.157	0.510	-0.175	0.156	-1.118	-0.255	0.157	-1.624
Female dummy	-0.059*	0.034	-1.750	-0.024	0.035	-0.702	0.035	0.034	1.047
Household head dummy	0.021	0.034	0.622	0.029	0.034	0.854	0.008	0.033	0.245
Primary decision maker dummy	0.004	0.031	0.119	0.015	0.031	0.482	0.011	0.031	0.372

* Significant at 10%.
** Significant at the 5% level.
*** Significant at the 1% level.

Table B.4: Descriptive statistics of outcome variables

Outcomes	**Full sample (n=1287)**		**Control group (n=412)**		**Subsidy treatment group (n=448)**		**Information treatment group (n=427)**	
	Mean	**S.D**	**Mean**	**S.D**	**Mean**	**S.D**	**Mean**	**S.D**
Purchase dummy	0.63	0.48	0.50	0.50	0.79	0.41	0.59	0.49
Purchase quantity (kg)	102.08	89.03	74.03	83.70	142.19	83.08	87.06	85.14

TABLE B.5: ATE on purchase dummy and purchase quantity

	Purchase dummy	**Purchase quantity (kg)**
Subsidy treatment	0.281***	68.158***
	(0.032)	(5.731)
Information treatment	0.081**	13.032**
	(0.032)	(5.799)
Observations	1287	1287

Note: Standard errors are reported in parentheses.
* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

TABLE B.6: ATE on purchase dummy and purchase quantity after controlling for baseline characteristics

	Purchase dummy	**Purchase quantity (kg)**
Subsidy treatment	0.281***	68.674***
	(0.032)	(5.675)
Information treatment	0.079**	12.706**
	(0.032)	(5.736)
Characteristics of household	Yes	Yes
Characteristics of respondent	Yes	Yes
Observations	1287	1287

Note: Standard errors are reported in parentheses.

Household characteristics include market distance, family size, VietGAP dummy, credit dummy, NTT organic fertilizer knowledge dummy, organic fertilizer usage dummy, tea farm, forest land, annual crop land, motorbike, TV, fridge, PC, and air conditioner.

Interviewee characteristics include age, education, and female dummy.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table B.7: CATE for VietGAP membership

	Purchase dummy	**Purchase quantity (kg)**	**Purchase dummy**	**Purchase quantity (kg)**
Subsidy treatment	0.347***	81.842***	0.341***	82.244***
	(0.061)	(11.173)	(0.060)	(10.922)
Information treatment	0.217***	40.587***	0.192***	36.133***
	(0.063)	(11.533)	(0.063)	(11.459)
Characteristics of household	No	No	Yes	Yes
Characteristics of respondent	No	No	Yes	Yes
Observations	339	339	339	339

Note: Standard errors are reported in parentheses.

Household characteristics include market distance, family size, VietGAP dummy, credit dummy, NTT organic fertilizer knowledge dummy, organic fertilizer usage dummy, tea farm, forest land, annual crop land, motorbike, TV, fridge, PC, and air conditioner.

Interviewee characteristics include age, education, and female dummy.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table B.8: Description of selected variables

Variables	Description
Baseline characteristics	
Household characteristics	
Market distance(km)	Distance from the household to the village market (km)
Family size	Total number of household members
VietGAP dummy	1 if household is currently a member of a VietGAP group; 0 otherwise
Credit dummy	1 if household currently has a loan from a financial institution; 0 otherwise
NTT organic fertilizer knowledge dummy	1 if household has ever heard about NTT organic fertilizer; 0 otherwise
Organic fertilizer usage dummy	1 if household has ever used organic fertilizer; 0 otherwise
Dummy for organic fertilizer usage Jan-Apr 2018	1 if household adopted organic fertilizer from January 2018 to April 2018; 0 otherwise
Quantity of organic fertilizer usage Jan-Apr 2018 (kg)	Quantity of organic fertilizer adopted from January 2018 to April 2018 (kg)
Tea farm	Total area of tea
Forest land	Total area of forest landholdings (ha)
Annual crop land	Total area of annual crop landholdings (ha) (paddy field)
Perennial crop land	Total area of perennial crop landholdings (ha) (land for cultivating tea and fruits)
Motorbike	The number of motorbikes owned by the household as of June 2018
TV	The number of TVs owned by the household as of June, 2018
Fridge	The number of refrigerators owned by the household as of June 2018
PC	The number of computers or laptops owned by the household as of June 2018
Air conditioner	The number of air conditioners owned by the household as of June 2018
Characteristics of interviewee	
Age	Age of the interview
Education (years)	Years of education of the interviewee (year)
Female dummy	1 if interviewee is female; 0 otherwise
Household head dummy	1 if interviewee is household head; 0 otherwise
Primary decision maker dummy	1 if interviewee is primary decision maker of the household; 0 otherwise
Outcome variables	
Purchase dummy	1 if household purchased NTT organic fertilizer; 0 otherwise
Purchase quantity	Quantity of NTT organic fertilizer purchased by household (kg)

