Dissertation

Essays on the Effects of Land Redistribution, Agricultural Extension, and Social Learning on Technology Adoption and Agricultural Productivity in Ethiopia

By

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Abstract

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The issue of poverty reduction has received considerable attention on the global development agenda. Since the vast majority of the poor in developing countries are residing in the rural areas, the governments in these countries have been implementing policies which raise the returns to the resources owned by the rural poor to reduce the poverty. Ethiopia is among the poorest and most vulnerable countries to extreme poverty because of its rapid population growth and less productive agricultural sector in which the vast majority of people are engaging. Like the governments in other poor countries, the post-1991 federal and regional governments in Ethiopia have also been implementing several agriculture focused policies and investments, such as investments in public agricultural extension, land redistribution in 1996/97 in Amhara region, landholding certification, and infrastructural developments to eradicate poverty by increasing agricultural productivity. The empirical evidence about the effects of the policies and investments has been, however, very limited. The purpose of this dissertation is to fill in these knowledge gaps by investigating the consequences of the 1996/97 land redistribution and the recent row planting promotion campaigns. The analyses are organized in two parts

where the first part analyzes the short-run and long-run consequences of the 1996/97 land reform in Amhara region whereas the second part examines the determinants and impacts of row planting adoption.

The results from the first part of the analysis showed significant negative relationships between the land reform and crop yield in Amhara region in the short-run. Analyses of the 2014 RePEAT household survey data from the affected farmers suggest that the reform might have distorted the allocation of inputs, such as oxen, in the short-run. The result of the long-run analysis of the land redistribution, on the other hand, shows that the reform was significantly associated with an increase in average intensity in short-term intermediate input use, short-term conservation practices, and crop yield in the region. The other finding in the long-run analysis is that those who received land are significantly associated with higher likelihood of carrying out stone terraces. In the second part of the analysis, the technical training which is offered by the local agricultural extension officers and the social learning from the nearest neighbors are found to be the key determinants of row planting adoption for cereal and legume production. The other finding in the second part of the analysis is that the impact of row planting varies across crops. The results for the major cereal crops suggest that row planting is associated with an increase in crop yield and crop income in the production for the tiny seed crops such as teff and wheat rather than for the production of large seed crops like maize. These suggest that row planting dissemination efforts should focus for the small seed crops where the broadcast sowing method is very inefficient.

Dedicated

To

My parents Endale Adane and Etenesh Ashebir

and

to my sisters and brothers

Summary of the Dissertation

The issue of poverty reduction has received much attention on the global development agenda. The goal of eradicating poverty has been the top priority among the eight Millennium Development Goals (MDGs) which were signed by 189 country leaders at the 2000 UN millennium summit. Since majority of the poor in developing countries depend on agriculture for their livelihood, most of the governments in these countries have been implementing policies and investments which enhance the productivity of rural households such as the dissemination of agricultural technologies, land reforms, and infrastructural developments. These pro-poor policies and investments brought remarkable reduction in the number of poor in developing countries. According to the 2015 MDG report the extreme poverty, which is measured by the percentage of population who earn less than $1 a day, decreased from 50 percent (in 1990) to 14 percent (in 2015).

Ethiopia is among the poorest countries and hence poverty reduction has been the priority target of the current government. It is also one of the 189 countries which signed the MDGs at the 2000 UN millennium summit. Since over 85 percent of the population in Ethiopia depends on agriculture for their livelihood, the policies implemented by the federal and regional governments have been centered on the agricultural sector to increase the productivity of the rural households. These include heavy investments in public extension programs, redistribution of land in some parts of Amhara region in 1996/97, the issuance of landholding certificates to smallholders, natural resource conservation, and infrastructural development programs. The policies and investments aim at improving farm

investments and crop yield by enhancing farmers' knowledge about productive technologies and agronomic practices, scaling-up best practices, allocating land from the land rich to the landless or land poor households to boost the efficient use of farmland, raising the tenure security perception of farmers, and integrating the rural households with markets (Benin, 2006; MOARD, 2010). Consequently, crop yield has improved and strong economic growth has been recorded especially after 2007. The increases in crop yield and growth rate have been accompanied by a marked reduction in poverty especially in the rural areas (MOFED, 2010; World Bank, 2015).

Even though the reports on the recorded poverty reduction in Ethiopia have been attributing the achievement to the agriculture centered policies and investments, the number of empirical studies on how these policies and investments affected technology adoption and agricultural productivity are limited. There are a few studies about the roles of agricultural extension and land certificate programs on farmers' agricultural technology adoption and productivity. Empirical evidence on the farm practice and productivity effects of the 1996/97 redistributive land reform and the recently promoted practices such as row planting methods for cereal and legume production are, however, extremely scant. The purpose of this dissertation is to fill in the knowledge gaps on the effects of the 1996/97 land reform and the determinants and impacts of row planting adoption. The findings of this study would suggest effective policies to reduce poverty by providing information on how and to what extent the land reform and the new agricultural technology had impact on farming practices and productivity.

The dissertation has two main parts and consists of seven chapters. The first part discusses about the short-run and long-run consequences of the 1996/97 land reform implemented in Amhara region on farming practices while the second part examines the role of extension services and social learning in the technology dissemination in cereal and legume production. Chapter 1 describes the introduction and Chapter 2 highlights the research gaps on land reforms. It also briefly describes about the implementation of the 1996/97 land redistribution in Amhara region and discusses the conceptual framework which shows the links between land redistribution, tenure security perception, farm practices, and crop yield. Chapters 3 and 4 discuss the outcomes of the regression analyses about the short-run and long-run effects of the land reform on farming practices and agricultural productivity. Chapter 5 briefly reviews the literature on agricultural technology adoption and investigates the roles of agricultural extension, social learning, and the other covariates on the adoption of row planting for cereal and legume production. Then Chapter 6 explores the effects of the row planting adoption on crop yield, value of yield, crop income, and profit. Finally, Chapter 7 concludes the dissertation with a brief summary of the main findings and concluding remarks.

The data used in this dissertation were obtained from two main sources. For the analyses of the short-run effects of the 1996/97 redistributive land reform in Amhara region, repeated cross-sectional data from the Agricultural Sample Survey (AGSS) of the Central Statistical Authority (CSA) was used. The other main data source is the survey in Ethiopia in 2014 as part of the Research on Poverty, Environment, and Agricultural Technology (RePEAT) project, which was conducted by the research team of the National Graduate

Institute for Policy Studies (GRIPS) in collaboration with the Ethiopian Development Research Institute (EDRI). In order to analyze the effect of the 1996/97 land redistribution implemented in Amhara, samples used not only from Amhara region but also from its neighboring region, Oromia, where no land redistribution was done after the government change in 1991. These two regions, Amhara and Oromia, share borders and also similar environment for farming especially in the districts that are close to the boundary which separates the two regions.

The main hypotheses tested in the first part of the dissertation which focuses on examining the effect of the land redistribution are the following:

Hypothesis 1: there was differential impact of the land redistribution program on agricultural productivity between beneficiaries who obtained land and losers who lost a part of their land due to the reform. Because of the large imperfections in rural markets for inputs such as labor, land, and oxen (own and/or hired for ploughing), there is allocative inefficiency in farm production coupled with the limited farming experience of beneficiaries as most of them were the youth, might have decreased the crop yield (kg/ha) on the allocated land in the short-run. On the other hand, the losers could increase the family labor and other resources per farmland on the land left to them after the confiscation and this might have increased the crop yield (kg/ha) on their remaining land. Hence, the overall effect of the land redistribution on crop yield in the short-run is ambiguous.

Hypothesis 2: in the long-run, the redistributive reform is expected to increase the average intensity and crop yield per farmland because even the poor beneficiaries, who might under use the received land in the short-run, would save over time to acquire the complementary inputs such as oxen to cultivate their farmland efficiently.

Hypothesis 3: The reform was implemented by classifying farmers based on their relationships with the previous political regimes into bureaucrats and non-bureaucrats and land was confiscated from former and allocated to those land poor non-bureaucrat sections. The use of the political relationship with the previous political regimes instead of using objective criterions such as family size might have resulted in a heterogeneous tenure security consequence within Amhara region. In other words, due to their favorable relationship with the current political regime, those who received land are expected to make large investments in long-term soil conservation methods and use organic fertilizers intensively than the non-beneficiaries especially from those who lost land.

The main findings from this analysis are as follows. In the short-run, the land redistribution was associated with a significant reduction of the crop yield in the region. Analysis of data from the 2014 RePEAT survey in Ethiopia suggests that the reform might have resulted in the overstocking of oxen among land losers, whereas the poor beneficiaries of the reform might not have efficiently utilized their land because of capital constraints and the absence of schemes to lessen their constraints. Support schemes like credit access for the poor beneficiaries might help to reduce the misallocation consequences of a redistributive land reform in the short-run. But in the long-run, the reform was associated with an increase in the average intensity especially in the short-term soil conservation practices, inorganic fertilizer use, and adoptions of HYV seeds and row planting practice. Consequently, it was associated with a significant increase in crop yield in the region.

The other important finding in Chapter 4 is the heterogeneous tenure security consequences of the reform within Amhara region. The most robust heterogeneous finding is the significant positive association between being a beneficiary in 1996/97 and the likelihood of carryout stone terraces. Stone terrace is the most common type of long-term soil conservation investment carried out by tenure secure farmers on sloppy parcels. Thus, this finding suggests that way the land redistribution was implemented increased not only the farmland of beneficiaries but also their tenure security compared to the non-beneficiaries. Reforms that improve the tenure security of the non-beneficiaries might help to stimulate long-term soil conservation investments in the region. The land per household in the region is already small but the regional land proclamation still allows redistribution of land if 80 percent of village residents favor land redistribution. Abandoning future land redistribution may be good especially for those who lost land in 1996/97 because most of them were the officers of the past regimes and might be more tenure insecure due to their political differences from the current political regime.

The hypotheses tested in the second part of the dissertation to examine the role of extension services and social learning in the dissemination of row planting practice and the impact of adoption on crop yield and income are given as follows:

Hypothesis 4: the access to agricultural extension services from the development agents and social learning from neighbor farmers are expected to increase the farmers' row planting adoption

Hypothesis 5: row planting adoption is expected to increase crop yield and the value of crop yield. But this practice increases the cost of production by increasing the man hours per unit of land and hence its effects on crop income and profit are ambiguous.

The results show that both training and social learning from neighbors have significant positive effects on row planting adoption. The results from the analysis of row planting impact, on the other hand, show significant positive relationships with the value of crop yield and crop income for teff and wheat production. But it has no significant relationship with the outcome variables for maize production. Since maize has a large seed size than the other main cereal crops, the farmers may be relatively efficient in sowing maize by the broadcast method. The analysis further show that row planting adoption is profitable only for wheat production among the cereal crops. However, family labor was evaluated at the village level market wage rate which is mostly observed during the peak harvest season due to the seasonality of labor demand and hence it might be too large compared to the shadow wage rate. Due to the difficulty of measuring profit, the results in the regression for crop income are used for policy suggestion because this measure at least takes the cost of purchased inputs into consideration. The findings suggest that row planting practice should be promoted especially for the production of the small seed crops where the broadcast sowing method is very inefficient.

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List of Acronyms

ATA	Agricultural Transformation Agency
AGSS	Agricultural Sample Survey
CSA	Central Statistical Authority
CAPI	Computer Assisted Personal Interview
DA	Development Agent
EDRI	Ethiopian Development Research Institute
EPLUA	Environmental Protection, Land Use and Administration Authority
HYV	High Yielding Varieties
KG	Kilogram
KM	Kilo meter
MDGs	Millennium Development Goals
PA	Peasant Association
RePEAT	Research on Poverty, Environment, and Agricultural Technology

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Chapter 1

Introduction

The issue of poverty reduction has received a considerable attention on the global development agenda. The goal of eradicating poverty has been the top priority among the eight MDGs which were signed by 189 country leaders at the 2000 UN millennium summit. Since the majority of the poor in developing countries depends on agriculture for their livelihood, most of the governments in these countries have been implementing policies and investment programs which enhance the productivity of rural households such as the dissemination of agricultural technologies, land reforms, and infrastructural developments. These pro-poor policies and investments brought remarkable reduction in the number of the poor in developing countries. According to the 2015 MDG report, the extreme poverty, which is measured by the percentage of population who earn less than $1 a day, decreased from 50 percent (in 1990) to 14 percent (in 2015).

Ethiopia is among the poorest countries and poverty reduction has been the priority target of the current government. It is also one of the 189 countries which signed the MDGs at the 2000 UN millennium summit. Since the vast majority of the poor in Ethiopia are also dependent on agriculture for their livelihood, special emphasis has been given to the agricultural sector by the current federal and regional governments of the country. These include heavy investments in public extension programs, redistribution of land in some parts of Amhara region in 1996/97, the issuance of landholding certificates to smallholders, natural resource conservation and infrastructural development programs. The policies and investments have aimed at improving farm investments and crop yield by enhancing farmers' knowledge about productive technologies and agronomic practices, scaling-up best practices, allocating land from the land rich to the landless or poor households to boost the efficient use of farmland, raising farmers' land tenure security, and integrating the rural households with markets (Benin, 2006; MOARD, 2010). Consequently, crop yield has improved and strong economic growth has been recorded especially after 2007. The increases in crop yield and growth rate have been accompanied by a marked reduction in poverty especially in the rural areas (MOFED, 2010; World Bank, 2015).

Even though the reports on the recorded poverty reduction in Ethiopia have been attributing the achievement to the agriculture centered policies and investments, the number of empirical studies on how these policies and investments affected technology adoption and agricultural productivity are limited. More specifically, the number of empirical studies on the 1996/97 land redistribution in Amhara region and the recently promoted row planting practice, an agronomic practice which requires the planting of cereal and legume crop seeds in rows at a lower seed rate, has been extremely scant. The purpose of this dissertation is to fill in the knowledge gaps on the effects of the 1996/97 land reform and the determinants and impacts of row planting adoption. The findings of this study would suggest effective policies to reduce poverty by providing information on how and to what extent the land reform and the new agricultural technology had impact on farming practices and productivity.

The dissertation has two main parts and consists of seven chapters. The first part discusses about the short-run and long-run consequences of the 1996/97 land reform implemented in Amhara region on farming practices and crop yield while the second part examines the roles of agricultural extension services and social learning in the technology dissemination in cereal and legume production. Chapter 1 describes the introduction and Chapter 2 reviews the research gaps on land reforms, describes the 1996/97 land redistribution in Amhara region, and finally develops a conceptual framework which shows how land redistribution affects input use, technology adoption, farm investment, and crop yield. Chapter 3 investigates the short-run effects of the redistributive land reform on farm practices and crop yield by a difference-in-difference estimation technique using repeated cross-sectional data from the AGSS. The main finding in this analysis is the significant negative relationship between the reform and crop yield. Analysis of data from the 2014 RePEAT household survey in Ethiopia suggests that in the short-run the reform might have distorted the allocation of key inputs such as oxen. Support schemes such as credit for the poor beneficiaries might help to reduce the resource distortionary consequences of land redistribution in the short-run.

In Chapter 4, the outcomes of the regression analyses on the long-run effects of the land reform on farming practices and crop yield are discussed using plot, household, and community level data gathered in the 2014 RePEAT survey in Ethiopia. The findings show significant positive relationships between the reform and the average intensity especially in the short-term soil conservation practices, inorganic fertilizer use, and adoptions of HYV seeds and row planting practice. Consequently, a significant relationship between the reform and an improvement in crop yield are observed. The other finding in this chapter is that only the beneficiaries of the reform have a higher likelihood of carrying out stone terraces, which is a type of long-term soil conservation investment. Since land was allocated from those who were officers during the previous political regimes to those who were “disadvantaged” households of previous political regimes, the significant positive coefficient of the beneficiaries’ dummy might be capturing the heterogeneous tenure security consequence of the reform in the region. In other words, those who had larger land in the past most specifically those connected with the previous political regimes might be tenure insecure due to their unfavorable relationship with the current political regime than the beneficiaries of the reform. Reforms which improve the tenure security of the non-beneficiaries of the 1996/97 land redistribution in Amhara region such as the abandoning of land redistribution might increase the long-term soil conservation investment in the region by enhancing farmers’ tenure security over their landholding.

The second part of the analyses is about the determinants and impacts of row planting. Chapter 5 briefly reviews the literature on agricultural technology adoption, and describes an overview of the promotion of row planting practice for cereal and legume production by the Ethiopian government, and presents the conceptual framework which show how agricultural extension and social learning affect row planting adoption and agricultural productivity followed by the investigation of the roles of agricultural extension and social learning on row planting adoption for cereal and legume production. The main data source for the analyses is the 2014 RePEAT survey data in Ethiopia. The simple Probit, matching, and spatial regressions are employed to estimate the effects of several covariates including agricultural extension and social learning on the probability of row planting adoption. The results from the regressions show that both the training by the public agricultural extension officers and the social learning from neighbors are the key determinants of row planting adoption. These suggest that the current extension approach where the extension agents are required to deliver direct extension services and also to facilitate group learning among neighboring farmers is an effective approach to disseminate new agricultural technologies.

The other finding in Chapter 5 is that the adopters are applying larger seed rate on their row planted plots than the rate recommended by agronomists. According to the DAs, the discrepancy is partly due to the poor implementation by the farmers. However, even the knowledgeable farmers could apply larger seed rate to mitigate the problem of non-germinating seeds. Hence, the reasons for the discrepancy need to be investigated empirically for an appropriate policy suggestion. If main reason for the discrepancy is poor quality or non-germinating seeds, improving their access to certified HYV seeds could alleviate the problem. Implementation inefficiency related problems, on the other hand, might be improved by increasing the farm level extension follow-ups of row planting adopters.

Chapter 6, on the other hand, examines the impacts of row planting adoption on crop yield, value of yield, crop income, and profit. The coefficients of the row planting measures show heterogeneous effects on the outcome variables depending on the type of crop. The results for the main cereal crops shows that row planting has significant positive relationship with larger value of crop yield and crop income for teff and wheat productions but not significant relationships with the outcome variables for maize production. The absence of a significant relationship in the case of maize might be related to its seed size probably because farmers are good at broadcasting large seed crops such as maize than the small seed crops. Moreover, those who broadcast maize seed could also transplant the seedlings from the high density to the low density parts of the plot at the early growing period as it is easier to do it due to its tall and thick seedling than the other cereal and legume crop seedlings.