TABLE B.9: ATE for purchase dummy and purchase quantity at final decision and initial decision

	Final decision		**Initial decision**	
	Purchase dummy	**Purchase quantity (kg)**	**Purchase dummy**	**Purchase quantity (kg)**
Subsidy treatment	0.281***	68.158***	0.257***	62.46***
	(0.032)	(5.731)	(0.032)	(5.789)
Information treatment	0.081**	13.032**	0.082**	13.000**
	(0.032)	(5.799)	(0.032)	(5.856)
Observations	1287	1287	1287	1287

Note: Standard errors are reported in parentheses.

Final decision reflected the purchase dummy and purchase quantity reported on the delivery date. It took into account 45 households who changed their decisions after the RCT section.

Initial decision reflected the purchase dummy and purchase quantity made at the end of the RCT session.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

TABLE B.10: Descriptive statistics of VietGAP members and VietGAP non-members

Variables	1		2		3	
	VietGAP members (n=339)		VietGAP non-members (n=948)		(1-2)	
	Mean	S.D	Mean	S.D	Mean difference	t-value
Household demographics						
Market distance (km)	1.733	1.104	1.958	1.198	-0.225***	-3.029
Family size	3.814	1.325	3.877	1.346	-0.062	-0.736
Credit dummy	0.345	0.476	0.336	0.473	0.009	0.288
Experience about bio-compost						
NTT organic fertilizer knowledge dummy	0.062	0.241	0.044	0.206	0.018	1.292
Organic fertilizer usage dummy	0.678	0.468	0.425	0.495	0.253***	8.209
Dummy of organic fertilizer usage in Jan-Apr 2018	0.437	0.497	0.204	0.403	0.233***	8.571
Quantity of organic fertilizer usage in Jan-Apr 2018 (kg)	290.103	591.622	113.434	326.627	176.670***	6.757
Land area (ha)						
Tea farm	0.359	0.206	0.308	0.239	0.051***	3.494
Forest land	0.200	0.503	0.225	0.474	-0.025	-0.826
Annual crop land	0.064	0.094	0.103	0.105	-0.039***	-6.098
Perrenial crop land	0.394	0.244	0.331	0.259	0.063***	3.904
Number of assets 6/2018						
Motorbike	1.802	0.780	1.755	0.879	0.047	0.871
TV	1.077	0.335	1.031	0.291	0.046**	2.403
Fridge	1.009	0.224	1.007	0.303	0.001	0.081
PC	0.130	0.354	0.109	0.344	0.021	0.965
Air conditioner	0.086	0.329	0.049	0.234	0.037**	2.232
Characteristics of interviewee						
Age	46.779	10.422	47.322	11.091	-0.543	-0.786
Education (years)	7.670	2.320	7.326	2.284	0.344**	2.368
Female dummy	0.431	0.496	0.473	0.500	-0.042	-1.328
Household head dummy	0.611	0.488	0.582	0.493	0.028	0.910
Primary decision maker dummy	0.743	0.437	0.698	0.459	0.045	1.569

* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.

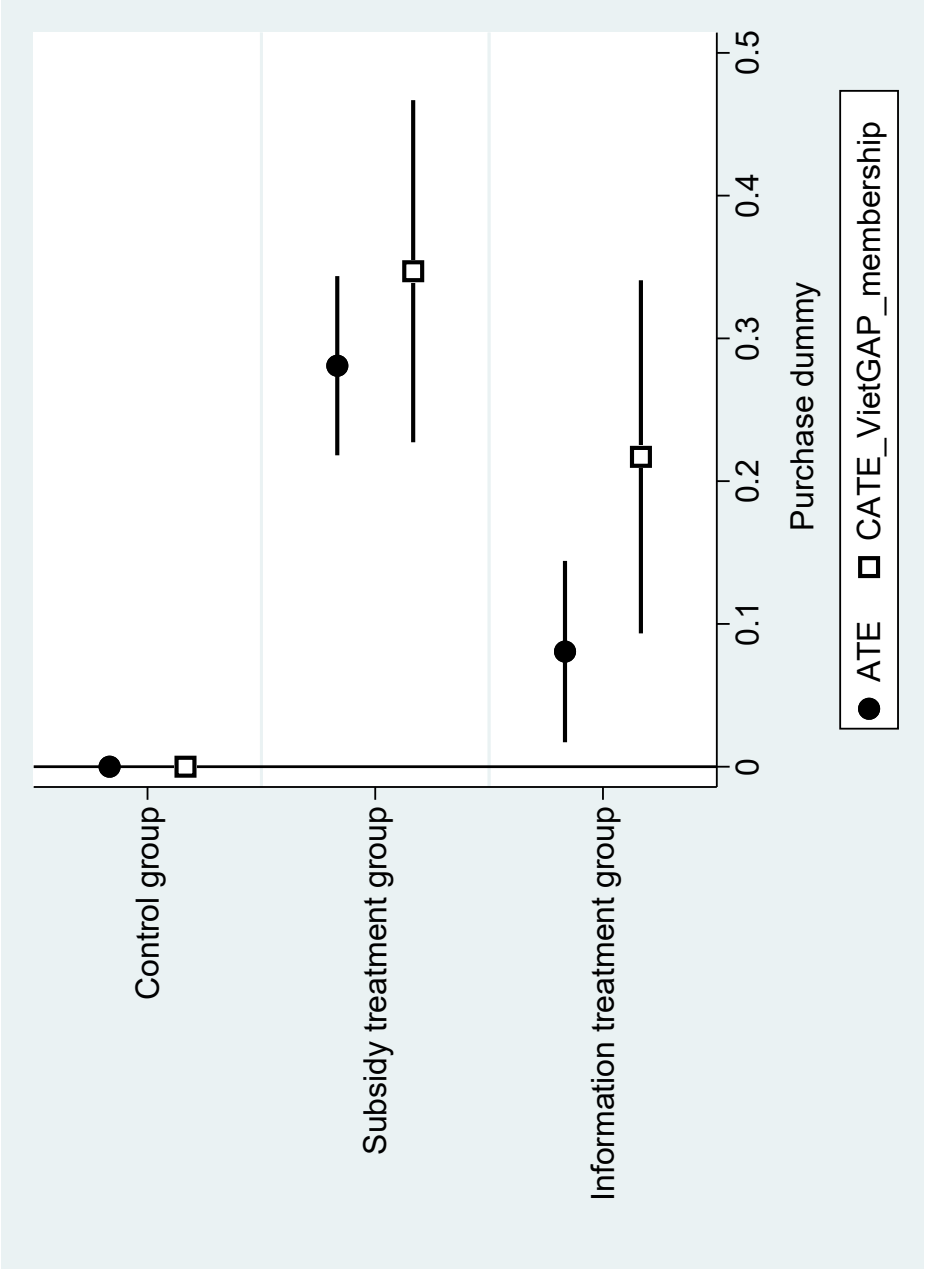

FIGURE B.1: ATE and CATE of VietGAP membership on purchase dummy

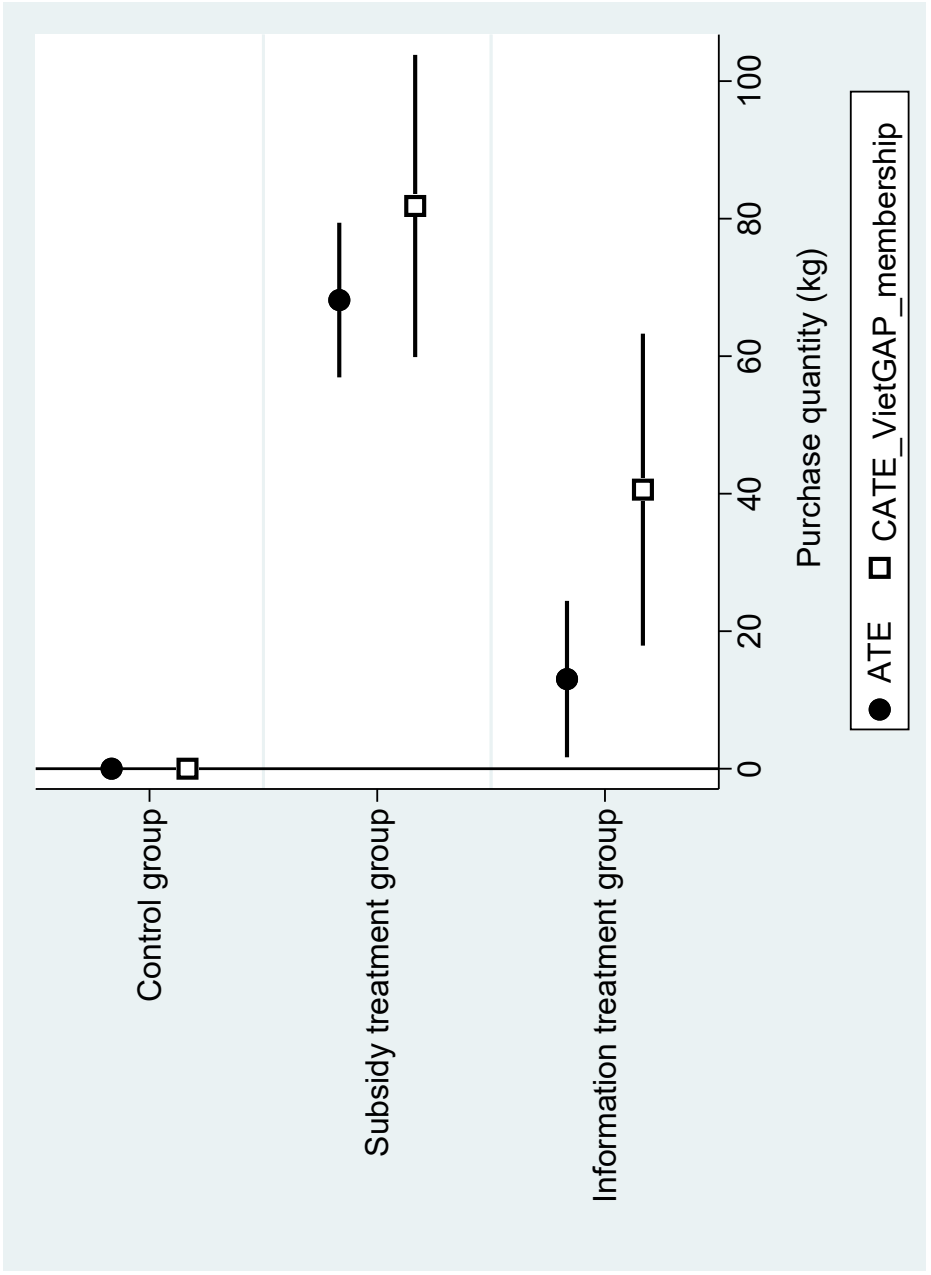

FIGURE B.2: ATE and CATE of VietGAP membership on purchase quantity

Appendix C

An appendix for chapter 4

Table C.1
Table C.2
Table C.3
Table C.4

Table C.1: Description of outcome variables

Outcome variables	Description
Total cash income per capita	Cash income is income from selling forestry products, crops, livestock, fish and income from salary, pension, self-business, subsidy and renting land without considering the costs for obtaining such income in 2014.
Total expenditure per capita	Total expenditure includes health expenditure, educational expenditure, food expenditure and other expenditure such as clothes, wedding gifts, and funeral money in 2014.
Educational expenditure per student	Educational expenditure includes tuition fees, admission fees, books, stationery, and living costs for students who must stay in a different area in 2014.
Health expenditure per capita	Health expenditure comprises the consumption of all health goods and services, for example, medicines, treatments and health checks, in 2014.
Food expenditure per capita	Food expenditure comprises money for food bought from the market such as staples, meat, and fish in 2014. Self-consumption is excluded in food expenditure.

TABLE C.2: ATET estimates with different sets of covariates

Outcomes	ATET (Million VND)		
	1:1 nearest-neighbor matching (PSM)		
	Base model	Model 1	Model 2
Total cash income per capita	-0.82	0.98	-1.97
	(0.65)	(0.58)	(0.32)
Total expenditure per capita	1.58*	1.62*	0.55
	(0.10)	(0.08)	(0.61)
Educational expenditure per student	1.61**	2.02***	1.54**
	(0.02)	(0.01)	(0.03)
Health expenditure per capita	-0.03	0.30	-0.14
	(0.90)	(0.27)	(0.75)
Food expenditure per capita	-0.45	0.02	-0.41
	(0.19)	(0.94)	(0.24)
	N = 289	N = 288	N = 289

The covariates used in the base model were age of household head, education of household head (years of schooling), gender of household head, number of family members working in the public sector, location dummy, and forest area (ha).