The final part of the analysis of the second part is about the profitability of row planting. Profit is computed as the value of crop yield less the costs of purchased inputs and own inputs. The own inputs such as family labor hours are imputed using the village level market wage rates. The regression results show that row planting is profitable only for wheat production among the main cereal. However, the use of village level market wage rate to impute family labor and oxen input might have exaggerated the total costs because the market for labor in the rural areas are seasonal and the demand is peak at the harvest season and hence more likely to be larger than the shadow wage rate. Thus, even though profit is the best measure of production efficiency, its measurement is difficult due to lack of data on the shadow wage rates and input uses. Another alternative outcome variable for policy suggestion is the crop income because it takes the costs of purchased inputs into consideration. Thus, government should strengthen the dissemination of row planting especially for the production of small seed crops such as teff and wheat where broadcasting seeds evenly at low seed rate is very difficult inefficient.

Chapter 2

The farm practice and agricultural productivity effects of the 1996/97 land redistribution in Amhara region

2.1 Introduction

The distribution of land has been often inequitable among households in most developing countries because aristocrats and colonialists had affected it in the past to consolidate their political and economic powers (Binswager, Deininger, and Feder, 1995). Since the markets for inputs, such as land, are imperfect or incomplete in developing countries due to the high transaction and supervision costs, the unequal distribution of agricultural land has resulted in inefficient use of the scarce resources (Deininger, Castagannini, and Gonzalez, 2004). Attempts have been made by governments to reduce the inefficiency in input use by allocating land from the land rich farmers to land poor or landless; however, most of these efforts have not succeeded due to the resistance from the landed classes (Chang, 2009).

Even though the issue of land reforms have been central in agricultural development, there are only a few studies examining the consequence of land reforms due to data limitation given the fact that a limited number of countries actually carried out the reforms (Besley and Burgess, 2000; Deininger *et al.*, 2008). In addition, most of the land reform related studies focused on tenancy reform rather than redistributive land reform although the latter is believed to have larger impact on efficient allocation of resources and poverty reduction than the former (Besley and Burgess, 2000). Moreover, most of the previous studies rely on highly aggregated data such as state or country level and their focus have been mainly on the short-run effects alone (Deininger, Jin, and Yadav, 2008).

Furthermore, there is no consensus in the existing studies as to whether land reforms increase farm investments and agricultural productivity or not. For instance, a significant positive relationship between land reform and rice yield was found in the Philippines because the beneficiaries of the reform adopted HYV seeds and fertilizers (Otsuka, 1991). Deininger, Olinto, and Maertens (2000) also reported significant positive effects of the land reforms on crop yield in the Philippines. In the case of India, Banerjee, Gertler and Ghatak (2002) reported positive agricultural productivity effects of a tenancy reform in West Bengal state because the reform enhanced the tenure security of tenants by outlawing tenant eviction and by increasing the tenants' share of the harvest from 50 to 70 percent. Besley and Burgess (2000), on the other hand, did not find any significant relationship between the land reforms in Indian states and agricultural productivity. Ghatak and Roy (2007), however, reported negative relationships between the tenancy reform and agricultural productivity in most of the Indian states because it increased the inequality in the distribution of the land under operation due to the poor implementation such as the under reporting of the total land by landlords and the eviction of the tenants and using hired labor in anticipation land legislations.

Therefore, it is important to provide additional evidence to the literature on the effects of land reforms on farm practice and agricultural productivity. I fill in this knowledge gap by analyzing farm practice and crop yield effects of the land redistribution which took place in Amhara region in Ethiopia in 1996/97. To the best of my knowledge, there are only two empirical studies, Benin and Pender (2001) and Benin (2006), on the farm practice and agricultural productivity effects of this particular land reform.[1] These studies show negative associations of the reform with stone terrace but a positive association with the value of crop yield. However, both of these studies examine only the short-run effects of the reform. This study analyzes both the short-run and long-run effects of the reform on farm practices and crop yield.

Moreover, these two existing studies on the land redistribution use the information of the farmers in Amhara region and compare the outcome variable within the region across villages, or formally Peasant Associations (PAs), with and without the implementation of the land redistribution in order to identify the effects of the land redistribution.[2] In other words, they consider the PAs with the land redistribution as the treatment group and the other villages as the control group within Amhara region in a natural experiment on a land redistribution policy. However, the identification strategy could be problematic if the PAs without the implementation are systematically different. Indeed, the reform seemed to be implemented in the PAs where there was a large demand for access to farmland. Hence, there might have been a systematic difference between the affected and the non-affected villages within Amhara region. For instance, according to the Awi zonal EPLUA officers, the reform was not implemented in 21 PAs (out of the total 171 PAs in the zone) because

[1] Studies on other topics related to the reform include: Ali *et al*. (2014) found negative effect of the reform on fertility rate; Ege (1997) studied the state vs farmer relations from the view point of the farmers during the reform. Gelaye (1999), on the other hand, documented the poets and poetries related to the reform.
[2] Peasant Association (Kebele) is the smallest administrative unit in Ethiopia including several local villages.

access to farmland was not a major problem in most of these PAs and due to weak local administration in some of the PAs.[3] Thus, the comparison between the PAs with and without implementation could result in a biased measure of the effect of the reform due to their systematic pre-existing differences. For example, the demand for access to land may be high in PAs where land productivity is very high, and then using the unaffected PAs as a control group could overstate the crop yield effect of the reform. To address this issue in this study, farmers from other regions which have not implemented land redistribution after the government change in 1991 but share similar agricultural environment to the Amhara region are used as a control group.

Since the country was under a socialist system during the 1974-1991 periods, most of the policies in those periods were national level and hence they affected farmers throughout the country. For example, all the regions were affected by the nationalization and redistribution of land in 1975. However, the centralized system was abandoned and ethnic federalism has been adopted after the 1991 regime change through armed struggle. Since then each region has been semi-autonomous and ruled by leaders elected from the dominant ethnic group in the respective region. The only administrative region that implemented land redistribution after the adoption of ethnic federalism is Amhara region where land was allocated from the land rich to the land poor farmers in 1996/97. Thus, the comparison group could be selected from the other regions for analyzing the effects of the 1996/97 land reform in Amhara region. Oromia is the preferred region for choosing the comparison group farmers because it shares large boundary with Amhara region and the border sharing

[3] Zones are the second highest administrative units next to regions which contain several woredas/districts.

administrative zones in these two regions have closely related agro-ecological characteristics.

For a further reduction in the estimation biases arising from agro-ecological differences between the treated and control groups, I use a type of regression discontinuity design in which the administrative boundary between Amhara and Oromia regions splits the PAs with similar pretreatment characteristics into treated and control communities. For this sake, data is taken from border sharing administrative zones of these two regions and more specifically from the districts that are closer to the boundary that splits these two regions. Data from CSA and the 2014 RePEAT surveys show that the type of crops varieties, their share in the total crop land and production, as well as the type of crop damage incidences are closely related especially for the border sharing administrative zones of the two regions. Therefore, the difference in the major outcome variables of interest between the treated and control groups conditional on the observable village, household, and plot characteristics could be associated with the 1996/97 land redistribution in Amhara.

Another issue which has not received attention in the previous studies is whether the reform has differential tenure security effects depending on how the reform was carried out. The reform was implemented by classifying farmers based on their relationships with the pre 1991 political regimes as *'ex-bureaucrat'*, *'medium'*, *'ex-oppressed'*, and *'youth'* instead of using the objective criterions such as family size. Land was reallocated from the *'ex-bureaucrat'* to the *'ex-oppressed'* and '*youth'*. Thus, the use of the political relationships of farmers to allocate land from one class to the other class might have resulted in a differential tenure security consequence within the region. More specifically, the tenure insecurity of those who had connections with the previous political might be higher than the beneficiaries due to their unfavorable relationship with the current political regime. This in turn could affect their soil conservation investments and productivity heterogeneously. The possible heterogeneous consequences are also rigorously investigated in this dissertation.

2.2 The 1996/97 land redistribution in Amhara region: evidence from implementation

The military regime, which came to power by coup in 1974, nationalized land ownership and redistributed rural landholdings in 1975. The main land allocation criterion was the household size (Holden and Yohannes, 2001). The Tigrean People Liberation Front (TPLF) had also redistributed farmland in 1980s in the parts of Tigray region which fall under its control.[4] According to Young (1997) the aims of these reforms by TPLF were to get the political support from the farmers especially among the youth for the war against the former military government.

In 1989, TLPF and Ethiopian People Democratic Movement dislodged the government forces from South Gondar and Wollo provinces of Amhara region and agricultural land was redistributed in these provinces in 1991 before the rebels remove the military regime from the capital city (Askale, 2005). After seizing power in May 1991, the coalition of rebel fronts established a transitional government which ruled the country until the first election

[4] TPLF had been a rebel group between 1974 and 1991 but it has been the representative of the Tigray region in the current ruling party known as Ethiopian People Republic Democratic Front (EPRDF) since the 1991 regime change.

in 1995. The question of land ownership was among the main debating topics between political parties during the transition. EPRDF, which was the dominant party during the transition period, was favoring the state ownership of land while most of the opposition parties were espousing for the private ownership of land. Land redistribution was banned during the transition period due to the absence of agreement on the ownership of land (Ege, 1997). The state ownership of land was declared in 1995 when the constitution was adopted.

In about one year after proclamation of state ownership of land in 1995, the Amhara regional government redistributed the rural land. This reform was a surprise to the regions' farmers because there were no hints which suggest the plan to redistribute landholdings (Ege, 1997). The areas affected most by the 1996/97 reform were peasant associations within East Gojjam, West Gojjam, Awi, and North Shewa administrative zones. According to Amhara regional government, the motives for the reform were fairness and efficiency or to increase the access to land for the landless or land poor farmers and to improve the efficiency in farmland use. Some researchers and opposition political parties, on the other hand, argue that the reform might have been a politically motivated action to punish the officers of the previous political regimes and to attract political support from others by giving land to those who were not politically connected with the previous regimes (Ege, 1997; Gelaye, 1999). Four committees, which comprise the ruling and opposition party members as well as the civil society organizations, were formed to implement the reform (Askale, 2005). The committees include the land possession verifying committee which was responsible for registering existing landholdings of farmers and verifying the eligible youth and households for extra land; land allotment committee to allocate the confiscated land from the land rich farmers to the youth and land poor farmers; and finally the grievance hearing committee which was responsible to adjudicate the grievances related to the reform implementation. These committees worked based on clear instructions from the higher authorities.

The land possession verifying committee registered the landholding information and the farmers' demographic characteristics. The farmers were classified into bureaucrats, remnant feudal, medium, poor, youth, and *mote-keda* classes during the pre-redistribution registration. Bureaucrats refer to those that had administrative positions during the 1975-1991 military regime and the remnant feudal are the farmers who were feudal lords before 1975 and had continued to own relatively larger land until 1996/97. The medium class refers to farmers who had reasonable farmland and no connections with the pre 1991 political regimes. The fourth category is the poor class that comprise the "disadvantaged" or farmers of tiny farmland or landless, and the fifth category is the youth which refers to dependent members who were 18 years old and over in 1996/97. The youths were further classified as son/daughter of bureaucrat/remnant feudal, medium, and poor. Finally, the *mote-keda* category refers to those landholders who either died or left the village and with no legal dependent member left in the village to claim the land. The land of *mote-keda* was confiscated entirely for allocation to those eligible for extra land.

The reform was implemented in three successive steps (Ege, 1997). The first step was the pre-redistribution registration of landholders and those eligible for extra land. The registration form has columns for the landholders' name, age, gender, plot size and use (farm land, trees, or homestead), and plot quality. The forms vary slightly across the classes. For example, the form to bureaucrats and remnant feudal classes has a column for recording the duty they were in charge during the previous political regimes. Figure 2.1 illustrates a sample pre-redistribution registration form to the bureaucrats and remnant feudal classes. The most stated positions include chairman, secretary, committee, local judge, and treasurer among others. In the case of the youth class, age information was very important because land was given only for those which turned 18 years old by the time of the pre-reform registration.

[Insert Figure 2.1 here]

Access to archived documents on the 1996/97 land redistribution is extremely restricted, but I managed to access some information for a few PAs. Since documents cannot be taken out from office for copying, a digital camera was used to capture the recorded information. Table 2.1 shows that the average landholding of the bureaucrats and remnant feudal farmers was relatively larger than the medium and poor classes. This is consistent with the government's claim that those who hold positions during the previous governments had larger land than those who were without positions. The farmland of these groups was, however, already small in absolute terms in some of the PAs, such as in Ateta Alayta of Awi zone.

[Insert Table 2.1 here]

The medium class farmers were treated fairly well compared to the bureaucrats even if they had large land because they did not work as officer before 1991. The poor or "disadvantaged" classes are the majority and their farm-size was very small or below one hectare in most of the PAs (Table 2.1). The pre-redistribution registration form for the youth class has columns for recording the name, gender, age, parent's class (bureaucrat, remnant feudal, medium, or poor), and land-size and quality (for those who had land before the reform). The majority of the youth were the son/daughters of poor households (Table 2.1).

[Insert Table 2.2 here]

After the completion of the pre-redistribution registration, the confiscation of land from the landed classes followed. A ceiling of one hectare was imposed on bureaucrats and remnant feudal farmer's landholding and a three hectare ceiling on the medium classes' landholding (Askale, 2005; Ege, 1997). These ceilings were decided and announced by the region's authorities after the completion of the pre-reform registration. The land in excess of the respective ceilings was confiscated from each farmer under these two categories. The survey data from the PAs of the three zones are consistent to this rule. For instance, the post redistribution holding of bureaucrats and remnant feudal classes in Woynam-Yetenb PA was one hectare while it was 2.75 hectares for the medium class farmers (Table 2.2). In the Agumamit and Ateta-Alayeta PAs, the post reform registration records obtained only for the poor and youth classes.

The final step was the allocation of the confiscated land from the landed classes to the eligible land poor farmers through a lottery method (Ege, 1997). The rule states that every poor household and married couple should get one hectare of land. Those households whose landholding size was deemed too tiny were entitled to extra land to the total limit of one hectare. For the landless youth, divorced, and unmarried, the rule allowed them to get 0.5 hectare or if they have some land before the reform, they receive extra land until the total limit of 0.5 hectare. In practice, there existed deviations from the rules because a mismatch between the confiscated land and the numbers of eligible farmers for extra land. According to the district officers, the communal land was also allocated to reduce the mismatch.

The post redistribution holdings for the beneficiaries' (land poor and youth) were recorded in one form and, therefore, the archive data do not help to analyze the changes in average holdings separately for each of these two classes. From Table 2.2 one can see that youth and poor households' average landholding was 0.5 ha in Woyenam-Yetenb as well as Agumamit. In the case of Ateyeta-Alayeta PA, the summary result is reported by the priority status of farmers for the land allocation. In this PA the potential beneficiaries were classified into first priority, second priority, third priority, and youth depending on household size and land was allocated in the order of priority.

2.3 Conceptual framework

One of the factors which affect the consequences of a redistributive land reform in developing countries is the inverse relationship between farm-size and productivity which indicates that smallholder farmers are more efficient in farmland use than large farmers (Cornia, 1985; Otsuka, Chuma, and Hayami, 1992). When the inverse relationship exists, the redistribution of land from the land rich to the land poor would enhance the average productivity.

The inverse relationship is often observed because small farmers mainly use family labor on their land, but large farmers largely depend on hired labor. In contrast to the hired labor which lacks incentive to work without a costly supervision, family labor has incentive to make an effective crop care such as soil conservation, weeding, and gathering without labor supervision. Moreover, small farmers might use intermediate inputs, such as inorganic fertilizers, intensively because these inputs are complementary with the labor use per farmland. The problem of supervision coupled with the imperfect and incomplete input markets in the rural areas often result in inefficiency in the large farms (Otsuka *et al*., 1992).

In addition to its effect on efficiency by improving the access to land for smallholder farmers, land redistribution might also affect the productivity by reducing the capital constraint of poor farmers in the long-run. The land poor households might use the acquired land as collateral to access credit that, in turn, increases their human and physical capital in the long-run (Deininger *et al*., 2000; Galor and Zeira, 1993). As their human and physical capital increases, their access to purchased intermediate inputs, such as inorganic fertilizers and HYV seeds improves (Cornia, 1985; Gul Unal, 2006). Thus, land redistribution can increase the efficiency in land use by increasing the number of smaller farmers who have more incentive to put labor and other resources per farmland than the larger farmers.

However, the inverse farm-size productivity relationship might not necessary hold in the short-run because of market failures in the input markets. Since the beneficiaries of land redistribution are often the landless or those own tiny land before the reform, the allocated land might not be utilized efficiently in the short-run because capital constraint could limit their access to the key complementary farm inputs such as oxen unless they get support in the form of credit and input subsidy (Chang, 2009). Moreover, most of the beneficiaries were land poor households and youth and hence their farming experience might have been limited in the short-run. Farmers could improve their farming skill as they work on larger land for several years than on tiny land for few years. Thus, the inverse farm-size productivity hypothesis is reasonable in the long-run after the beneficiaries adjusted their capital and farming skill. But in the short-run, the overall effect of land redistribution on farmland use efficiency is ambiguous.

The other channel that land redistribution affects farm practices and agricultural productivity is through its effect on the tenure security perceptions of farmers. Studies suggest that land redistribution decreases tenure security perception of farmers over their landholdings in affected districts (Deininger and Jin, 2006). Moreover, the tenure security perception might depend on the farmer's relationship with the political regime. For instance, Goldstien and Udry (2008) found that farmers with administrative power in the community tend to choose farm practices which enhance soil fertility for longer-period than the other farmers. A similar consequence would be found in Amhara region because its administrative regional government implemented the land redistribution by classifying farmers into bureaucrats, medium, and poor or "disadvantaged" classes based on their relationships with the previous political regimes as instead of using objective criterions such as family size. The details of the implementation process and the farmers' classification are offered in Section 2.2. Thus, those classified as "oppressed" classes were favored and hence their relationship with the current political regime would be good whereas those who served the previous political regimes lost their land regardless of their family size and farming capability and hence their relationship with the current government relationship might be unfavorable. Thus, the land reform might have differential tenure security consequence within the region where those categorized as 'oppressed' in the past could be more secure under the current regime whereas the previous bureaucrats could be less secure under the current regime.

The changes in tenure security as a result of the reform may affect the farmer's investments and input use. Enhanced land rights due to higher tenure security increase productivity by encouraging investment decisions (Feder, 1987). Tenure insecurity, on the other hand, increases current consumption at the expense of capital accumulation; consequently it decreases agricultural productivity (Besley, 1995; Otsuka and Place, 2006; Place, 2009). Empirical studies have shown significant negative relationship between long-term farm investments such as stone terraces and tenure insecurity (Deininger and Jin, 2006; Nega, Adnew, and Gebreselassie, 2002; Gebremedhin and Swinton, 2003).