In model 1, informal loans dummy and dependent ratio variables were added to the base model while forest area (ha) was excluded from base model.

In model 2, age squared of household head and education squared of household head were added to the base model while number of family members working in the public sector was excluded from the base model.

Table C.3: Assessing matching quality for different sets of covariates

Covariates	Before matching			After matching								
				Base model			Model 1			Model 2		
	N	Mean	p-value	N	Mean	p-value	N	Mean	p-value	N	Mean	p-value
Location dummy	289	-0.10*	0.10	289	0.05	0.32	288	0.00	0.93	289	0.06	0.26
Age of household head	289	-3.21**	0.02	289	0.71	0.32	288	-0.15	0.87	289	-0.14	0.88
Education of household head	289	-0.10	0.78	289	-0.26	0.27	288	-0.26	0.5	289	-0.28	0.23
Number of family members working in public sector	289	-0.09	0.15	289	-0.02	0.47	288	0.01	0.68	289		
Informal loans	289	-0.05	0.18				288	0.01	0.69	289		
Forest area	289	-0.74	0.17	289	-0.60	0.11				289	-0.04	0.91
Crop area	289	-0.02	0.53							289		
Dependent ratio	289	0.04	0.15				288	-0.01	0.55	289		
Gender of household head	289	0.00	0.89	289	0.01	0.54	288	0.01	0.41	289	-0.01	0.33
Age squared	289	-262.80**	0.03								-1.49	0.99
Education squared	289	-0.81	0.89								-4.49	0.30

TABLE C.4: Means of some basic characteristics between our sample and previous studies

Variables	Mean of our sample	Mean of previous studies in Northern mountainous areas	Mean of previous studies in whole country
Age of household head	42.75	45.64 (Xuan Luan and Anh, 2015)	43.4 (Fujii, 2018)
Years of education of household head	7.16	9.07 (Xuan Luan and Anh, 2015)	76.8% has no education (Dang, 2012) 44% completed grade 6 (Dang, 2012)
Gender of household head (made dummy)	0.94	n/a	0.972 (Fujii, 2018)
Number of members in household	4.14	4.4 (Phung et al., 2016) 5.5 (Xuan Luan and Anh, 2015)	5.1 (Fujii, 2018) 4.7 (Dang, 2012)
Number of household members/relatives working in the public sector	0.22	0.27 (Xuan Luan and Anh, 2015)	n/a
Percentage of poor and near-poor households	39.9	39.7 (Phung et al., 2016)	n/a
Dependent ratio [Ratio of number of dependent people (age <15 or age >60)/Family size)]	0.29	n/a	0.34 (Fujii, 2018) [Ratio of number of dependent people (age <15 or age >65)/Family size)]

Appendix D

An appendix for Onsite Team Project

D.1 Background of onsite team project

- General situation in Japan

Agriculture plays an important role in not only food consumption but also land conservation, biodiversity conservation, landscape formation and culture succession (MAFF, 2014). Preserving agricultural income, ensuring food security, and maintaining cultural landscapes are also the major objectives for agriculture policy which are included in Japanese Basic Law and Basic Plans (OECD, 2009). Japan is now facing with high depopulation, especially for municipalities where agriculture, forestry and fisheries workers have larger shares, the population will decrease rapidly (Figure D.1).

Moreover, in Japan, farming population are mainly aging people. Figure D.2 shows that people whose ages are over 65 years old make up for 61 percentage of core persons mainly engaged in farming while people whose ages are less than 50 years old only account for 10 percentage. That leads to the fact that the abandoned cultivated land area grows up significantly because of the retirement of aging farmers. Therefore, it is essential to support agriculture activities.

- Study site: Sera town

Sera town is located in the central of Hiroshima prefecture. This region has been facing several issues as follows:

(1). Land abandonment and ineffective agriculture land use.
(2). Depopulation and aging population.