The empirical evidence regarding the relationship between tenure security perception and purchased intermediate input uses, such as inorganic fertilizers and HYV seeds are, however, less conclusive. For instance, Hagos and Holden (2014) reported positive effects of landholding certificates on the use of inorganic fertilizers and HYV seeds adoption in Tigray region in Ethiopia. Holden and Yohannes (2001) and Place and Hazel (1993), on the other hand, are among the studies which did not found any significant relationship between tenure insecurity and the use of intermediate inputs. However, Ricker-Gilbert, and Florx (2014) reported a positive relationship between tenure insecurity and intermediate input use from a focus group discussion with farmers; which may be due to the desire of tenure insecure farmers to extract their land as much as they can by using chemical fertilizers while the land is under their control.

Regarding the relationship between organic fertilizers and tenure security perceptions, Gavian and Fafchamps (1996) argue that manures are bulky and non-marketable. Thus, tenure insecure farmers only shift their use from the less tenure secured to the more tenure secured plots. However, some of the inputs for manure, such as cow dung, are marketable in Ethiopian because farmers use it to make cow dung cakes which are usable for heating and cooking in their households and to sell part of it to earn income mostly to the urban households. These alternative roles of the cow dung might induce the tenure insecure farmers to reduce the use of organic fertilizers for enhancing soil fertility.

Figure 2.2 summarizes the reviews of the theoretical and empirical literature on the relationship between land redistribution, tenure security perception, investment, input use, and crop yield. The arrows in the chart indicate causation. The pathway in the left side corresponds to the resource reallocation channel and the right side corresponds to the tenure security channel. The left side of the chart show how redistributive land reform improves agricultural productivity by reducing the land inequality across farm households. Access to land also decreases the capital constraint for the farmers who were landless or land poor before the redistribution. The right side of the chart, on the other hand, shows how land redistribution affects input use, farm investment, and crop yield through its effect on the tenure security perception of farmers. The changes in soil conservation investments, intermediate input use, and technology adoptions from the two channels could affect crop yield. Crop yield, in turn, may affect the soil conservation practices and technology adoptions.

[Insert Figure 2.2 here]

Chapter 3

The short-run effects of the 1996/96 land redistribution on farm practices and agriculture productivity in Amhara region

The discussion in this chapter is the continuation of the literature reviews and the conceptual frameworks of Chapter 2. The short-run effects of the land redistribution on farm practice and agricultural productivity are investigated in this chapter using repeated cross-sectional data from the AGSS. The discussion begins with the empirical specification followed by the hypotheses, data analyses, and finally the conclusions and policy implications.

3.1 Empirical specification

In the conceptual framework section of Chapter 2, two main channels, the changes in farmland per household and tenure security perception, through which land redistribution affects farm investment, input use, and crop yield, were discussed. However, the AGSS data, which is the main data source in this chapter, has no information on the tenure security perception of farmers. Moreover, the data is repeated cross-sectional and this precludes the use of past values of continuous treatment variables, such as the farmland per household, because their values cannot be observed more than once for each household

(D'Haultfoeuille *et al.*, 2013). Thus, due to data limitation the two channels are not discussed separately in analyzing the short-term effects of the reform[5]

Repeated cross-sectional data, however, allows estimating the effects of a binary treatment variable (D'Haultfoeuille *et al.*, 2013; Imbens and Wooldridge, 2008). Suppose there are two comparable groups that are observed both before and after an intervention and only one group received treatment in the second period. Then the effect of the treatment on the treated group can be measured using the control group under conditional independent assumption between the treatment variable and the potential outcome variables.

Equation (3.1) shows the basic relationship between the dependent variables and 1996/97 land reform in Amhara region. The reform is captured by an interaction of two dummies *DAmhara*T*. Where *DAmhara* is a region dummy which takes one for Amhara region which is the only region where the 1996/97 land redistribution took place and zero for Oromia region (control area); and *T* is a year dummy which takes one for post-reform years (1997/98-1999/00) and zero for the pre-reform years (1995/96-1996/97). The regional governments have started the issuance of landholding certificates since 2000. But the AGSS data has no information on landholding certificate and related variables. To reduce the confounding effects of the other land related reforms data is used for the years before 2000 where there were no major reforms in both the Amhara and Oromia regions other than the 1996/97 land redistribution in the former.

[5] The analysis in Chapter 4 gives emphasis to each channel using detailed data from the 2014 RePEAT survey in Ethiopia.

$$y_{cedt} = \beta_0 + \beta_1 DAmhara * T + X\delta + \varepsilon_{cedt}. \quad (3.1)$$

The subscripts *c, e, d,* and *t* denote crop, enumeration area, district, and year, respectively, and y_{cedt} denote the dependent variables namely average inorganic fertilizer use (kg/ha), crop yield, and value of crop yield. The coefficient of the *DAmhara*T* term captures the overall effect of the land redistribution, which is the sum of its resource reallocation and tenure security perception effects, so long as the factors which influence the outcome variables other than the land redistribution are controlled. Since enumeration areas (EAs) are the lowest units for reporting of crop yield in the AGSS, the dependent variables represent the EA level average value of each variable. For inorganic fertilizer variable plot level regression results are additionally reported because there is a plot level data for this dependent variable. The vector *X* represents the other covariates, and ε_{cedt} is the error term. Equation (3.2) presents the extended version of equation (3.1) with more details on the vector *X*.

$$y_{cedt} = \beta_0 + \beta_1 DAmhara * T + H_{edt}\gamma + P_{cedt}\delta + C_c\theta + D_d\omega + YR_t\mu + \varepsilon_{cedt}. \quad (3.2)$$

The variables in vector H_{edt} denote the EA level characteristics of households and landholders such as average of household size, the proportions male landholders, and the proportion illiterate landholders among others. The covariates in vector P_{cedt} , on the other hand, denote the plot characteristics aggregated at the EA level such as the mono-crop dummy, the proportion of plots affected by shortage of rain, the proportion of plots affected by excessive rain. Finally, D_d, YR_t, and C_c denote district, year, and crop fixed effects, respectively. The year fixed effects capture the effects of factors that would cause changes in the outcome variables over time even in the absence of a policy change, while the district fixed effects and crop dummies respectively measure the effects of district specific characteristics and crop specific attributes on the outcome variables. The parameter β_1 is the DID estimate which measures the overall effect of the land redistribution in 1996/97 in Amhara region.

3.2 Hypotheses

Two hypotheses are proposed based on the literature and the conceptual framework in Chapter 2. Since the data is repeated cross-sectional which does not allow measuring the tenure security perception and resource reallocation consequences separately, the hypotheses are about the overall effect of the reform without making distinctions between the two effects.

Hypothesis 3.1: Even though the beneficiaries of the l996/97 land redistribution were the poor who are less likely to buy inorganic fertilizers, there was an already existing national level program since 1994 which ensures the access to fertilizer for cereal and legume producing farmers on credit at a very small interest rate. Hence, that scheme might have lessened the financial constraint to the beneficiaries for acquiring inorganic fertilizer even in the short-run. Moreover, the losers of the reform who are likely to increase the family labor hour per farmland after the reform could also increase the use of inorganic fertilizer because family labor and inorganic fertilizer are complementary inputs in increasing crop yield. Therefore, the overall effect of the land redistribution on inorganic fertilizer use (kg/ha) in Amhara region is expected to be positive even in the short-run.

Hypothesis 3.2: There were no support schemes to help the poor beneficiaries to access the key inputs such as oxen and hence the crop yield from the land they received might have declined in the short-run.[6] In addition to the capital constraint, some of the beneficiaries were the youth with limited farming experience and that could also reduce they crop yield on the received land in the short-run. The losers, on the other hand, could put more family labor hour per the farmland left to them and that might increase the crop yield. Moreover, they could increase the intensity of intermediate inputs such as inorganic fertilizers as these inputs are complementary with the increase in family labor per farmland in increasing crop yield. Therefore, the overall effect of the land redistribution on crop yield in the short-run is ambiguous.

3.3 Data sources and descriptive results

3.3.1 Data sources

The data for the analysis in this chapter was obtained from the Agricultural Sample Survey (AGSS) of CSA, a survey which has been conducted in every year since 1995/96. The samples are chosen in a two-stage stratified cluster sampling design where the

[6] The access to inorganic fertilizer scheme which is described in hypothesis 3.1 was not only for the beneficiaries. It was a national level scheme introduced in 1994 and continued until 2010.

administrative zones are the stratum and the EAs are the clusters.[7] The EAs are selected from each stratum in the first stage and then 25 farm households are selected randomly from each selected EA in the second stage. Then data about the demographic households and land holders as well as rich plot level information such as name of the planted crops, type and quantity of inputs used, and the types of major crop damages are collected from the sample households. But there is one exception in the number of sample farmers for the crop yield information. CSA uses the crop cutting approach to gather the crop yield from a 4 meter by 4 meter (=16m2) area from each of the plots cultivated by the 15 sub-sample farmers (out of the 25 sample farmers) due to cost reason. The sub-samples are selected by systematic sampling from the sample list in each EA (from 11th through the 25th in the list). The average EA level yield of each crop is then computed as the simple arithmetic mean of the of the crop yield of the respective crops from the crop cut areas. Due to the fact that crop yield is collected from the subsamples; CSA experts recommend that crop yield should not be analyzed below an EA level.

In addition to the AGSS, the farm gate prices of crops were obtained from the Producer Price Survey to compute the value of crop yield. However, the producer Price survey was not carried out in 1995/96. Since crop prices were generally stable in the 1990s, the average district price of each crop in 1996/97 was used to compute the value of crop yield in 1995/96.[8] Moreover, data from the 2014 RePEAT survey in Ethiopia is used to analyze the

[7] According to CSA definition, an EA is an area containing 150-200 households; and agricultural household refers to households that have at least one member that engages in crop cultivation or rearing livestock.
[8] For example, the GDP deflator for 1995/96 was 99.7 and for the year 1996/97 it was 99.4. http://www.economywatch.com/economic-statistics/Ethiopia/GDP_Deflator/

transmission mechanisms through which land redistribution affects input use, soil conservation practices, and crop yield in the short-run.

3.3.2 Study sites

The analyses focus on the East Gojjam, West Gojjam, Awi, and North Shewa administrative zones of Amhara region because these were the most affected parts of the region by the 1996/97 land redistribution (Figures 3.1 and 3.2).[9] These administrative zones share border with some of the administrative zones in Oromia region. For instance, West Gojjam and Awi administrative zones are neighbors with the East Wellega administrative zone of Oromia region (Figure 3.1)[10]. The agro-ecological characteristics are closely related among the border sharing administrative affected and control zones such as in the share of crop area and production volume for the major crops (Table 3.1). To give an example, maize accounts for about 25 percent of the crop land and 50 percent of the production volume between 1997 and 1999 both in West Gojjam as well as in East Wellega zones. There is also an agro-ecological similarly between the North Shewa zones of Amhara region and the North and East Shewa zones of Oromia region (Table A.5).

The closely agro-ecological characteristics in the border sharing administrative zones, therefore, allows using control groups from border sharing administrative zones of Oromia region to investigate the effects of the land redistribution in Amhara region. I defined a

[9] The agro-ecologies of East Gojjam is relatively dissimilar in terms of the major type of crops area coverage and production share than the control groups. Thus, only the districts that are geographically near to the East Wellega (control group) are used in the analysis.
[10] East Wellega zone decentralized into two zones in 2005 (East Wellega and Horo Guduru)

group of districts that are located close to either side of the demarcation between the two administrative regions between Gojjam and East Wellega (hereafter called the "nearby group") to further reduce the agro-ecological heterogeneities between the comparable groups. Reasonable numbers of comparable EAs are obtained from both the affected and unaffected sides in the districts within about 50 km from either side of the border separating these border sharing parts of the two regions. Moreover, regressions are also estimated using zonal level comparable groups. The discussions and policy implications are based on the estimates which are robust in the regressions using the "nearby group" as well as in the zonal level comparison groups.

[Insert Figures 3.1 and 3.2 here]

3.3.3 Descriptive results

Land redistribution related variables such as the years of land redistribution and size of received/lost land are not available in the AGSS data.[11] But comparing the changes in the demographic characteristics of the landholders between the affected and the unaffected areas might show how the reform affected the demographic composition of households in the affected areas. For instance, women were neglected in the access to farmland during the previous political regimes. But the women and also the youth received due attention during the 1996/97 land redistribution (Askale, 2005). The pro women and youth nature of the

[11] Household level land redistribution experiences of farmers was collected in the 2014 RePEAT survey and the data is analyzed in the next chapter when I investigate the long-term consequence of the reform

reform are observed through the changes in the demographic characteristics of landholders (Table 3.2).

The results in the top and bottom panels of Table 3.2 show the summary statistics for the periods before and after the reform, respectively. The results in Columns (1) and (2) provide the number of observations and mean values of the variables in the control group (East Wellega). Columns (3) and (6) indicate the numbers of observations in West Gojjam, and West Gojjam and Awi zones (combined), respectively. The mean value of variables in West Gojjam, and West Gojjam and Awi (combined) are not reported to save space. Instead, the mean difference (MD) which is the mean value of the variables in the control group or East Wellega less the mean value of the variable in the affected administrative zones are reported. For instance, the MDs in Column (4) show the mean value of the variable in East Wellega less the mean value of the variable in West Gojjam, and the MDs in Column (7) indicates the differences of the mean value of the variables in East Wellega less the mean value of the respective variable in the two zones or West Gojjam and Awi zones.

Comparing the MD of variables between the upper and lower panels of Table 3.2 shows the relationships between the land reform and the demographic characteristics. For example, the MD in the upper panel of Column (4) reveals that the percentage of male landholders in West Gojjam was 6.3 percentage points larger than in East Wellega before the reform. The bottom panel, on the other hand, indicates that the difference decreased to 0.6 percentage points after the reform which suggests an inverse relationship between the proportion of male landholders and the reform. The MD in Column (7), which is obtained by taking both West Gojjam and Awi in the treated group, also shows a consistent result. Moreover, the reform is associated with an increase in the number of young cohort landholders but with a decrease in the household size and land per household variables. These changes reflect the pro women, landless, newly couple, and youth nature of the reform.

[Insert Table 3.2 here]

In addition to the relationship of the reform with the demographic characteristics of landholders, its correlations with farm practices and crop yield are also investigated (Table 3.3). The results in Columns (4) and (7) of Table 3.3 show the mean value of each variable in East Wellega less the mean value of the corresponding variable in West Gojjam, and West Gojjam and Awi (combined), respectively. The mean difference in the inorganic fertilizer use (kg/ha) suggests a negative association with the redistributive land reform. But detailed exploration of inorganic fertilizer data shows that there are some outliers especially in West Gojjam zone in 1995/96. A positive relationship between the reform and fertilizer use are obtained when the outlier observations of inorganic fertilizer (values which exceed three times the standard deviation from its median) are excluded.

There is also data about organic fertilizer, HYV seeds adoption, irrigation, and pesticide but each of these variables has excessive number of zeros both in the affected and control and their changes over time are not economically significant. Finally, the reform was negatively associated with the crop yield (kg/ha) as well as with the value of crop yield.

For instance, the result in Column 4 of Table 3.3 shows that the average crop yield in West Gojjam was 98 kg larger than the average crop yield in East Wellega before the reform, but it was below the average crop yield in East Wellega by 28 kg after the reform. Crop yield could be reduced by various factors including rainfall variation, crop disease, animal damages, and so forth. Table 3.4 shows the summary statistics of the incidences of major crop damage types in the affected and control groups. The results show that the proportion of crop plots affected by the crop damaging factors is relatively larger in Amhara administrative zones than in Oromia zones both before and after the land redistribution. Therefore, these variables are included in regressions to capture their effect on crop yield.

[Insert Tables 3.3 and 3.4 here]

3.4 Regression Results

The regression results for inorganic fertilizer and crop yield are presented in Tables 3.5 and 3.6, respectively.[12] The district, year, and crop fixed effects are included in each regression. Since the error terms are likely to be spatially correlated within the EAs, the standard errors are clustered at the enumeration area level in each year. The estimates are first reported for the "nearby group" (which is indicated by the shaded part in Figure 3.1) followed by the results for the zonal level analyses in West Gojjam zone, and West Gojjam and Awi zones (together), respectively (using East Wellega as a control group).[13] The

[12] The data for crop area under HYV seeds, organic fertilizer, and irrigation have excessive number of zeros and hence the results are not reported because the estimates are less precise and unstable.
[13] Moreover, the results for the analysis of the reform effect in the North Shewa zone in Amhara region (using North and East Shewa zones of Oromia as a control group) are reported in the appendix table or Table A.1.

estimates from the "nearby group" might reduce the biases arising from agro-ecological differences between the treated and control groups. But more emphasis is given to the estimates which are significant both in the "nearby group" as well as in the regressions which compare the large administrative zones because the intensity of the reform implementation might be vary across districts.

3.4.1 The regression results for inorganic fertilizer use (kg/ha)

Table 3.5 shows the marginal effects of Tobit regression for inorganic fertilizer use (kg/ha). The measure of the land redistribution is positive in all regressions and significant in 2 (out of 3) regressions. Its coefficient in Column (1) or "nearby group" suggests that the land redistribution was associated with doubling of the inorganic fertilizer use (kg/ha).[14] The insignificance of the land reform in Column (2) is probably due to the large number of outliers of the fertilizer use variable in West Gojjam zone in 1995/96. The estimate in Column (3) is positive and significant, and the estimate suggests that the reform was associated with a 50 percent increase in the inorganic fertilizer use (kg/ha) in the West Gojjam and Awi zones (compared to the entire East Wellega zone). The increase in the number of observations after combining the data of the two affected administrative zones might have reduced the influence of the outliers on the coefficient of the land reform. Column (1) of Table A.1 also shows a significant positive relationship between the land reform and inorganic fertilizer use in the North Shewa zone in Amhara region.

[Insert Table 3.5 here]

[14] The marginal effects are a bit larger because the absolute quantity of inorganic fertilizer was not so large.

The plot level regression result in Table A.2 also show a positive relationship between the reform and inorganic fertilizer use. In sum, the results reveal positive relationships between the reform and inorganic fertilizer use but the relationships are robust only in the "nearby group". Analyses of data from the 2014 RePEAT survey in Ethiopia also show that most of the beneficiaries and losers increased the use of inorganic fertilizer in the short-run after the reform (Table 3.7). Although most of the beneficiaries of the reform were poor, that may not have hindered them from accessing inorganic fertilizer because the government had been distributing inorganic fertilizer to farmers on credit scheme at a very low interest rate since 1994 (Matsumoto and Yamano, 2010). The losers who are likely to increase their family labor hour per farmland after the land redistribution (due to an inverse relationship between farm-size and productivity) may have also increased the inorganic fertilizer use (kg/ha) because it is a complementary input with labor use in increasing crop yield.