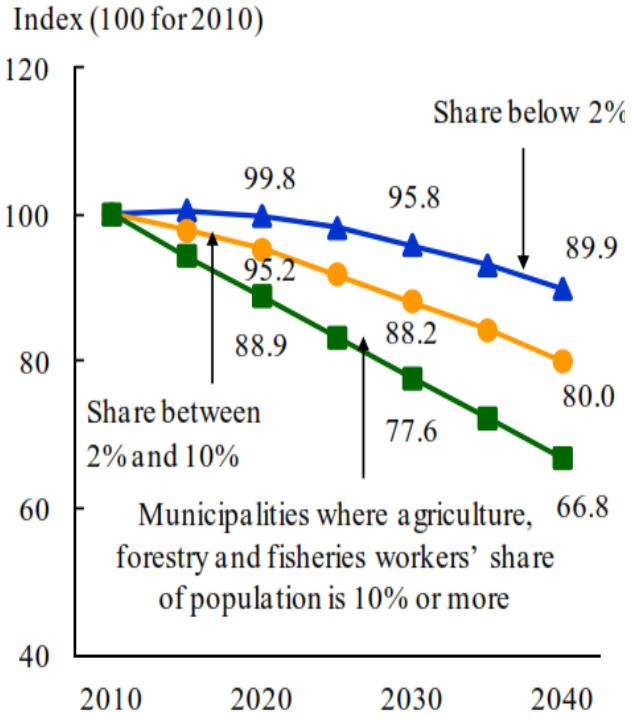

FIGURE D.1: Changes in municipal population indexes (By share for agriculture, forestry, and fisheries workers)

(Source: Prepared by MAFF based on "Population Projections for Japan by Region (March 2013)" released by the National Institute of Population and Social Security Research)

(3). Lack of public transportation and road condition.
However, agriculture and tourism have been well developed here compare with other areas in Hiroshima. Matsutake mushroom, pear, tomato and rice are famous agriculture products. Besides, there has been several community-based agriculture unions established in Sera. Therefore, Sera is a suitable case study for our project.

D.2 Objective of onsite team project

The final goal of our project is to promote agriculture in Sera town. We divide this objective into three sub-objectives as follows.

- Objective 1 (Cultural perspective): To understand agricultural land use and suggestions to prevent farmland abandonment
- Objective 2 (Technical perspective): To propose the system of agriculture support by video surveillance
- Objective 3 (Social perspective): To promote local agriculture product

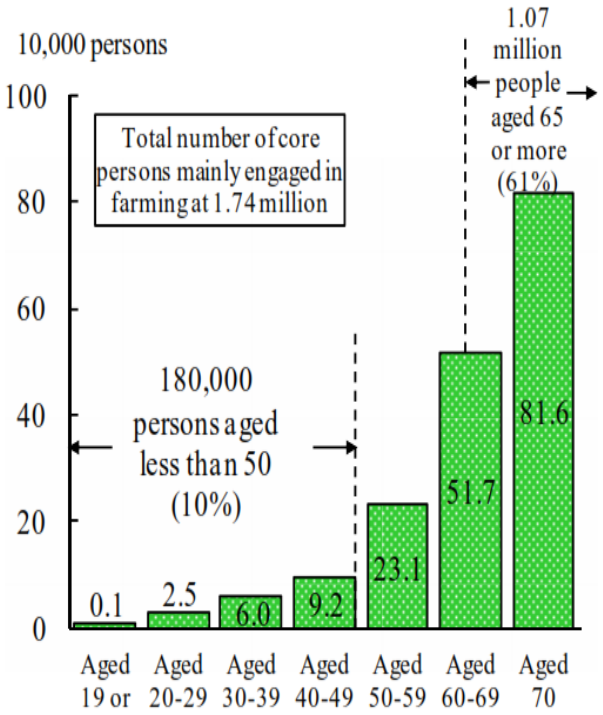

FIGURE D.2: Core persons mainly engaged in farming by age group in 2013

(Source: MAFF, "Survey on movement of agricultural structure")

Regarding social objective, I try to understand the customer's preference on purchasing local products. After that, we can design the labels of local products to fit the demand of customer. Sera is famous for flowers and fruits. However, it is difficult to keep fresh fruits in long time. Local farmers often make proceed products from fresh fruits such as jam, candy and jelly. In the project, I took pear jam as an example and conducted a survey in Sera road side station to obtain customer's preference on buying pear jam.

D.3 My role in the onsite team project

Each member in my team worked hard and contributed a lot to the success of this project. As a social student, I was mainly responsible for designing the survey and analyzing the data to achieve the third objective. Because I had many experiences to carry out survey, I gave a lot of comments to my team-mates to design their questionnaires effectively. I was also in charge of making a video clip to advertise Sera. My detail works were explained in the next session.

D.4 My works related to onsite team project

- Field trips to Sera

To achieve the project goal, my team visited Sera many times.