Regarding the other covariates of inorganic fertilizer use, emphasis is given to the significant coefficients to save spaces. The discussion is based on the coefficients in Table 3.5. From the household characteristics, household size has significant positive association with inorganic fertilizer use (kg/ha) in Column (2). Since household size could be a proxy for family labor in the rural areas, the positive sign of household size might be reflecting the complementarity between family labor and inorganic fertilizer use. The proportion of uneducated landholders in an EA (compared to the proportion of grade 4 or above completed landholders) is negatively associated with the inorganic fertilizer use but the proportion of landholders between grades 1 and 3 is associated positively with intensive use of inorganic fertilizer. The results suggest that formal education increases the use of inorganic fertilizer because it may increase the farmers' awareness and knowledge about new agricultural technologies and improved practices. But the significant positive coefficient for the proportion grade 1-3 landholders (than the proportion of grade 4 or above completed landholders) might be because the more educated might choose crops which do not require much labor and fertilizer due to family labor constraint as they may engage in non-farm activities such as salaried jobs and trading in the nearby towns.

From the plot and crop characteristics, inorganic fertilizers use is large on mono-crop plots than on intercrop plots which may be capturing the fact that intercropping is practiced in the production of legumes and some of these crops do not require urea as they fix atmospheric nitrogen. The proportions of plots that experienced a shortage of rain are negatively associated with the inorganic fertilizer use because its effectiveness declines when there is no sufficient soil moisture. The estimate of excessive rain, on the other hand, suggests that high rainfall did not decrease the inorganic fertilizer use (kg/ha). This is probably because farmers might wait to apply of inorganic fertilizers until the rain declines or they could carry out soil conservation practices such as drainage ditches to reduce the washing away of the inorganic fertilizer.

3.4.2 The regression results for crop yield and value of crop yield

The regression results for crop yield (kg/ha) and value of crop yield (ETB or Ethiopian Birr) on land redistribution and the other covariates are reported in Table 3.6. Land redistribution has significantly negative coefficients in all of the crop yield as well as value of crop yield regressions. Its coefficients in Columns (1) and (2), which are based on the "nearby group", shows that the reform was associated with a 30 percent decline in crop yield and with a 36 percent decline in the value of crop yield. The coefficients of the land redistribution in Columns (3) and (4), which are obtained by zonal level comparison or between West Gojjam and East Wellega, suggest that the land redistribution was associated with a 16 percent decline in crop yield and a 41 percent decline in the value of crop yield. Consistent estimates for the land redistribution are found when the samples in Awi zone are additionally included with West Gojjam in the affected group (Columns (5) and (6) of Table 3.6).

The results in Columns (2) and (3) of Table A.1 also show the negative correlation of the land reform with the crop yield and value of crop yield in the North Shewa administrative zone in Amhara region. In sum, the results show that the reform was negatively associated with crop yield as well as with the value of crop yield in the short-run. The significance of the land reform coefficient in all of the regressions for crop yield shows the robustness of its negative estimate. The result contradicts the findings reported in Benin and Pender (2001) and Benin (2006) which showed positive coefficient of the reform on the value of crop yield obtained by comparing the crop yield between the affected and unaffected villages within Amhara region. However, their estimate could be biased if the reform was implemented on the very productive areas and/or if the reform was held only in the areas where local administrations are strong.

[Insert Table 3.6 here]

Regarding the estimates for the other covariates, the coefficient of mono-crop is positive in all the regressions and significant in 5 (out of 6) regressions. Its positive estimate could be related the better crop care, such as weeding and harvesting on the right time, on mono-crop plots unlike intercrops where different crops which could germinate and ripe at different time are planted on one plot. The estimates of crop damage incidences such as crop disease, insect and pests, and excessive rains are also negative and significant which suggests how detrimental these factors are for crop yield (relative to plots which did not experience crop damage).

3.4.3 The transmission mechanism

To find out how the land redistribution affected agricultural productivity in the short-run, a data from the 2014 RePEAT survey in Ethiopia was used. The survey has information on farm investments and input uses of each farmer in the first three years after the latest land redistribution. The summary results are reported in Table 3.7. Since family size and farming capability were not taken into consideration during the reform, the land ceiling might have resulted in under use of the resources of bureaucrats and remnant feudal farmers in the short-run. The descriptive summary result is consistent with this claim. For example, about 61 and 37 percent of those who lost land in 1996/97 reported that the land redistribution forced them to underuse oxen and family labor, respectively.

[Insert Table 3.7 here]

The beneficiaries that comprise those who were land poor households and youth, on the other hand, reported that they increased the use of inputs after the land reform. However, most of these farmers were landless before the reform. For instance, about 76 percent of the sample of beneficiaries of the 1996/97 reform in the 2014 RePEAT survey indicated that they were landless before the redistribution. Hence, the reported increases in input uses by these farmers could be reflecting the very low input use by them before the reform. Due to their poor asset base and the high imperfections in the input markets, the beneficiaries might have used very small quantity of the key complementary inputs with land than the required quantities in the short-run. The capital constraints and the unavailability of other schemes such as credit schemes to help the poor beneficiaries after the reform mighty have resulted in a misallocation of inputs in the short-run. Other studies also documented similar result. For instance, Benin (2006) reported that both man hours and oxen hours were significantly lower in the villages affected by the 1996/97 reform than the unaffected villages in Amhara region. Therefore, the main transmission mechanism through which the land redistribution reduced crop yield in the short-run is by distorting the allocation of key farm inputs such as oxen.

3.4.4 Placebo Regressions

This section offers evidence which shows that the estimates are not confounded with other interventions. The estimates of the land redistribution might be spurious if there was another intervention in Amhara region during the study period or if there was another reform within the control groups. I reviewed documents that show regional and national level events most specifically in relation to agriculture. To the best of my knowledge the notable policy difference between Amhara and Oromia regional governments was the 1996/97 land redistribution in the former region. Evidence from other studies also confirmed this fact. For instance, the major rural land related interventions which were implemented by the last three regimes from the early 1960s to the early 2000 are documented in Rahmato (2004). According to this document, the 1996/97 land redistribution stands out as the major intervention in the period between 1995 and 1999.

The robustness of the coefficients of the reform measure are also checked by regression methods. The coefficient estimates of the land redistribution could be spurious if a significant variation exists within the treated and/or within the controlled areas. For the robustness of the foregoing estimates there should not be significant differences in the dependent variables across districts within the Amhara region and across districts within the control groups. Placebo regressions conducted using data only from Amhara region and only from Oromia region. For the regression which uses data only from Amhara region, districts from some part of the region are considered placebo control group. Similarly, for the regression which uses data only from Oromia, some of the districts are defined as placebo treated group. The artificial policy variable is generated by the interaction of the placebo treatment status dummy and the year dummy which takes one in the post reform period and zero otherwise. The coefficients of the artificial policy variable should be insignificant for the foregoing interpretations on the coefficients of the actual policy variable to hold.

Two sub groupings created from the districts in the Gojjam province. The first group is the shaded parts of Gojjam provinces from Figure 3.1 as the affected group and districts in the un-shaded part of the same province as a placebo control group. Secondly, West Gojjam zone considered as the affected administrative zone using Awi zone as the placebo control group. For East Wellega, the districts in the shaded part of East Wellega zone on Figure 3.1 are used as a placebo affected group and the districts in non-shaded part of the zone as control groups. The placebo regressions results for inorganic fertilizer use (kg/ha) and crop yield are reported in Tables A.3 and A.4, respectively. None of the placebo policy variables are significant in the regressions for inorganic fertilizer use as well as in the regressions for crop yield and value of crop yield. Hence, there are no evidences of confounding effects which invalidate the results in the main analysis.

3.5 Conclusion and policy implications

The analysis in this chapter investigated the short-run relationship of the 1996/97 land redistribution in Amhara region with inorganic fertilizer use, crop yield, and value of crop yield. A difference-in-difference estimation method was employed to examine the relationships using a control group from the border sharing administrative zones of Oromia region, a region where there has not been a redistributive land reform after the 1991/92 regime change. The first result is that the reform was positively associated with inorganic fertilizer use (kg/ha) and the relationships are significant especially in the “nearby group” or in districts which are relatively closer to the border separating the two administrative regions. Even though land was given to the poor households, they might have not been constrained to access fertilizer as there was a national level scheme to ensure the farmers on credit at a very small interest rate. The losers, who were more likely to increase family labor effort per household land after the reform due to an inverse relationship between farm-size and productivity, might have also been induced to use fertilizer intensively because of the complementarities between family labor and inorganic fertilizer in increasing crop yield.

The relationships of the land reform with crop yield as well as with the value of crop yield were, however, significantly negative. Since family labor and farming capability (such as the number of oxen) were not taken into consideration during the land allocation, the land ceiling on the bureaucrats and remnant feudal classes might have resulted in an underuse of their resources such as family labor and oxen in the short-run. Analysis of data from the 2014 RePEAT survey in Ethiopia also suggests that the reform has distorted the resource allocation in the affected areas in the short-run. In this regard, about 61 and 37 percent of losers reported that in the short-run the reform forced them to underuse their own oxen and family labor, respectively. Because of the imperfections in the markets for inputs in the rural areas, the beneficiaries who were predominantly land poor or landless before the reform might have been unable to access some of the key inputs like oxen in the short-run. Moreover, some of the beneficiaries were the youth who are more likely to be less experienced in farming and this in turn might have also contributed to the decrease in crop yield in the short-run.

The findings suggest that land redistribution should be accompanied by support schemes for the poor beneficiaries to lessen their financial constraint for the access to key farm inputs such as oxen to reduce the negative effect of land redistribution on production efficiency in the short-run. Rural capacity building might also help to reduce the resource misallocations by stimulating the market for inputs in the rural areas. Most of the institutions which facilitate input transactions such as the rental of land for duration of three or more years are not easily accessible or the contracting parties need to travel to the district cities. Improving such facilities at peasant association and/or village levels could improve the market for inputs.

Chapter 4

The long-term consequences of the 1996/97 land redistribution on farm practices and agricultural productivity in Amhara region

A brief review of the 1996/97 land redistribution in Amhara region and the description of a conceptual framework which show the relationships of the reform with the farm practices and crop yield were offered in Chapter 2. This is a continuation of that chapter and provides empirical evidence on the long-term consequences of the reform on farm practices and crop yield. The analyses begin with the empirical specifications and hypotheses followed by the discussion of results and the concluding remarks, respectively.

4.1 Empirical specification

As discussed in Chapter 2, there are the two channels, the changes in land size per household and tenure security perception, for the redistribution to affect farming practices and productivity. One of the approaches to examine the effects of programs such as land redistribution is the use of control groups and this approach requires data from closely related areas of the affected and unaffected administrative regions. The 2014 RePEAT survey data in Ethiopia could be used for employing the control group approach to investigate the long-term consequence of the 1996/97 land redistribution in Amhara region because the survey covered the North Shewa zone of Amhara region and the border sharing zones of Oromia region (Noth Shewa and East Shewa) (Figure 3.2). Using control groups from border sharing zones helps to reduce estimation biases arising from agro-ecological differences between the treated and control groups.

In addition, the three zones had been under the same administrative division called Shewa *Kifle Hager (Kifle Hager* means a semi-country in Amharic*)* until 1991. The main criterion for the *Kifle Hager* based administrative divisions was the geographic proximity regardless of the ethnicity and other aspects of the inhabitants. But after the government change in 1991, ethnic based federalism was adopted and the administrative divisions were redefined based on ethnicity of the inhabitants. This has separated some of areas which were under one *Kifle Hager* into different ethnic based regions after 1991. For instance, the Amhara ethnic inhibited parts of the former Shewa *Kifle Hager* were classified as North Shewa zone in Amhara region, while the Oromo ethnic inhibited parts of were categorized in three zones in Oromia region as North Shewa, East Shewa, and West Shewa.[15] Thus, the control groups are not only closely related with the treated groups by their agro-ecologies but also by the type of administration they experienced until 1991.

Moreover, the farmers in the control group are bilingual who speak both Afan Oromo and Amharic and most of them are Orthodox Christian believers like the farmers in the Amhara region.[16] These agro-ecological, social, cultural, religious, and linguistic similarities in these border sharing farming areas are likely to attenuate the estimation biases arising from the dissimilarities between the comparable groups. Variables such as

[15] The West Shewa zone of Oromia is not considered because it does not share border with the affected parts of the Amhara regional zones.
[16] The working language of Ethiopian Orthodox Christian religion has been Amharic

landholding certificate, access to fertilizer on credit, and infrastructures are controlled in each regression to account for the effects of policies and investments other than the land redistribution. Moreover, the results are checked for robustness by estimating village fixed effect regressions for each region.

A key explanatory variable for analyzing the land redistribution effect is the Amhara region dummy denoted by *DAmhara*, which takes one for Amhara or the only region where the 1996/97 land redistribution took place and zero for the control group or border sharing zones of Oromia region. The coefficient of *DAmhara* dummy captures the net land redistribution effect which is the sum of the resource reallocation and tenure security effects conditional on the observable covariates. The specification is based on the conditional independence assumption of the potential outcome variable denoted by y_{pci} with *DAmhara* after controlling for the vector of observable exogenous variables, *X*. The specification is given below in equation (4.1).

$$\mathrm{y_{pci}} = \beta_0 + \beta_1 \mathrm{DAmhara} + \mathrm{X}\delta + \varepsilon_{\mathrm{pci}}. \qquad (4.\ 1)$$

where the subscripts *c* and *i* denote crop type, and household, respectively while p denotes parcel for soil conservation variables (because these variables are reported at parcel level) and it represents plot for the intermediate input uses and crop yield. y_{pci} denotes the different outcome variables: soil conservation methods, intermediate input use, HYV seed adoption, row planting practice, crop yield, and value of crop yield. X is as the vector of observable village, household, and plot characteristics; and finally ε_{pci} is the error term.

The specification in equation (4.1) does not help to separately measure the tenure security perception and the resource reallocation effects of the reform. Since the farmland per household was directly affected by the reform, additionally controlling of this variable might help to disentangle the average resource reallocation effect. In other words, the land redistribution increased the number of small farmers who have incentive to increase the intensity in family labor hours per farmland in the affected areas than in the control areas. The kernel density in Figure 3.3 suggests land inequality is lower in Amhara than in the control areas. A significant negative coefficient of farmland per household could signify the average gain in land use efficiency in the affected areas due to the land reallocation.[17] If farmland per household captures the reallocation effect, then the coefficient of *DAmhara* shows the tenure security perception effect. The specification with the farmland variables is presented in equation (4.2) as follows.

$$y_{pci} = \beta_0 + \beta_1 \text{DAmhara} + \gamma \ln(\text{farmsize}_i) + X\delta + \varepsilon_{pci}. \qquad (4.\ 2)$$

Using the specification in equation (4.2) it is possible to drive the estimates for the tenure security and the resource reallocation effects of the reform. For simplicity, there are only two explanatory variables in equation (4.2): $DAmhara$ and $ln(farmsize_i)$. Then the average predicted value of the dependent variable for the treated (Amhara) and control (Oromia) groups are given by equations (4.3) and (4.4), respectively. The total difference in the average of the predicted value of the dependent variable between the treated and control

[17] This relationship is also checked for robustness by village fixed effect regressions separately for the treated and control groups. If the 1996/97 reform improved the land use efficiency, then the coefficient of farmland per household should be smaller or insignificant in the affected areas than in the control groups.

groups is shown in the left hand side of equation (4.5). The terms in the right hand side of equation (4.5), on the other hand, shows the decomposition of the total effect into the two effects where the product of $\hat{\gamma}$ and the mean difference in farm-size per household between the two groups captures the average resource reallocation effect; and $\widehat{\beta_1}$ explains the portion explained by the change in tenure security perception as a result of the land redistribution.

$$\overline{y_{Amh}} = \widehat{\beta_0} + \widehat{\beta_1} + \hat{\gamma}[\overline{\ln(\text{farmsıze})_{Amh}}] + \overline{\varepsilon_{Amh}} \, . \tag{4. 3}$$

$$\overline{y_{orom}} = \widehat{\beta_0} + \hat{\gamma}[\overline{\ln(\text{farmsıze})_{Orom}}] + \overline{\varepsilon_{Orom}}. \tag{4. 4}$$

$$\overline{y_{Amh}} - \overline{y_{Orom}} = \widehat{\beta_1} + \hat{\gamma}\left[\overline{\ln(\text{farmsız})_{Amh}} - \overline{\ln(\text{farmsız})_{Orom}}\right] + \overline{\varepsilon_{Amh}} - \overline{\varepsilon_{Orom}}. \tag{4. 5}$$

The other aspect of the land redistribution is the issue of heterogeneous tenure security consequence. As described in Chapter 2, the reform was implemented by classifying farmers based on their relationships with the previous political regimes instead of implementing it on objective criterions such as family size. Thus, the approach was divisive and discriminatory for those who were officers during the past regimes. To account for this issue, the farmers in Amhara region are classified into unaffected, beneficiaries, and losers depending on how the reform changed their farmland and then the dummies denoted by *DUnaffected*, *DBeneficiaries*, and *Dlosers* which respectively takes a value one if the farmer's land size was unchanged/increased/decreased by the 1996/97 land reform and zero otherwise are included as shown below in equation (4.6).

$$y_{pci} = \beta_0 + \beta_1 \text{DUnaffected} + \beta_2 \text{DBenefciaries} + \beta_3 \text{Dlosers} + \gamma \ln(\text{farmsize}_i) + X\delta + \varepsilon_{pci}. \tag{4. 6}$$

Given farmland per household and the other observable covariates, significant differences between *DUnaffected*, *DBeneficiaries,* and *Dlosers* dummies suggest a heterogeneous tenure security consequence within the region. The sizes of land received (*LReceived*) or land lost (*LLost*) in 1996/97 could also be highly associated with the tenure security perceptions of farmers and hence they are used as alternative measures of heterogeneous tenure security and used as presented below in Equation (4.7). Focus is given to the results which are consistent and robust in regressions obtained using the treatment dummies and the sizes of land received and lost.

$$y_{pci} = \beta_0 + \beta_1 \text{DAmhara} + \beta_2 \text{LReceived} + \beta_3 \text{LLost} + \gamma \ln(\text{farmsize}_i) + X\delta + \varepsilon_{pci}. \tag{4. 7}$$

In addition, propensity score matching method is also employed but only for analyzing the impact of the reform on the losers' farm practices. The main variable used for matching are the land-size of losers just before the reform and the current landholding size for the control farmers. The reason is that most of the losers could have continued to hold larger proportion of their pre reform landholding if they were not affected in 1996/97. The other additional variables for the matching include gender, age, and the education status of the head. Then the weighted regressions are estimated for the matched samples. The propensity score approach was not used to for the beneficiaries and unaffected categories because there are no appropriate variables which help to find the matches fir these groups.

4.2 Hypotheses

Based on the literature and conceptual framework in Chapter 2, the following hypotheses are proposed.