First of all, we visited "Agricultural Committee" in Sera City Office to introduce our project and get basic information about agriculture in Sera. After getting the permission and suggestion from Sera City Office, we contacted community-based agriculture cooperation (Kirarikariyama) in Sera. We introduced our project to the local people and got wonderful supports from them.

We participated in several agricultural activities with local farmers such as Chinese cabbage planting and harvesting, rice planting and harvesting. Through these activities, we could communicate with local farmers and understood their difficulties.

Moreover, we also conducted two surveys in Sera. The first survey, targeting on customer's behavior, was carried out in Sera road side station. The second survey, targeting on farmer's perception, was carried out in Kirari-Kariyama community and Kurohada community.

- Survey in Sera

To attain the social objective, I conducted a survey in Sera road site station from March 3rd to March 4th, 2018. I would like to estimate Japanese customer's preference on purchasing local processed product (pear jam).

This survey has two parts: a randomized conjoint experiment and a structure questionnaire.

A randomized conjoint experiment: adopted from the work of (Hainmueller and Yamamoto, 2014).

Table D.1 shows the attributes and attribute's level. I highlighted the baseline information.

By a software, I random the order of attributes and their levels to make a choice set. The flow of our experiment was given as follows.

(1) Introduction

"We are students from Hiroshima University. We are conducting a project in Sera to promote agricultural development as a part of our doctor course. This is purely an academic work and hass no direct relations to neither government projects nor private

TABLE D.1: Attributes and their levels

No.	Attributes	Level 1	Level 2	Level 3
1	Price of pear jam (200gram)	220yen	**420yen**	720yen
2	Origin of pears	**Sera**	Hiroshima	Japan
3	Preservative information	**Yes**	No	
4	Presence of nutritional claim	**No statement**	Pears contain high level of vitamin C	
5	Extra suggestion to use pear jam	**No information**	Tea	Yogurt

businesses. Any information we obtain from you should be confidentially treated and used only for academic purposes. Thus, your individual information will never be disclosed. We highly appreciate your time and kind cooperation to our research activities. Do you kindly agree to join our survey?"

(2) After a customer agreed to participated in our survey, we explained about the experiment in detail.

"We would now like to ask you to make some product choices. In each case, there are two products (Pear jam) and we ask you to make rankings among three options.

The rankings are 1) most preferable choice, 2) second preferable choice and 3) least preferable choice.

Situation: Imagine that you are shopping at Sera michinoeki. One item that you plan to purchase is a jar of pear jam (net weight: 200gram). On the shelf you see two pear jam products. They are identical in size (200gram) – the only differences are those identified on the label. We ask you to review these and indicate which of the products you would choose to purchase. Please remember that you, as do all consumers, have a limited amount of funds available for food purchases. Try to make your purchase decision just as you would in real life".

(3) The example of a choice set and questionnaire structure.

Table D.2 showed an example of a choice set. Each customer was asked four times with four different choice sets. After that, they would answer the questionnaire structure. The questionnaire structure has 19 questions about characteristics of respondents such as age, gender, education level, job and so on.

TABLE D.2: Example of a choice set

		Choice A	Choice B	Choice C
Att 1	Presence of nutritional claim	No statement	Pears contain high level of vitamin C	I do not want to buy
Att 2	Preservative information	No information	No information	
Att 3	Origin of pears	Hiroshima	Sera	
Att 4	Price of pear jam (200gram)	420 円	720 円	
Att 5	Extra suggestion to use pear jam	No information	Mix with yogurt	
	Your Ranking (1, 2, 3) ==>			

D.5 Outcomes

There were 101 customers who participated in our survey. Table D.4 showed the descriptive statistics of sample.

TABLE D.3: Descriptive statistics of sample

Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
Female dummy	101	0.49	0.50	0	1
Age	100	57.04	14.48	20	88
Family size	100	2.74	1.37	1	8
Food expenditure per month (JPY)	67	51,940.30	29,027.29	10,000	150,000
Time from house to Sera road side station (minutes)	98	75.46	59.26	5	330

The average age of our sample is 57 years old. The youngest person was 20 years old while the oldest person was 88 years old. 49% of sample are female and 51% sample are male. On average, they spent around 52,000JYP per month for foods. It took around 75 minutes on average to go to Sera road side station from their house.

Figure D.3,D.4,D.5 showed the living place, education level and occupation of respondents respectively. In general, most of sample people lived in Hiroshima, accounted for 72%. Main occupation was company staff, followed by housewife and retirement. Their educational level was mainly high school and bachelor degree.