Hypothesis 4.1: Land redistribution increases the number small farmers who have more incentives to carry out the farming activities like the soil conservation practices, ploughing, and weeding using family labor instead of hired labor. Moreover, due to the complementarity between family labor and intermediate inputs in increasing crop yield, the small farmers might be induced to use fertilizers intensively and to adopt HYV seeds and improved sowing methods. Thus, the reform is expected to enhance the average intensity and crop yield in Amhara region.

Hypothesis 4.2: As reviewed in Chapter 2, empirical studies have shown negative relationships between land redistribution and long-term farm investments such as stone terraces. Similarly, the Amhara region dummy in equation (4.2) is expected to have significant negative coefficients in the regressions for organic fertilizer use and for stone terrace investments on the sloppy parcels.

Hypothesis 4.3: Even though the land redistribution could increase the overall tenure insecurity in Amhara region, the favored ones or the land beneficiaries could have higher tenure security than the non-beneficiaries due to their favorable relationship with the current regime while the losers could be the most insecure due to their collaboration with the previous political regimes. Thus, beneficiaries are expected to have a higher likelihood of carrying out long-term soil conservation investments and using organic fertilizers than the non-beneficiary classes ingeneral. Similarly, the unaffected farmers are expected to have higher likelihood of carrying out stone terraces and use organic fertilizers intensively than the losers.

4.3 Data Source and descriptive statistics

4.3.1 Data Source

The analysis in this chapter is based on the data collected in Ethiopia as part of the RePEAT project.[18] Three RePEAT surveys have already been conducted in Ethiopia in 2005, 2007, and 2014. But the sample sizes were small in the first two waves especially in Amhara region. Moreover, detailed data about land redistribution was not collected in the first two waves. The 2014 wave, on the other hand, has large sample size and detailed information on land redistribution. Hence, the main analysis in this chapter is based only on the third RePEAT wave. Even though the survey covered wider geographical areas, data is used only from the North Shewa zone of Amhara region and from the North and East Shewa zones of Oromia. These administrative zones are close to each other and shares border, and focusing on these closely located areas helps to reduce the estimation biases related to agro-ecological heterogeneities. The third wave interviewed about 146 and 164 farmers from these border sharing zones of Amhara and Oromia regions, respectively.

[18] The RePEAT project is an on-going longitudinal rural household survey project in three East African countries, namely, Kenya, Uganda, and Ethiopia. The project has started since 2003 by the research team in National Graduate Institute for Policy Studies (GRIPS) and local collaborators in each country.

4.3.2 Descriptive statistics

Table 4.2 shows the summary statistics of demographic characteristics of farmers and their landholding. The results for the samples in Amhara are presented by their treatment status in 1996/97. The losers were the oldest with an average of 60 years old whereas the beneficiaries were the youngest with an average of 45 years old (as of 2014) and these shows the pro youth nature of the reform. Comparison of the land before and after the redistribution shows that the reform reduced the average landholding of losers from 4 to 2 hectares and increased the beneficiaries' landholding from 0.4 to 2 hectares. The distribution of landholding and land under operation are roughly equal across the three categories with averages of about 1.6 and 1.9 hectares, respectively.[19] These suggest that the land redistribution might have reduced the inequalities in landholding and the land under operation. The average net landholding and land under operation in the control group (N & E. Shewa zones of Oromia) are about 2.4 and 2.7, respectively. Dadi *et al.* (2004) also reported an average net landholding of 2.5 hectares in the North and East Shewa zones of Oromia region. As can be seen in Figure 3.3, the inequality in landholding between farmers in Oromia is larger than in Amhara.

Table 4.3 reports the summary statistics of soil conservation methods, parcel characteristics, input use, and crop yield. The most common types of soil conservation methods in the study areas are stone terraces, contour plough, and drainage ditches and/or

[19] The larger land under operation than the holding size across the three classes is because some landholders rent out their land and reside in the nearest town for self-employment, schooling or other reasons. These farmers lose the land only if they are employed in the public sector on permanent basis.

check dam. Stone terraces are series of platforms constructed on the sloppy parcels using stones to protect soil from erosion; and contour plough is the plowing across the slope to reduce soil erosion in the time of heavy rainfalls. The drainage ditches, on the other hand, are small or moderate created depressions or trenches to protect water from entering the plot and to channel it to a constructed check-dam and/or river. Check-dams and drainage ditches have complementary roles but the most common one in the study areas is the drainage ditch system. The collected data for these two practices takes a value one if the farmer carried out check-dam and/or drainage ditches on the parcel and zero otherwise.

The summary statistics in Table 4.3 shows that stone terrace investments (on sloppy parcels) are the highest for the beneficiaries with 32 percent (out of their total sloppy parcels). The losers and unaffected farmers, on the other hand, have more proclivities for contour ploughs and drainage ditches/check-dam, which are short-term soil conservation methods, instead of stone terraces. The summary statistics of plot-level variables show that both losers and beneficiaries are associated with intensive uses of inorganic fertilizers and adoptions of HYV seeds and row planting than the control groups. Finally, all the three categories in Amhara have larger average crop yield than the control groups.

4.4 Regression results

Before proceeding to the discussion of the regression results, it is worth to describe the rationales for choosing the Amhara region, beneficiaries, losers, and unaffected dummies in the empirical specification to capture the tenure security perception effects of the reform over the self-reported binary measures of tenure security perceptions. Firstly, a quasi-experimental approach which uses control groups from the border-sharing administrative unaffected areas is used to measure the effect of the reform and the treatment dummies suits this identification strategy compared to the self-reported binary measures of tenure security perception. Second, the reform might have affected the tenure security perception of the farmers depending on how they were treated (benefited, lost, or unaffected) and this issue can be better captured by the treatment status dummies. Finally, the reviews of empirical studies which used binary measures of tenure security perception shows that these measures are not good predictors of farm investment (Fenski, 2011). If this is the case, then measures which are defined based on how the farmers were treated during land redistribution could be better alternatives over the self-reported binary measures in predicting farm investment and productivity.

It is also necessary to show the relationships between the treatment measures in the empirical relationship and the self-reported measures of tenure insecurity. The regression for the tenure insecurity measure, which is a dummy variable that takes one if the farmer expects land redistribution in the next 10 years or uncertain and zero otherwise, on the treatment dummies and on a vector of household level characteristics including age, gender, and years of schooling of the head and village characteristics are estimated but only the coefficients of the treatment dummies are reported to save space (Table A.5). Similar approach was employed to investigate the determinants of tenure insecurity, measured by expectation of land reallocation in the next 30 years, in the case of China (Kimura *et al.*, 2011). The signs of the treatment dummies are with the expected sign but they are not significant. The Amhara dummy is positively associated with high tenure insecurity probably because this is the only region affected by land redistribution after the 1991 regime change. Heterogeneous tenure security consequences are also observed within Amhara. More specifically, the beneficiaries are the least likely to be tenure insecure whereas the losers and the unaffected are more likely to be tenure insecure.

The remaining parts of the discussions are organized as follows. The results of the regressions for soil conservation practices are discussed first followed by the results for intermediate inputs and crop yield, respectively. Probit and Tobit regression models are respectively used to estimate the dummy and censored dependent variables while crop yield and value of crop yield are estimated by the simple linear regression. The marginal effects computed at the average value of each covariate.

4.4.1 The regression results for soil conservation methods

In this section emphasis is given to the results of soil conservation investments on sloppy parcels because they are the more vulnerable to erosion than the non-sloppy parcels. The non-sloppy parcels also need soil conservation methods especially the short-term methods such as drainage ditches to protect erosion related to flooding and high runoff during the rainy seasons. Table 4.4 reports the marginal effects from the Probit regressions for the soil conservation methods on sloppy parcels. The Amhara region dummy is positively associated with the probability of carrying out the short-term conservation methods but significant only in the case of contour plough. Its relationship with stone terraces is, however, negative though the coefficient is not significant. In the regression for soil conservation methods using the entire parcels, the Amhara dummy is significantly positive on the short-term soil conservation methods (Panel A of Table 4.5). The marginal effects suggest that the farmers in Amhara region are associated with a respective 14 and 3 percentage points' larger probability of carrying out contour ploughs and check-dam/drainage ditches than the control groups.

The negative relationship of the Amhara dummy with stone terraces on sloppy parcels and its positive association with the short-term soil conservation methods might associated with the tenure insecurity problem in the region. The returns of long-term soil conservation methods cannot be fully reaped within the short-term unlike the short-term conservation methods. Hence, in areas where tenure insecurity is high, farmers might show more proclivity to the short-term conservation practices over the long-term ones. Other studies which found similar result include Deininger and Jin (2006) who showed a decline in stone terraces in the districts affected by recent land redistributions. Gebremedhin and Swinton (2003) also found that tenure secure farmers have larger likelihood of investing in stone terraces whereas tenure insecure farmers practice the short-term soil conservation methods such as soil bunds.

[Insert Tables 4.4 and 4.5]

The coefficients in Columns (4)-(6) of Tables 4.4 and 4.5, on the other hand, are obtained by controlling the beneficiaries, losers, and unaffected dummies instead of the

Amhara dummy. The coefficients of these dummies help to see whether the reform has a heterogeneous tenure security effect within Amhara region or not. The dummy for beneficiaries is positive and significant in the regression for stone terraces on sloppy parcels. Its marginal effect in Column (4) of Table 4.4 shows that being a land beneficiary is associated with a 19 percentage point larger probability of carrying out stone terraces on sloppy parcels than the average control group. The null hypotheses that the coefficient of the beneficiaries' dummy is not significantly different from the coefficients of the losers' dummy and the unaffected dummy in the regressions for stone terraces are rejected with p-values of 0.000 and 0.007, respectively. Hence, being a beneficiary is associated with 23.7 and 22.4 percentage point larger likelihood of carrying out stone terraces than the unaffected and the loser farmers of the region, respectively. The coefficient of the loser dummy in the weighted regression on the matched samples suggest that those who lost land are 7.6 percentage point less likely to carry out stone terraces than their matches in the control group (Panel C of Table 4.5).

Consistent results are obtained for the beneficiary dummy on stone terraces when the regressions on the entire parcels are estimated and also when sizes of received and lost land are controlled instead of the beneficiary and loser dummies (Panels A&B of Table 4.5). The results from the village fixed effects in Table A.6 also show significantly positive coefficients for the beneficiary dummy and the land received variables in the regressions for stone terraces on sloppy parcels. These show the existence of a robust relationship between being a beneficiary and the likelihood of carrying out stone terraces in Amhara region. Those who were "disadvantaged" in the previous political regimes were favored during the implementation of the 1996/97 land redistribution and that special favor might have enhanced their tenure security over their landholding so long as the same political regime stays in power, and the high tenure security is a good incentive to practice long-lasting investments such as stone terraces on parcels. This finding is consistent with the third hypothesis.

The coefficients for the losers and unaffected dummies, on the other hand, are negatively associated with stone terraces on sloppy parcels but positively associated with the short-term soil conservation methods. Significant coefficients for both dummies are found in the regression for the short-term conservation methods on the entire parcel observations. The losers are significantly associated with both contour plough and check-dams/drainage ditches, and the unaffected are significantly associated with check-dam/drainage ditches. The coefficient for beneficiary dummy is also significantly positive in the regression for contour plough when the entire parcel observations are used but its marginal effect is significantly lower compared to that of the loser dummy. The results using the dummies for the beneficiaries, losers, and unaffected generally suggest that those who received land are more likely to carry out stone terraces on sloppy parcels whereas the losers and the unaffected groups are more likely to implement the short-term soil conservation methods.

Farm size, the second main variable of interest has a negative sign but significant only in the case of stone terraces and check-dams (Table 4.4). The significance of farm-size prevailed only in Oromia when village fixed effect are controlled (Table A.6). The difference in farm-size between the small and large farmland holders is small in the case of Amhara region which is more likely due to the 1996/97 land redistribution. Thus, there are no significant differences in soil conservation investments between different farm-size holders in the region. But the distribution of farmland in the control areas is inequitable and hence there is a significant difference on the soil conservation investments between the small and the large farmland holders. In other words, the small landholders in the control could put significantly larger family labor per farmland to carry out labor intensive soil conservation practices than the large farm landholders. These results are consistent with hypothesis 4.1.

4.4.2 The regression results for intermediate input uses and technology adoption

The regression results for fertilizer use (kg/ha), HYV seed adoption, and row planting practice adoption are reported in Tables 4.6 and 4.7. Since there are five outcome variables, the space limitation does not allow presenting the estimation results with Amhara dummy and with unaffected, beneficiary, and loser dummies in one table. Hence, in Panel A of Table 4.7 the coefficients for the Amhara dummy and farmland are reported but the coefficients for the other covariates are not reported to save space. The results show that the Amhara dummy is negatively associated with organic fertilizer use but not significantly. Its negative sign is consistent with the second hypothesis that majority of the farmers in Amhara region might be discouraged to use organic fertilizers due to tenure insecurity. But it has significant positive relationship the use of dap (kg/ha), HYV seed adoption, and row planting adoption. There is no consensus in the literature about the relationships between tenure insecurity and the use of short-term intermediate inputs. The results in Table 4.6 which control for the unaffected, beneficiaries, and unaffected dummies instead of the Amhara dummy might help to better understand the relationships between the tenure security measures and the short-term intermediate inputs.

The coefficients for beneficiaries and losers are positive and significantly larger than the coefficient for the unaffected group in the regressions for dap (kg/ha), and adoptions of HYV seeds, and row planting.[20] The coefficient of the beneficiaries dummy suggest that those who received land in 1996/97 apply 60 percent more dap (kg/ha) and they are also 8.3 and 2.3 percentage point more likely to adopt HYV seed and row planting than the unaffected farmers. In Section 4.4.1, a significant relationship between the beneficiary dummy and stone terrace investment was uncovered. Thus, the significant positive coefficient for this dummy in Table 4.6 suggests that those who received land might be also increasing the use of the short-term inputs because these inputs are complementary with stone terraces in increasing crop yield.

[Insert Table 4.6 and 4.7 here]

Being a loser is also associated with an 80 percent increase in the use of dap (kg/ha), and an 8 and 2.8 percentage point increase in the probability of adopting HYV seeds and row planting than the unaffected group in Amhara. The results from the weighted regression on the matched samples also show that losers are significantly associated with

[20] The null hypotheses that the coefficient for unaffected dummy is equal to the coefficient for the beneficiary and losers are both rejected.

increased use of dap (in kg/ha) (Panel C of Table 4.7). These results might be probably due to the substitution of inorganic fertilizers for the organic ones by the losers due to tenure insecurity. As can be seen in Table 4.6 and Panel B of Table 4.7, the coefficients for both the loser dummy and the size of lost land are negative in the regressions for organic fertilizer use (kg/ha). When village fixed effects are additionally controlled, both the loser dummy and the size of lost land have significant negative relationship with organic fertilizer use (Panels D&E of Table 4.7). Thus, those who lost might be responding behaviorally by substituting the short-term inputs for the long-term ones due to tenure insecurity.

Regarding farm-size, its coefficient is negative in three (out of five) regressions in Table 4.6, and in four (out of five) regressions in Panels A and B of Table 4.7. But interpreting its coefficients as an improvement in resource reallocation effect for these inputs is problematic because the expected results are not obtained when village fixed effects are additionally controlled. Since farmland per household is more equitable in Amhara than in Oromia, the difference in the intensity in the intermediate input use between the smaller and larger farmland holders should have been smaller than in Oromia. But the results show that the coefficients of farmland are significantly negative only in Amhara when village fixed effects are controlled (Table 4.7 Panels D-F).

The contrasting result in the village fixed effect might be related to the difference in the access to inorganic fertilizers for the poor farmers between the two regions. Both regional governments distribute inorganic fertilizers to farmers. In Oromia, the distribution is only on cash basis but in Amhara region the poor farmers can acquire fertilizer by paying some upfront payment while the non-poor acquires only on a cash payment. About 22 percent of the samples farmers from Amhara region reported that they received inorganic fertilizers on credit but none of the farmers in Oromia have such access (Table 4.2). The dummy of fertilizer credit which takes one for farmers who received inorganic fertilizer from the scheme and zero otherwise is controlled. But this dummy may not fully capture the program effect because the upfront payments and quantity of fertilizer varies within the eligible farmers depending on their wealth status. If the land poor farmers in Oromia had access to inorganic fertilizers on credit, then the coefficient of farm-size in the village fixed effect for the Oromia samples could have been significantly negative and larger than the coefficient in the regression for the Amhara samples.

4.4.3 The regression results for crop yield and value of crop yield

The regression results for crop yield and value of crop yield are reported in Table 4.8. In Columns (1) and (2), farm-size is excluded from the model so that the Amhara dummy captures the total effect of land redistribution. The Amhara dummy is positive and significant on both the regressions for crop yield and value of yield which indicates a strong positive relationship between the reform and the agricultural productivity in the region. When farm-size is included in Columns (3) & (4), the Amhara dummy remains positive and significant but its coefficient declined which is probably because farm-size captures the resource reallocation effects of the reform. The coefficient of the Amhara dummy in Columns (3) and (4), therefore, captures the tenure security perception effect as farm-size disentangles the resource reallocation effect. Even though the Amhara dummy is associated negatively with organic fertilizer use and with the stone terrace investment on sloppy parcels, its association with the short-term soil conservation practices and short-term intermediate inputs was significantly positive. Hence, it is not a surprise to find a significant coefficient for the Amhara dummy in the regressions for crop yield and the value of crop yield.

In Columns (5) & (6), the dummies for unaffected, beneficiaries, and losers are controlled instead of the Amhara dummy. All of the three dummies are significantly positive on crop yield as well as on the value of crop yield. The pairwise comparison of the coefficients for the three dummies shows the coefficients for the unaffected dummy is slightly lower compared to the other two dummies but the differences are not significant. These suggest that there are no evidences of significant heterogeneous tenure security consequences within Amhara even though significant heterogeneities are observed in the regressions for soil conservation investments and intermediate input uses.

[Insert Table 4.8 here]

The land redistribution is also associated with an increase in the average yield due to the resource reallocation effect. The decline in the coefficient of the Amhara dummy in the regression for crop yield from 0.42 in Column (1) to 0.29 in Column (3) when farm-size is additionally controlled shows how much farmland is important in capturing the resource reallocation effect of the reform. The other way to look at the resource reallocation effect of the reform on crop yield is to look at the sign and significance of farm-size. It is negative and significant on both crop yield and value of crop yield. By applying the formula in equation (4.5), the average increase in crop yield due to the resource reallocation is about 11 percent.[21] Consistent results are obtained when the size of land received and lost instead of the dummies for beneficiaries and losers (Table A.7 Panel-A). The weighted regression on matched samples for the losers also revealed significant resource reallocation effects of the land redistribution on the value of crop yield (Panel B of Table A.7). The coefficients farm-size remain significantly negative especially in Oromia after the village fixed effects included (Panels C-E of Table A.7). There are also indications of an inverse relationship in Amhara region in the village fixed effects, but the magnitude of the relationships and the level of significance are very small compared to the magnitude and significance in Oromia (Panels C & D of Table A.7).

In Section 4.4.3, the results showed that the significant differences observed between the small and larger land holders in terms of intermediate use in Amhara than in Oromia despite the large inequality in farmland in the later. The most probable factor for the observed difference in the coefficient of farm-size between the two regions in the regression for the intermediate inputs is the fertilizer access to the poor on credit scheme in Amhara region, and this program might have attenuated the resource reallocation effects of the land redistribution in Amhara. To disentangle the contribution of the input credit program to the inverse relationship, the intermediate inputs are additionally controlled in

[21] The reallocation effect is given computed as -0.55*(0.86-1.07)= 0.11, where 0.86 and 1.07 are the averages ln(farm-size) in Amhara and Oromia, respectively, and -0.55 is the coefficient of farm-size in the regression for crop yield.

the village fixed effect regressions as a robustness check (Table A.8). The results show that neither the coefficient size nor the level of significance of farm-size changed in Oromia by additionally controlling the intermediate inputs. But controlling for the intermediate inputs in the Amhara samples resulted in a decrease in the coefficient of farm-size and significance. Indeed the significance of farm-size disappeared on the regression for crop yield and become close to insignificance in the regression for the value of crop yield in Amhara. These suggest that through its resource reallocation effect, the land redistribution has significantly improved the average crop yield in Amhara region.

4.4.4 The other correlates of farm practices and crop yield

This section offers a brief discussion on the other covariates of the outcome variables. Emphasis is given to the significant coefficients to save spaces. The interpretations are based on the marginal effects in Columns (4)-(6) of Table 4.4 for the soil conservation methods and Columns (1)-(5) of Table 4.6 for intermediate inputs and row planting; and the coefficients in Columns (5) and (6) of Table 4.8 for the crop yield and value of crop yield. The discussion begins with the household characteristics and move onto the parcel, plot, and village level characteristics.

From the household characteristics, the coefficient of male head dummy is positive on stone terraces but negative on contour plough and check-dams practices. These signs suggest that the male headed households might have more incentive to make investment on long-term soil conservations whereas the women headed have more proclivity for the short-term soil conservation methods probably because they may be less tenure secured than the male headed because of gender inequality. The male head dummy has significant positive sign on row planting which might be due to their better access to agricultural extension than female headed households. The year of schooling of the head is also positively associated with stone terraces, check-dams, and crop yield which show the importance of formal education on farm practices and crop yield by increasing farmers' awareness and knowledge about new technologies and improved farming methods. The age of the head, on the other hand, is significantly negative in the regressions for inorganic fertilizers (kg/ha), row planting adoption, crop yield, and value of crop yield probably because older farmers could be conservative to adopt new technologies and to try new farm practices (Gul Unal, 2006).

Livestock (in tropical livestock unit), number of oxen, and value of assets are controlled as measures of wealth.[22] The coefficients of these covariates are significantly positive in most of the regressions and the results suggest that access to capital is a key to increase farm investment and crop yield. The relative farm-size per capita, which is the ratio of farm-size per family size to the village average farm-size per family size, is controlled to test whether the tenure insecurity varies with the relative position of farmers in terms of their farmland (Alemu 1999 in Holden and Yohannes, 2001). This measure was expected to be negative on long-term investments if the relatively larger farmers were more insecure than the small farmers due to fear of land redistribution. But its coefficient is

[22] Tropical Livestock Unit helps to quantify several livestock types in standardized units. More about the index can be found at http://www.fao.org/ag/againfo/programmes/en/lead/toolbox/Mixed1/TLU.htm

insignificant in the regressions for soil conservation methods and significantly positive on the quantity of organic fertilizer (kg/ha) and crop yield. These suggest that there are no evidences of an inverse relationship between tenure security and the relative position of the household in landholding. It is possible that farmers with a higher position in terms of relative landholding in the villages could be politically and economically influential in their villages and that in turn might increase their tenure security (Holden and Yohannes, 2001).

The coefficient of the dummy for the access to inorganic fertilizer on credit scheme is significantly positive in the regressions for inorganic fertilizer variables (kg/ha), crop yield, and value of crop yield; but its coefficient in the regressions for organic fertilizer use (kg/ha) and HYV seed adoption are significantly negative. The negative coefficient of the scheme on organic fertilizer might be because the poor beneficiaries could substitution the inorganic fertilizers for the organic to use the animal wastes such as cow dung to make cow dung cakes for income generation by selling it to urban households as firewood. The negative correlation of the scheme with HYV seeds adoption, on the other hand, might be because those eligible for the scheme are too poor to buy improved seeds on cash.

From the parcel and/or plot level characteristics, the coefficients of parcel size are significantly positive in the regressions for all the three soil conservation methods which suggest that farmers give priority to the protection of larger parcels over the smaller ones probably due to the scale advantage on the former. The coefficient of plot size is significantly positive in the regression for HYV seed adoption but significantly negative on row planting. The negative correlation with row planting may be due to the fact that farmers in the study areas are planting teff crop in rows which is very time consuming due to the tiny seed of this crop and farmers could chose smaller plots due to labor constraint.

The measures of land fragmentation indicators, the number of parcels and Simpson Index, have mixed signs in the regressions.[23] The net effect of the number of parcels is significantly negative in the regression for stone terraces on sloppy parcels but significantly positive on the quantity of organic fertilizer use (kg/ha).[24] Even though the coefficients of number of parcels and its square are insignificant on crop yield, the sign of their coefficients suggest that the number of parcel are associated positively with crop yield but at a decreasing rate. The coefficient of Simpson Index, on the other hand, is significantly negative on the value of crop yield which suggests that land fragmentation is detrimental to crop yield.

From the studies in other countries, a study in the case of Japan uncovered unambiguous significant negative coefficients for both the number of parcels and the SI in the regressions for agricultural efficiency (Kawasaki, 2010). The unambiguous negative effects of land fragmentation indicators in Japan but the mixed result for these measures in Ethiopia could be due to the difference in risk coping mechanisms between farmers in advanced and developing countries. The farmers in developed countries could have better risk coping mechanisms and hence land consolidation might increase their agricultural efficiency. But farmers in developing countries may not have risk coping mechanisms

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[23] SI = $1 - \frac{\sum(A_i^2)}{(\sum A_i)^2}$ where A_i is the i^{th} parcel size in hectare (Kawasaki, 2004). An SI value that is close to zero indicates more consolidation and an index value close to one indicates larger fragmentation.
[24] The net effect refers to the marginal effect obtained from the linear and quadratic terms.

when crops fail. One way to mitigate the magnitude risks of crop failures is to spread inputs over scattered parcels to reduce spatially varying risks of crop production (Gul Unal, 2008).

The dummy for leased-in parcel, parcels under share-cropping or fixed rental contracts, is significantly negative in the regression for organic fertilizer use (kg/ha).[25] Organic fertilizers increase soil fertility and crop yield for longer period but the tenure period over leased-in parcels is often short. As a result, farmers might be reluctant to apply this input on leased-in parcels due to tenure insecurity (Givian and Fafchamps, 1996). Its coefficient is also negative in the regression for crop yield but not significant. The negative sign is most probably due to the limited use of inputs such as organic fertilizers and the Marshallian inefficiency on the share-cropped plots.

The coefficient of distance from home to the parcel (in terms of walking minutes) is significantly positive on inorganic fertilizer use (kg/ha) but significantly negative on organic fertilizer (kg/ha). The results suggest that those who use both inputs allocate the organic fertilizers to the nearby parcels and the inorganic fertilizer to the distant ones because organic fertilizers are bulky to transport to distant parcels whereas the inorganic fertilizers are non-bulky to transport. A negative relationship also observed between crop yield and the parcel distance which might be related to the more care on nearest neighbors such as protection from animal damages and family labor input due to their nearness over the distant ones.

[25] Since fixed rental plots are very small, a leased in dummy that takes one for either share-cropping or fixed rented land and zero otherwise is controlled using owner operated parcels as reference category.

The coefficients of the dummies for self-reported soil quality measures (the reference category is poor quality) are positive in the regressions for organic fertilizer use (kg/ha) and crop yield. But they are negative on row planting probably because farmers in the study areas are new to this practice and trying it mostly for teff crop which has a very tiny seed and very labor demanding to planting in rows. Hence, farmers might be trying on their less fertile plots to avoid risks of decline in crop yield before scaling up it to their most fertile plots. The coefficient of steep slope parcel is positive in the regressions for soil conservation methods on sloppy parcels but significant only on check-dams/drainage ditches. These positive signs suggest that farmers give priority to the protection of the erosion prone over the less prone parcels. The coefficient of rocky parcel dummy is significantly positive in the regression for organic fertilizer use (kg/ha). This is probably because farmers often construct houses in rocky areas for safety from flood during the rainy seasons. Hence, the parcels close to the home could be rocky but farmers could continue to use organic fertilizers on such parcels because it is easier to transport organic fertilizers.

The coefficient of steep slope parcel dummy is significantly negative on inorganic fertilizer use (kg/ha); and the dummy for rocky-surface parcel dummy is significantly negative on inorganic fertilizer use (kg/ha), and on the adoptions of HYV seed and row planting. These show that farmers are reluctant to apply purchased inputs on sloppy and rocky parcels probably due to the low return from such parcels as they are not suitable for farming. The dummies of crop damages have negative associations with crop yield and most of the coefficients are significant.

The other covariates controlled in the regressions are the village characteristics. The accessibility variables have mixed signs in the regressions. For instance, distance from the nearest woreda/district town is positively associated with stone terraces, check-dams, and crop yield which could be because farmers close to towns reduce soil conservation investments due to fear eviction due to the expanding urbanization. The respective coefficients for the access to transport and distance from the nearest market variables are positive (negative) in the regressions for soil conservation methods. The distance from market has the expected negative coefficient in the regressions for inorganic fertilizers and the values of crop yield.

The number of landless households are negatively associated with stone terraces and organic fertilizers but positively with check-dam construction, urea use (kg/ha), and row planting adoption. Probably a large number of landless households signify a high pressure for land reallocation and that in turn reduce the long-term investments by increasing the tenure insecurity of the landholders. The coefficient of population density is significantly positive in the regression for stone terraces.

4.5 Conclusion and policy implications

In this chapter the long-term effects of the 1996/97 land redistribution in Amhara region on farm practices and crop yield were investigated. The total effects of the redistribution were disentangled into tenure security and resource reallocation consequences. Moreover, the heterogeneities with regard to the tenure security consequences are investigated by classifying the farmers in the affected region into beneficiaries, losers, and unaffected depending on the change in their farm-size as a result of the reform.

The coefficient of the overall tenure security perception measure shows that the reform is weakly associated with the declines of organic fertilizer use stone terrace investments on sloppy parcels but it is strongly associated with increases the short-term soil conservation methods and use of short-term intermediate inputs. These results suggest that the majority of the farmers in Amhara tend to choose short-term soil conservation methods and intermediate inputs over the long-term soil conservation methods and intermediate inputs like organic fertilizers. This is probably due to the high tenure insecurity because it reduces their incentives to do long-term investments as the return from these investments may not be fully reaped in the short-term. But the overall effect of these changes on crop yield is significantly positive.

The results further show that there are heterogeneities even within the Amhara region. Those who received land during the 1996/97 land redistribution have a higher likelihood of carrying out stone terraces than the non-beneficiaries. Land was mostly given to the land poor classes who did not play any administrative role during the past regimes and to their children. Hence, their favorable relationship with the current political regime could be the driving factor which enhanced their tenure security and stone terraces investment on sloppy parcels. The other important finding is that the land redistribution brought a significant gain in the efficiency of farmland use. In other words, by transferring land from land rich to land poor farmers, the reform increased the family labor hour per farmland for the several farming activities in the region. The gains in the resource reallocation gains are significantly large in stone terraces, check-dams/drainage ditches, and finally on crop yield and value of crop yield.

Before putting forward our policy suggestions, I want to point out that the analysis in this chapter is based on small cross-sectional affected sample households from North Shewa administrative zone in Amhara region using control groups from neighboring administrative zones of Oromia region. Thus, further longitudinal based studies from the other zones of the region are necessary to generalize the results. Despite these limitations, the findings have important policy implications. First, the current regional land proclamation allows further redistribution if 80 percent of the village residents vote for it. However, land per household is already small and further land redistribution may not be feasible and could affect the tenure security of those who have no favorable political relationship with the current regime. Abandoning land redistribution from the regional land proclamation could increase tenure security and stimulate long-term investment on farmland.

Second, efforts to increase employment opportunities in the nonagricultural sector might reduce the fear of land redistribution in the future by absorbing the landless youth from the rural areas. Thirdly, rural capacity building which facilitate land transaction could stimulate the transfer of land from the inefficient to the efficient farmers especially in the control areas where landholdings are less even. Furthermore, voluntary land consolidation programs for the relatively larger farmers might reduce inefficiencies related to large fragmentation. Fourthly, increasing the poor farmers' access to fertilizer and HYV seeds on credit could boost agricultural intensification.

Chapter 5

Agriculture extension, social learning, row planting practice adoption, and agricultural productivity in Ethiopia

5.1 Introduction

The adoption of new and improved agricultural technologies by farmers in developing countries has attracted considerable research interest among development economists because it is a key factor to increase productivity and farm income (Feder, Just, & Zilberman, 1985; Foster and Rosenzweig, 2010). The dissemination speed of these technologies, however, has been slow especially in SSA where agricultural productivity has remained low (Bulte, Beekman, Di Falco, Hella, & Lei, 2014; Matsumoto, Yamano, & Sserunkumma, 2013; World Bank, 2008). The major constraints to adopt these technologies in developing countries include credit constraint (Croppenstedt, Demeke, & Meschi, 2003; Simtowe, Zeller, & Diagne, 2009; Zeller, Diagne, & Mataya, 1998), lack of risk coping mechanisms (Dercon and Christiaensen, 2011; Karlan, Osei, Osei-Akoto, & Udry, 2014; Liu, 2013), poor access to information (Aker, 2011; Otsuka, 2006), poor infrastructural development, market imperfections, and heterogeneous agro-ecological systems (Otsuka, 2006; World Bank, 2008).

The effort to overcome the barriers of agricultural technology adoption has increased over time through investments on public agricultural extension; but the impacts of the extension on farmers' awareness, knowledge, and productivity have been limited (Aker, 2011; Anderson and Feder, 2007; Davis, 2008). For instance, the current government of Ethiopia has been investing heavily on public agricultural extension especially for the dissemination of inorganic fertilizers and HYV seeds. The empirical studies showed significant positive association between agricultural extension and crop yield in Ethiopia but the crop yield is still much lower than the intended level (Spielman, Kelemworq, & Alemu, 2011). The studies on the determinants of inorganic fertilizers and HYV seeds adoption showed that both agricultural extension and learning from neighbors played a key role in the late 1990s when majority of the farmers had no prior knowledge about the technologies but after some time only the learning from neighbors was an important determinant of adoption (Krishnan and Patnam, 2013). These suggest that the role of technology specific extension services might decline over time and strategies for an efficient use of the agricultural extension are necessary.

It seems that the government has learnt from the evaluation of the extension system. This can be seen from the type of technologies that received emphasis in the agricultural extension over time and the extension approach. Recently emphasis has been also given to promote improved agronomic practices in addition to inorganic fertilizers and HYV seeds. Moreover, unlike the previous extension approach where the extension agents were only delivering the extension services to each farmer, the recent extension approach requires them to facilitate group learning between neighboring farmers. After classifying farmers based on their proximity, they offer training for the more capable farmers from each group. The trained farmers are in turn required to pass the acquired knowledge to their respective group members through group discussion, training, and plot demonstration from adopter neighbors.

Row planting, which is a new planting practice of cereal and legume seeds in rows at a reduced seed rate, is the major agronomic practice that the government of Ethiopia has given much emphasis recently. In Ethiopia, most of the farmers practice an inefficient traditional broadcast sowing method which is the scattering or broadcasting of seeds by hand and usually require large quantity of seed per hectare (Asargew, Bitew, Asfaw *et al.,* 2014; Vandercasteelen, Dereje, Minten, & Tafesse, 2013). Planting seeds in rows could be superior in raising crop yield than the broadcasting method because it reduces the competition for soil nutrients and moisture between seedlings, makes it easy to carry out weeding, and allows each seedling to have multiple branches or tillers (Abate, de Brauw, Minot, & Bernard, 2014; Vandercasteelen *et al.*, 2013). Since this improved planting method is a new to most farmers, agricultural extension could be an effective means to disseminate the practice and to stimulate group learning about the practice.

Although the government of Ethiopia has given much emphasis to disseminate the row planting practice, studies on the determinants of row planting adoption and its impact on crop yield are limited. There is only one study on the determinants of row planting adoption in Ethiopia. Todo *et al. (*2012) studied the role of development agents and social networks on the diffusion and adoptions of compost and row planting. Their study, however, is based on small samples drawn from the wheat potential areas in Arsi administrative zone of Oromia region. Hence, their finding is not representative for non-wheat potential areas.

Moreover, their analysis is at household level and cannot control plot and crop characteristics. Row planting adoption might be highly dependent on the type of crop to be planted because different crops have different seed sizes and the probability of row planting adoption is expected to be large for the large seed crops than the tiny ones. In other words, farmers are more likely to adopt row planting in planting large seed crops such as maize over the small seed ones because it is easier to plant the large seed crops in rows than the small ones. Plot level analysis is appropriate to explore the determinants of row planting as it allows to control the plot attributes and crop fixed effects.

Using a data that has richer information on farmers' experience in agricultural extension programs and interactions with development agents, this chapter explores the roles of agricultural extension, social learning, and other covariates on row planting adoption on cereal and legume crop plots in Ethiopia. One of the differences of this analysis from Krishnana and Patnam's (2013) study is on the type of investigated technologies. Their study was about determinants of inorganic fertilizers and HYV seeds adoption, whereas the current study is about the determinants of row planting adoption. The second difference is on the level of analysis. The studies in both Todo *et al.* (2012) and Krishnan and Patnam (2013) are household level analyses. But the analysis in this chapter is at plot level which controls for the plot characteristics and crop fixed effects and these helps to reduce the plot and crop related omitted variable bias problems of the household level analysis of technology adoptions.

Moreover, in addition to the analysis using the entire cereal and legume crop plots information, analysis is conducted using the subsamples or individual crops, such as the determinants row planting for teff production, as a robustness check. Another difference from earlier studies is that in this study the impacts of two alternative sources of learning are compared, learning from neighbors and homophilic (farmers with similar demographic characteristics) adopters. The result helps to evaluate the effectiveness of the current extension approach, where the nearest neighbors are targeted for social learning, from alternative approaches such as homophilic approaches of extension.