The main findings were indicated in figure D.6. In general, customer's decision was affected by price, origin information, nutrition claim and usage information. Probability of the pear jam being purchased reduced by 11.9% if price increased to 720JYP. It also

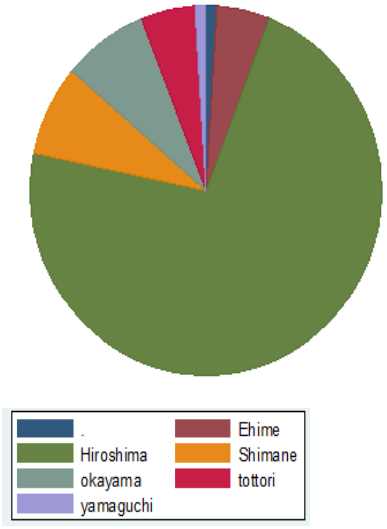

FIGURE D.3: Living place

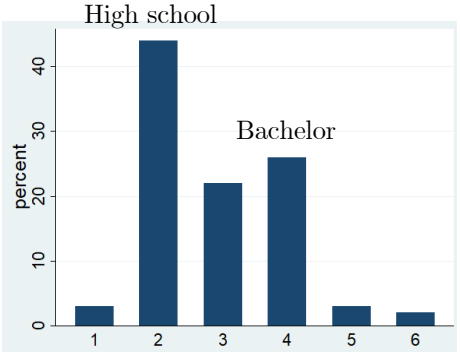

FIGURE D.4: Educational level

FIGURE D.5: Educational level

decreased by 7.5% if the origin information was given as Japan instead of Sera. However, if the nutrition claim statement (pears contain high level of vitamin C) was given on the label, probability that customer purchased the pear jam increased by 6.2%. It also rose from 6% to 8% if extra usage information (mix with yogurt or tea) was shown on the label of product.

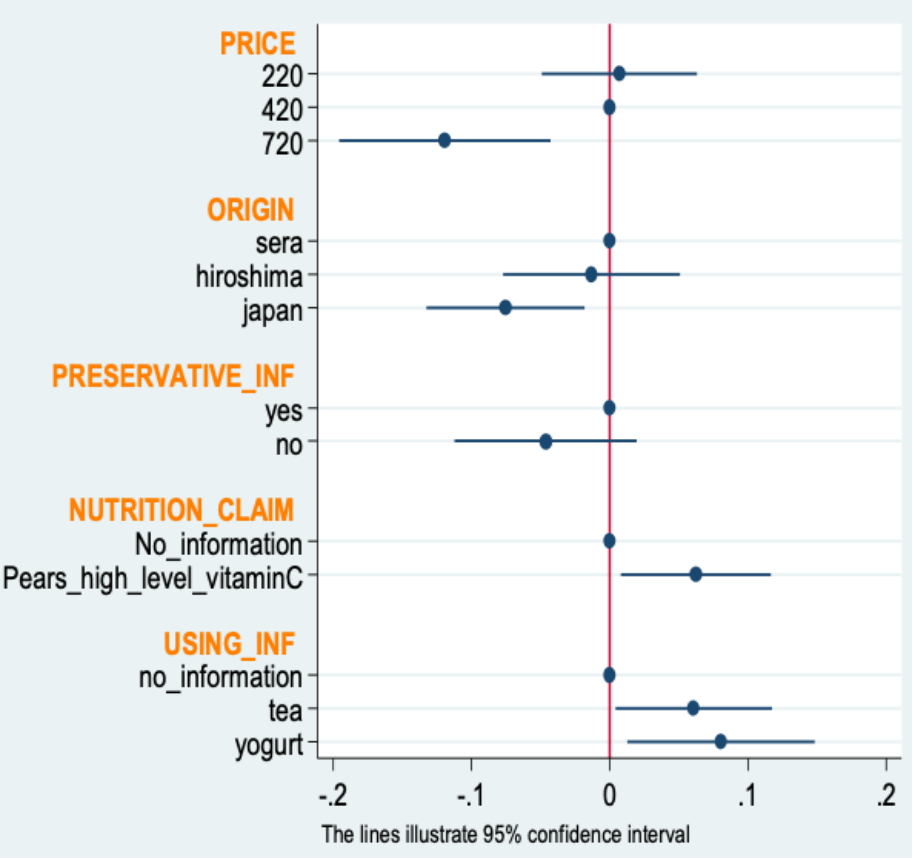

FIGURE D.6: External validity results

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