Regarding the impact of row planting adoption, few studies have attempted to investigate the effect of row planting adoption on crop yield. Most of the studies are, however, based on data from the research centers and model farmers and their findings are not representative. For instance, using data from the first row planting trail experiment at the Debrezeith Agricultural Research Center, Berhe and Zena (2009) reported a fourfold increase in teff yield on row planted trail plots (compared to broadcasted trail plots). Similarly, Asargew *et al*. (2014) showed an increased in crop yield in the range of 29 to 39 percent over the broadcast method from the 2012/13 experimental plots in Adet Agricultural Research center.

The other evidences are based on data from the model farmers. For instance, ATA (2013) reported a 70 percent increase in crop yield on row planted teff plot over the national average. Vandercasteelen *et al.* (2013), using sample of teff package farmers, also reported a yield impact of row planting in the ranges between 2 and 17 percent, which is much lower than the result reported by ATA (2013). There are also a few studies about the impacts of row planting on wheat yield in Ethiopia. For instance, Alemu *et al.* (2014) showed that row planting increases wheat yield by 14 percent but only in the highlands. Abate *et al*. (2014) also found a 13 percent larger wheat yield for the farmers that applied the HYV seeds, recommended quantities of inorganic fertilizers, and row planting compared to the control farmers (who did not receive any of the three packages).

The earlier studies gave much emphasis on the yield impact with limited emphasis on crop income and profit. The study by Vandercastleeen *et al. (*2014) is the only study that gave emphasis on the high labor requirements of row planting practice among the participants for teff row planting trail experiment. Row planting of cereal and legume seeds in rows is a very labor intensive practice than the traditional planting practice. Moreover, row planting adopters' could increase the use of complementary inputs such as inorganic fertilizers and HYV seeds to maximize the return from their investments (Bulte *et al.*, 2014). These in turn results in an increase in the total costs of production and hence, the change in crop yield might capture not only the impacts of adopting the new practice but also the effects of the changes in complementary input uses among others. The alternative outcome measures such as the value of crop yield, crop income, and profit are better than the yield for evaluating the impact of the row planting adoption as these measures account the costs of the complementary inputs associated with the technology under consideration. Chapter 6 explores the effects of row planting adoption on crop yield, value of crop yield, crop, income, and profit.

5.2 Row planting promotion in Ethiopia.

In Ethiopia, the public agricultural extension has been largely focusing in disseminating inorganic fertilizers and HYV seeds. However, the extension approach has also given emphasis to improved agronomic practices recently in addition to disseminating inorganic fertilizers and HYV seeds. Row planting is the major agronomic practice that attracted the policy makers' attention recently. It requires planting seeds in rows and leaving some space between rows so that weeding becomes easier and competition between seedlings for soil nutrient declines. Figure 5.1 illustrates the differences between row planted and broadcasted methods in the case of teff production.

[Insert Figure 5.1 here]

The promotion of row planting and trial experiment in Ethiopia has been spearheaded by the Ministry of Agriculture (MOA) and Agricultural Transformation Agency (ATA) in collaboration with the Ethiopian Institute of Agriculture and the Regional Bureaus of Agriculture (ATA, 2013). The existing evidence shows that most of the row planting trail experiments and promotions has been for teff production. The first trail experiment of teff row planting was in 2008 at Debre Zeith Agricultural research center (Berhe and Zena, 2009). The yield from the row planted plots of this trial was four times larger compared to the yield from broadcast trial plots. That was an encouraging return; therefore, the MOA and ATA facilitated further experimental trials at the other research centers and farmers' plots.

The farm level trail of the new planting method started in 2011 with 1400 farmers who received training, free HYV of teff seed and the recommended quantities of inorganic fertilizers for their experimental plots. The number of farmers covered by the package to try planting of teff in rows on experimental plots increased to 70,000 in 2012 (ATA, 2013). Farmers were recommended to use a seed rate in the range of 5 to 10 kg/ha under row planting, 3 to 5 kg/ha under transplanting methods (ATA, 2013). Farmers use a seed rate of 30-50 kg/ha under the traditional method of sowing teff (ATA, 2013). Most of the invited farmers carried out the row planting method on their experimental plots and the average yield from this method was 70 percent larger than the national average (ATA, 2013). Because of the encouraging returns both at the research center and farmer trial plots, MOA and ATA rolled out the practice national wide in 2013/14 (ATA, 2013; Vandercasteelen *et al.,* 2013). Most of the farmers received training and attended workshops at the nearest farmer training centers. But the incentives which were given to induce farmers to try out row planting, such as the free access to the recommended quantities of inorganic fertilizer and HYV seeds for the experimental plots, were abandoned during the roll out stage.

The other main cereal crop where row planting has been promoted most is wheat. Alemu *et al. (*2014) argue that farm level trail of row planting wheat crop started in the Arsi zone of Oromia in 2009. But a large scale promotion of row planting for wheat production took place in the 2013/14 main farming season (Abate *et al.,* 2014). Farmers received training about planting of wheat in rows and they were recommended to apply a seed about 100 kg/ha (Abate *et al.,* 2014). Even though the existing studies are largely about row planting in the cases of teff and wheat production, during the pilot survey I found that farmers apply row planting for several cereal and legume crops. This is because the development agents have been teaching and training them about the superiority of the row planting over broadcasting method on crop yield of cereal and legume crops in general. Thus, the determinants and impacts of row planting for cereal and legume production are examined in this study.

5.3 Conceptual Framework

There are several sequential cycles in agricultural activities such as the crop planning, land preparation, seed selection, crop planting/sowing, weeding, harvesting, threshing, and marketing. Farmers need information in each of these sequential stages. Mittal *et al. (*2010) broadly classified the information seeking stages into three: knowhow, context, and market stages. At the "knowhow stage", farmers want information to decide what crop to cultivate and the type of seed to be applied. In the "context stage", farmers want information about best farm practices such as whether to plant crops in rows or to sow by the traditional method, weather predictions, and plant protection methods against pests and insects. Finally, in the "market stage" farmers seek information about prices of their crops and high price seasons to maximize their sales revenue. Extension and social learning, therefore, affects agricultural activities by affecting the information needs of farmers at the knowhow, contextual, and market stages.

In addition to the agricultural extension and social learning, there are several other factors which affect agricultural technology adoption and productivity. The major factors of adoption were briefly highlighted at the beginning of this chapter in Section 5.1. For the purpose of establishing the conceptual framework, the factors affecting adoption of technology are broadly classified into three: direct agricultural extension services, social learning, and the other factors (such as credit, risk, and access to infrastructures). Figure 5.2 shows the relationships of these factors with technology adoption and agricultural productivity. The bottom left box shows the effects of direct agricultural extension services offered by developments agents including training, demonstration of plots, and farm visits. These services increase the farmers' awareness and practical knowledge about new technologies which are indicated by the upward arrow from the bottom left box.

In the recent extension approach, the development agents are also required to facilitate group learning among neighboring farmers. The right directed arrow from the bottom left box indicates the effect of the development agents on social learning. Farmers also learn about new agricultural technologies from the other farmers especially from their neighbors and homophilics farmers. The box in the bottom right shows the social interaction effects on technology adoption and other farming practices. The farmers could affect the direct extension service, which is denoted by the left directed arrow from the bottom right box. Like the direct agricultural extension services, the social learning from other adopters also increases the awareness and practical knowledge of farmers about new and improved technologies (Conley and Udry, 2010; Munshi, 2004; Foster and Rosenzweig, 1995). This is indicated by the box in the second row. The increased awareness and practical knowledge of farmers from the direct extension and social learning in turn increases the likelihood of adopting the new technologies. The upward directed arrow from the box in the second row from the bottom indicates the effects of the extension and social learning on adoption of new technologies.

The effects of the other factors such as credit constraint (Croppenstedt *et al*, 2003), lack of risk coping mechanisms (Dercon and Christiaensen, 2011), and other characteristics like plot size, slope and quality, crop attributes, and village as well as district characteristics. These factors could affect agricultural productivity directly and also indirectly through their effect on technology adoption (Benin, Nkonya, Okecho *et al.*, 2011). There are two arrows from the left box in the third row. The top arrow indicates the direct effects of the other factors on productivity whereas the bottom arrow indicates their effect on technology adoption and their indirect effects on agricultural productivity.

[Insert Figure 5.2 here]

5.4 Hypotheses

Based on the conceptual framework and empirical literature, the following hypotheses are proposed:

i. Agricultural extensions such as farmer training, knowing many development agents and frequent contacts with development agents for extension services, increase the likelihood of row planting adoption for cereal and legume production.

ii. The likelihood of row planting adoption increases with the number of other adopters of the practice within the village.

iii. The row planting adoption is expected to increase crop yield and value of crop yield. However, its effects on the crop income and profit are unpredictable because it might also raise costs of production.

5.5 Data source

The data for analyzing the determinants of row planting adoption and its impacts is from the survey data in Ethiopia that was collected in 2014 as a part of the RePEAT project. The Ethiopia RePEAT surveys were conducted in 2004, 2007, and 2014. The 2004 round has two components. The first is a village survey in 100 villages in 100 Kebeles in Amhara, Oromia, and SNNP regions after stratifying by the administrative zones. [26] The second component was the household survey that interviewed a randomly selected 10 households from each of the 42 randomly selected villages (out of the 100 villages covered in the village survey). The second round survey in 2007 successfully tracked 408 out of the original 420 households. The 2014 survey visited the 100 original villages covered in the

[26] In the RePEAT village survey, one local village was selected from each Kebele.

first round village survey and interviewed 10 new households randomly selected in each of the 100 villages and 380 original sample households visited in 2004 and 2007.[27]

The 2014 survey has three components: household, village, and DA surveys. The household survey collected a range of information such as households' farming and non-farming activities, their interactions with development agents, land access, physical assets, consumption, and members' characteristics. The village survey has the basic village level information such as the access to several types of facilities, types and prices of major crops, local non-farm job opportunities. Finally, the DA survey collected key information from development agents on extension activities for local farmers.

The 2014 round is the only wave that has rich information on planting practices and the DAs activities. Moreover, the first two waves have much smaller sample size and did not collect information about the crop planting methods because row planting was unknown to most farmers when the earlier surveys were carried out. Because of these reasons, only the 2014 survey data was used even though there is panel information for the subset of sample households. Although the data for this study is cross-sectional, the cross-sectional analyses are still helpful to identify the farmers that have a difficulty of trying the best farm practices (Moser and Barrett, 2006).

[27] The data from 21 of the sample households was lost due to a problem in one of the Tablet computer during the interviews. The data was collected by Computer Assisted Personal Interview (CAPI).

5.6 The effects of agricultural extension and social learning on row planting adoption

5.6.1 Empirical specifications

Before discussing the model specifications, it is necessary to elaborate how the land redistribution in Amhara region in 1996/97 is controlled in the regressions for row planting adoption. As explained in Chapter 2, this particular reform was implemented only in Amhara region. The village dummies are included in each regression for the row planting adoption to account for geographic specific reforms such as the 1996/97 land redistribution in Amhara.

5.6.1.1 Simple Regression

To explore the effects of training, social learning and the other factors on smallholder farmers' row planting adoption, the following regression equation is specified.

$$RP_{pqiv} = \alpha + \beta_1 Train_i + \beta_2 KnowAdopter_i + H_i\gamma + P_{pi}\delta + C_q\theta + V_v\omega + \varepsilon_{pqiv}. \quad (5.1)$$

where the subscripts p, q, i, and v denote plot, crop, household, and village, respectively. RP_{pqiv} is a dummy variable which takes a value one if household i in village v planted crop q by row planting method on plot p and zero otherwise**.** $Train_i$ is a dummy variable which takes a value one for households with one or more invited family member for row planting training in the 2013/14 pre-planting farming seasons and zero otherwise. The reason for choosing training invitation over participation is due to the unavailability of the actual participation data. According to information obtained from the DAs, the participation rate for a training invitation in rural Ethiopia is very high or more than 90 percent. [28] One of the reasons for the high participation rate is the smaller opportunity cost of attending trainings to farmers as a result of small farmland and limited non-farm employment opportunities in the rural areas. Another reason is that the DAs often arrange trainings and workshops on religious holidays of the farmers when they refrain from carrying out any farming duty on their farmland by their own will.

The evidence from other studies also suggests the higher compliance rate of smallholder farmers for training invitation in rural Ethiopia. For instance, the data in the study by Vandercasteelen *et al. (*2013) show that about 76 percent of the 600 randomly assigned farmers to carry our row planting for teff in 2012/13 complied with the program. Since some of the non-compliers might have attended the training, the participation in the training among the invited could exceed 76 percent. This shows that participation in training upon invitation is very high among farmers in Ethiopia and the invitation to training to training is a good proxy for the actual participation. The coefficient of the invitation variable measures the intention to train and it might understate the average treatment effect of training on the participants. Thus, its coefficient serves as a conservative estimate of the training impact on the adoption of the improved planting method.

The other main variable of interest is the dummy of knowing other row planting adopters denoted by $KnowAdopter$ which takes a value one if the farmer knows other row

[28] The contact details (phone numbers) of the DAs who work in the survey villages were gathered during the survey. The phone numbers used to ask information about farmers regarding their participation in training upon invitation.

planting adopters within the village and zero otherwise. This is one of the measures of social learning because farmers might strive to learn from other adopters if they know any other adopter within the village. In Section 5.6.1.3, alternative measures of social learning are used. In addition to training and social learning, several household and plot characteristics which are denoted respectively by vectors H and P are controlled. Moreover, the crop and village fixed effects that are denoted respectively by vectors C_q and V_v are controlled; and finally ε_{pqiv} denotes the error term.

5.6.1.2 Weighted regression on matched samples

One of the challenges in estimating the impacts of programs such as row planting training is the non-randomness of the training variable. One of the techniques to reduce the estimation biases arising from a non-random placement of programs is the propensity score matching and weighted regression on matched samples. According to Imbens and Wooldridge (2008), weighted regression on matched samples has a robustness advantage over the simple propensity score matching estimates because the weights reduce the correlations between the treatment status and the exogenous regressors, and the regression controls the effect of the exogenous regressors. This technique has been recently used by other researchers. For instance, Benin *et al.* (2011) also employed the technique to investigate the agricultural income effects of the National Agricultural Advisory Services program in Uganda.

The balancing test using $Train$ as treatment variables showed that the heads of households with one or more invited members for training were largely male headed, younger, attained higher schooling, large family size, and members of farmers association than the non-invited heads before the matching (Table A.11). But most of the significant differences disappeared or reduced after matching the households by the invitation for training. The $KnowAdopter$ dummy is again treated as exogenous because the balancing test did not show notable significant differences in the explanatory variables value between those who know other adopters and those who do not know. The balancing test results by $KnowAdopter$ dummy are not reported to save space but can be obtained upon request. Equation (5.2) shows the propensity score matching specification using invitation for row planting training as the outcome variable.

$$Train_i^* = \{Z_i'\varphi + u_i\}. \qquad (5.\ 2)$$

The weighted regression on matched samples use the samples of treated and control group from the common support region. The matching estimation is at a household level because invitation is a household level variable. The variables in Z_i term of equation (5.2) are a vector of pre-determined household level variables such as the head's age, gender, and years of schooling, and adult family member size. The results in the last four Columns of Table A.11 shows that the mean differences in most of the key variables such as age, gender, years of schooling, and membership to farm association between the invited and non-invited households for row planting training are either insignificant or declined after matching. This shows that matching has reduced the differences in the observable characteristics among the treated and comparable groups. Each observation in the treated group gets a weight of one if it is in the common support, and the weight for each control observation is the numbers of times it was used as a match for treated observations. Then, the weight information for matched households is merged with the plot level data. After that, the specification in equation (5.3) is estimated by weighted regression using the weights from the matching estimation of equation (5.2) as the frequency weights. The term w under each subscript in equation (5.3) below denotes that the model is a weighted regression. The other variables and subscripts are as defined equation (5.1).

$$RP_{pqiv} = \alpha + \beta_{1w}Train_i + \beta_{2w}KnowAdopter_i + H_i\gamma_w + P_{pi}\delta_w + C_q\theta_w$$

$$+V_v\omega_w + \varepsilon_{pqiv}. \qquad (5.3)$$

5.6.1.3 Spatial regression models

The dummy of knowing other row planting adopters within in the village, which is the measure of social learning used in equations (5.1) and (5.3), might be a less precise measure of social learning. For example, a farmer may know other row planting adopter but may not contact the adopter frequently due to a large physical distance between their homes. Thus, it is necessary to use additional measures of social learning that have detailed information aside from the dummy of knowing other adopters. This section specifies the model by defining informative measures of social learning by utilizing the spatial and demographic information gathered during the survey. Two alternative spatial measures of social learning are used. Since neighboring farmers interact more often and exchange ideas and information about farming and new technologies (Krishnan and Patnam, 2013), the first measure of social learning exploits the information on the inverse of the physical distance between the farmers' residential compounds.

The other measure is the learning from homophilic farmers or farmers of closely related demographic characteristics such as gender, literacy status, belief, ethnicity, and age (Rogers, 2003). Interpersonal contacts and information exchanges between the homophilics are often high and that is an important mechanism to disseminate the awareness and knowledge about new technologies and improved farm practices (Genius *et al.*, 2013; Rogers, 2003). The results from these two alternative measures of social learning are compared to comment on whether the current extension approach, which focuses on the facilitation of social interaction of nearby farmers, is the better approach than the alternative approach or not. Two spatial weighting matrices are employed, one is for the nearest neighbors and the other is for the homophilic method.

The nearest neighbor measure is based on the spatial information of households location. The distance in kilometer between a farmer *i* and each of the remaining N-1 farmers ($d_{ij,}$ *j* is the j^{th} farmer) is computed using the GPS coordinate information, which was captured at the household compound during the household survey. Then, the result is presented in matrix *W*, which is a square matrix of dimension 1266 by 1266.[29] The diagonal elements of *W* are zeros (at the diagonal *i=j* or distance from own home is zero). After that,

[29]The dimension is given by the numbers of cereal or legume crop producing farmers in 2013/14 seasons. Out of the total 1359 farmers, about 1266 of them produced at least one or more of the cereal or legume crops. Most of the remaining farmers are engaged in the production of vegetables and permanent crops such as inset.

the non-diagonal elements of the pairwise distances (d_{ij}) are replaced by the respective inverse values ($1/d_{ij}$) so that a larger *ij* element in *W* indicates a higher degree of proximity between the i^{th} and the j^{th} farmers. Krishnan and Patnam (2013) employed this approach to measure the impact of social learning from neighbors on the adoption of HYV seeds and inorganic fertilizers. In their approach, the neighbors for farmer *i* are farmers from the same village and whose house is not more than one kilometer away from farmer *i's* house or $(1/d_{ij})>1$. They further restrict the size of neighbors to a farmer to at most five.

$$W=\begin{bmatrix} 1/d_{11} & 1/d_{12}\cdots & 1/d_{1N} \\ \vdots & \ddots & \vdots \\ 1/d_{N1} & 1/d_{N2}\cdots & 1/d_{NN} \end{bmatrix} = \begin{bmatrix} 0 & w_{12}\cdots & w_{1N} \\ \vdots & \ddots & \vdots \\ w_{N1} & w_{N2}\cdots & 0 \end{bmatrix} \qquad (5.4)$$

According to Krishnan and Patnam (2013), the one kilometer radius and limiting the maximum size of neighbors to five in the empirical model to make a resemblance between the empirical model and the current agricultural extension approach in Ethiopia where the very nearby six farmers targeted to stimulate group learning about new technologies and ideas. This study followed their approach but the main analysis is at plot level while their analysis is at household level. The other difference is that they dropped small percentage of households with no neighbor within one km radius. There are 24 sample households are islands or have no any neighbor in the current data but instead of dropping these households each of them allowed to have one nearest neighbor within the village, even though their nearest neighbor is more than one kilometer away. Thus, each household has at least one neighbor in the current study. The spatial weighting matrix is row standardized so that each row sum is unity.

The measure of social learning in spatial analysis is given by the coefficient of the spatial lag term denoted by the term $\sum_k W_{ik} RP_k$ in equation (5.5). This term is the products of the i^{th} row of W and the column vector of the household level row planting adopter dummy RP_k, which takes a value one if the household implemented a row planting in one or more of her cereal or legume crop plots and zero otherwise. The subscript k denotes the nearest neighbors where the ik elements of W are non-zero. The autoregressive term is first obtained by using the household level information, and then it is merged with the plot data to regress at plot level. Equation (5.5) shows the spatial autoregressive model for the adoption of row planting on plot p by farmer i.

$$RP_{pqiv} = \alpha + \beta_1 Train_i + \beta_2 \sum_k W_{ik} RP_k + H_i\gamma + P_{pi}\delta + C_q\theta + V_v\omega + \varepsilon_{pqiv}. \qquad (5.5)$$

Estimating equation (5.5) by ordinary regression such as Linear Probability Model (LPM) might result in biased estimates because of reverse causality. The adoptions of the non-traditional planting methods are determined simultaneously or one's adoption affects the neighbors' adoption and vice versa. This estimation problem is known as the endogenous peer effect (Manksi, 1993). According to Kelejian and Prucha (1998), vectors of X, WX, W^2X,…are valid instruments for the endogenous term $\sum_k W_{ik} RP_k$, where X is the vector of exogenous explanatory variables of neighbors. Since the spatial matrix is computed at a household level, WX is defined only for the household level variables such as the head's age, gender, education, and the size of adult family members. Identification is guaranteed by the non-linearity of W because its elements which are computed based on GPS information have many variations.

However, the regressors of the neighbors' could also directly affect the dependent variable or $Cov(RP_{pqiv}, WX)$ could be non-zero and this problem is called the contextual effect. If this is the case, then the use of WX as instrument for $\sum_k W_{ik} RP_k$ may not work. The definition of the social learning in equation (5.5) is, however, based on two restrictions in the elements of W. The first is that neighbors should be within one kilometer radius; and the second restriction is that the maximum size of each farmer's neighbors is restricted to at most five. These restrictions increase the non-overlapping neighbors in the entire system and that in turn increases the exogenous components of the endogenous peer effect term (Krishnan and Patnam, 2013).[30] Suppose there are only three farmers a, b and c in a village, where b is neighbor with both a and c, but a and c are not neighbors. Then, the effect by farmer c on farmer b increases the exogenous variation of the right hand side of the relationship of $RP_a = f(RP_b)$, where RP_a and RP_b are the values of row planting adoption of farmers a and b, respectively. Thus, the instruments for the spatial lag term are the exogenous explanatory variables of the non-overlapping nearest neighbors which affect the spatial autoregressive term exogenously.

Equation (5.5) is also applicable for the homophilic based measure of social learning. The only difference is in the definition of the spatial weighting matrix, W. The elements of W in the homophilic approach are constructed using three demographic variables of the head: gender, literacy status, and age. For farmers i and j to be in the same homophilic group, first both households should be residents within the same village, and the heads'

[30] About 86 percent of the sample farmers have 5 or more neighbors within 1 km radius. Hence, the restriction of neighbors at most 5 neighbors increases the number of non-overlapping neighbors.

gender and literacy status should be the same. If any one or more of these is violated, then the *ij* element of W takes a value zero. If these conditions are fulfilled and the absolute value of the age difference between the i^{th} and j^{th} farmers is less than five years, then the *ij* element of W takes a value that is the inverse of their absolute age difference. Since the inverse of a zero age difference does not exist for two equal age farmers, a 0.5 year difference is used instead of zero so that the *ij* element of W takes a value two for equal age pair of farmers. Equal age means more similarity and hence higher likelihood of interaction between equal age household heads.

$$w_{ij} = \begin{cases} \frac{1}{|agedf_{ij}|} & if\ 0 < \ |agedf_{ij}| <= 5 \\ 2 & if\ |agedf_{ij}| = 0 \\ 0 & if\ |agedf_{ij}| > 5 \end{cases} \quad (5.6)$$

where $|agedf_{ij}|$ in equation 5.6 is the absolute difference in the age between the i^{th} and j^{th} farmers. The first two conditions hold only if the i^{th} and j^{th} farmers have identical gender and literacy status (can read and write or not). The literacy status is used instead of the actual years of schooling because variation in the years of schooling is very small.

The *ij* element of *W* takes a value zero if the absolute age difference between *i* and *j* is over 5 years, and its diagonal elements are zeros. Genius *et al. (*2013) restricted the absolute age difference between peers not to exceed three years but the three year restriction resulted many islands (farmers with no peer) due to the large variation in the heads age. That is why the age difference is raised to 5 years. Even at the five year age difference, about 389 of the households did not have homophilic based peers and hence they were not included in the regressions which use the weighted average of homophilic peers. The spatial weighting matrix, W, is row standardized so that each row sum is unity.

The 2SLS estimation is employed like the nearest neighbor approach using X and WX as instruments for $\sum_k W_{ik} RP_k$. However, the numbers of non-overlapping neighbors are quite limited in the homophilic approach because the variation across heads' age is high. One solution to minimize the contextual effects when non-overlapping peers are few is to exclude the main explanatory variables used for constructing W (age, gender, and education) from the instrument or WX list. Thus, these three variables are not included in the WX vector when the 2SLS is estimated.

5.6.2 Descriptive statistics

Table 5.1 provides the summary statistics for the household level variables used in the analyses. Panel A shows that the access to agricultural extension is generally larger for row planting adopters than the non-adopters. For instance, about 97 percent of the adopters know how to carry out row planting in contrast to 63.7 percent of non-adopters. Regarding training, about 23 percent row planting adopters than non-adopters reported that one or more of the household's members received invitation for row planting training during the pre-planting season of 2013/14. In terms the number of contacts with the DAs during the main farming season, the row planting adopters contacted three times as much as the non-adopters did. Finally, about 93 percent of the row planting adopters knew other row planting adopter farmers within their village, but only 67 percent of the non-adopters did so.

[Insert Table 5.1 here]

The summary results from hypothetical risk and time preference games are reported in Panel B. Explanations about the games and the measures variables derived from them is offered in Annex 1. As can be seen from the table, there are no major statistical differences in the risk attitudes and time preferences between row planting adopters and non-adopters. Panel C shows the results for the membership of local social networks. The most common local social networks include *idir*, *senbete*, *mahber*, and farm association. *Idir* is an association established by residents within villages or workers at work place to raise funds for help during emergency such as in the death of family members, whereas *Mahber* and *senbete* are Orthodox Christian religion followers associations' where the party is at the members' home in the case of *mahber* and at church for *senbete*. The results show that the non-adopters of row planting are more likely to be members of local social networks than the adopters. The results look surprising but the within village variation of these variables is small and hence membership to these associations may not necessarily associated with the adoption of the practice.

The demographic characteristics of adopters and non-adopters of row planting are reported in Panel D. The heads of the row planting adopter households (compared to the non-adopters head) are largely male, younger in age, and attained higher years of schooling.

Household size and number of adult members are also larger for the adopters than the non-adopters. Finally, Panel E summarizes income and value of assets for the adopters and non-adopters of row planting. The results show larger income from self-employment and value of assets of row planting adopters than non-adopters. The income from non-own labor sources such as remittances, grants, and loans are also larger for the adopters than the non-adopters. But livestock value is larger for the non-adopters than the non-adopters probably because some of the non-adopters of row planting might have more preference for livestock production than crop cultivation.

The plot and parcel level data are also summarized (Table 5.2). Panel A compares the seed rate between plots under broadcast and row planting methods. As expected, farmers apply smaller quantity of seeds under row planting compared to the broadcasting method. For instance, the seed rate on row planted crop plots is below one-half of the rate on broadcast plots when all cereal and legumes considered. Consistent results obtained in the case of individual crops. For instance, farmers reduced the quantity of teff seed by 17 kg/ha and maize seed by 12 kg/ha when they use row planting instead of broadcasting method.

Although row planting is associated with significant reductions in the seed rate than the traditional method, the observed seed rates on the row planted plots are larger than the recommended rates by agronomists. Farmers are recommended to apply 5-10 kg/ha in the case of teff (ATA, 2013) and 100 kg/ha in the case of wheat (Abate *et al.*, 2014). But the data shows that farmers apply 33 kg/ha for teff which is more than three times the recommended rate. Similarly, farmers apply 140 kg/ha for wheat under row planting which is about 40 percent larger than the recommended rate. In another study, Abate *et al.* (2014) also reported a seed rate of 153 kg/ha among the farmers who planted wheat in rows. These results show that there are discrepancies in the seed rates on row planted plots between the recommended and the actual quantities. These large discrepancies might suggest either implementation inefficiency, problems related to non-germinating seeds because farmers predominantly use less quality traditional seeds, or both factors. According to the DAs, one of the reasons for the discrepancy is the inefficient implementation of the practice by farmers. Finally, Panel B shows the parcel characteristics and there are notable differences in soil conservation investments, slope, and quality of parcels row planting adopting. These variables are controlled to lessen omitted variable bias related problems in the regressions.

[Insert Table 5.2 here]

5.6.3 Regression results

The regression results are discussed in two sub-sections. The estimation results obtained by the Probit and weighted regression are discussed in Section 5.6.3.1 followed by the discussion of the spatial regression results in Section 5.6.3.2. The average marginal effects are reported in each regression table.

5.6.3.1 Simple regression and weighted regression results

Table 5.3 reports the average marginal effects of the probit regressions for row planting adoption. Column (1) is based on the entire cereal or legume producing farmers.

Using the entire sample households might result in biased estimates if the exposure to new farming technologies and improved practices is heterogeneous across farmers (Kabunga *et al.,* 2012). For instance, simple regression estimates could overstate the impact of training on adoption if the extension agents targets capable and educated farmers (Lambrecht, Vanlauwe, Merckx, & Maertens, 2014). Thus, the training effect is checked for robustness by regressions on sub-samples of farmers who are aware and knowledgeable about row planting. The result with subsample of farmers who ever heard about row planting of cereal or legume crops and with subsample of farmers with practical knowledge on how to carry implement row planting are reported in Columns (2) and (3) of Table 5.3, respectively.

The measure of training is significantly positive. Its marginal effect in Column (1) shows that the invitation for row planting training increases the likelihood of adopting the non-traditional planting method by 6.8 percentage points. Its average marginal effect declined to 6.3 percentage points when the regression is based only on subsample of households who are aware about row planting practice (Column 2). The result suggests that the estimate of training on the entire sample farmers overstates the effect of training when the heterogeneity in awareness exposure is not taken into consideration. The estimate of training in Column (3), on the other hand, suggests that the average effect of training increases the likelihood of adopting row planting by 7.6 percentage points after running the regression on subsamples who know how to implement row planting.

[Insert Table 5.3 here]

The marginal effect of training in Column (3) is a sort of surprising because if both the adopters and non-adopters know how to implement row planting, then the marginal effect of training on adoption should have declined than the effect in Column (1). The contrary result could be related to the large heterogeneity in knowledge among those who know how to implement row planting. Even though farmers believe that they know how to carry out row planting, their knowledge might be inadequate and heterogeneous. For example, some households reported that they know how to implement row planting but they did not try it. About 65 percent of these farmers reported that the main reason for not adopting the practice is because they find the practice as tedious and excessively labor demanding (Table A.10). The farmers with some know how about row planting practice, however, might have higher likelihood of trying the new method if they get access to training. This is because farmers might learn easier ways of implementing row planting than they used to know when their access to training and other extension services increase.

The other approach to deal with the non-random invitation to training is the weighted regression on matched samples. Column (4) of Table 5.3 shows the average marginal effect from the weighted regression on matched samples for row planting adoption. The estimate for the training variable suggests a 7.5 percentage point increase on the probability of adopting row planting. This estimate of training in the matching method is consistent with the results without matching methods which are reported in Columns (1)-(3). These suggest that training about row planting has robust positive relationship with the adoption of the practice.

The estimates of the other agricultural extension variables are also positive. For instance, frequent contact with development agents during the main farming season for advisory services is significantly associated with row planting adoption. Its estimate in Column (1) suggests that a one percent increase in the number of extension contacts is associated with a 0.028 percentage point increase on the probability of carrying out row planting. Knowing many development agents is also associated with row planting adoption though its coefficient is not significant.

Regarding the result for social learning, the dummy of knowing other row planting adopters within the village is significantly associated with row planting adoption. Its estimate in Column (1) show that knowing other adopters is associated with a 9.6 percentage point increase in the probability of row planting adoption. Consistent estimates obtained for this measure in Columns (2)-(4). These suggest that there is a robust relationship between knowing other adopters of row planting and one’s own adoption of the practice. Thus, the estimates of training and knowing other row planting adopters dummy suggest that both the direct extension services and the social learning from other farmers are important determinants of row planting adoption.

The coefficients for crop dummies are the other important variables of interest because the decision of choosing between row planting and broadcasting might depend largely on the type of crop. Thirteen crop dummies are included in the regressions using the dummy for barley as a reference category. But only the estimates of the three main cereal crops are reported to save space. A large and significant positive association uncovered between the maize dummy and row planting adoption. The dummy for wheat crop is also significantly associated with row planting adoption but the teff dummy has a negative association with row planting adoption though its estimate is not significant.

The p-values to test the null hypothesis that there are no significant differences between the crop dummies of main cereal crops are reported in the last three rows of Table 5.3. The results show that the coefficients of teff dummy are significantly smaller than the coefficients for maize and wheat dummies. The negative association of row planting with teff crop dummy is most probably because planting this crop in rows is difficult and time consuming than the other crops due to its tiny seed. From the legume crops, the dummies of bean, hair coat bean, and ground nuts have significant positive associations with row planting adoption because these crops have larger seed size than the reference crop. These suggest that the crop attributes are important determinants of row planting adoption and estimations which do not control crop dummies in row planting regressions might be prone to omitted variable bias.

The foregoing analyses are based on the entire cereal and legume crops. However, the government has given special emphasis to the promotion of row planting specifically for teff production because it is produced by most farmers in the country but research which improve the productivity of teff yield has been low. To investigate the contribution of the recent extension focus on teff, a probit regression for row planting adoption using teff subsample plots are reported in Table 5.4. The extension measures are associated with a significant increase in the probability of adopting row planting on teff plots. For instance, invitation for row planting training increases the probability of row planting adoption on teff plots by 14.2 percentage points. Knowing one more DA is also significantly associated with a 5 percentage point increase in the likelihood of row planting adoption for teff production. The dummy of knowing other row planting adopters is not significant in the case of teff. But the spatial measures of social learning variables, which are explored in the next spatial regression section suggests significant effects of the learning from other adopters.

[Insert Table 5.4 here]

Regression results with alternative measures of row planting adoption are offered in Table 5.5 as robustness check for the effects of extension and social learning measures. Since row planting requires applying smaller quantity of seeds than the traditional method, the logarithm of seed rate (kg/ha) is used as the dependent variable in Panel A. Training is negative in 2 (out of the 4) regressions and the measure of social learning is negative in all of the four regressions. But none of their coefficients are significant. The only variable that has a significant negative association with the seed rate from the main extension variables is the number of times the farmer contacts with the DAs during the main farming season (Column 4 of Table 5.5).

[Insert Table 5.5 here]

The dependent variable in Panel B is a dummy variable which takes a value one if the household practiced row planting in any one or more of her cereal and legume crop plots and zero otherwise. The results show that the coefficients for both training and knowing other row planting adopters are significantly positive. In Panel C, the dependent variable is the share of cereal and legume crops planted by row planting method out of the total cereal and legume crop types cultivated in 2013/14, and in Panel D it is the share of cereal and legume crop area under row planting method out of the total cereal and legume crop area. The coefficients of both training and knowing other adopters are positive and significant on these two measures of row planting adoption. The results in Panels B to D, therefore, suggest the robustness of training and social learning impacts on the alternative measures of row planting adoption. The estimates in Panel A, on the other hand, suggest the limited impacts of extension and training farmers' practical knowledge.

5.6.3.2 The spatial regression results

The main difference between the discussion in section and the one in Section 5.6.3.1 is on the measures of social learning. The social learning was measured by a dummy variable which takes one if the farmer knows other adopter of row planting and zero otherwise. This dummy is a less precise measure because it does not vary with the size of adopter neighbors and peers. The discussion in this section takes the size of adopter neighbors and peers into consideration. Two alternative measures of social learning employed: the weighted averages of nearest neighbor adopters and homophilic adopters of row planting within the village. These two measures have been already described in Section 5.6.1.3.

However, the availability many adopter neighbors and peers may not necessarily imply that every farmer is aware about the new practice. For instance, the farmer may not be aware about row planting if her relationship with neighbors is unfavorable. To account for this issue, an interaction of the dummy of knowing other adopters with the weighted average of nearest neighbor adopters and homophilic adopters are also used as alternative measures of social learning. The regression results are reported in Table 5.6. Linear probability Model (LPM) and 2SLS regressions are employed to estimate the coefficients. The social learning in Columns (1)-(3) is the weighted average of nearest neighbors and in Columns (4)-(6) it is the weighted average of homophilic adopters.

The results from the LPM regression show a negative association between the social learning and row planting adoption. But because of reverse causality between the dependent variable and the spatial autoregressive term, the LPM estimates could be biased. When there is a simultaneity problem, the direction of the bias in the LPM is unpredictable. It overstate (understate) the marginal effects if the relationship between the dependent and endogenous variables is positive (negative). An adopter of a technology might affect its neighbor to try the technology but this is not always the case. For instance, row planting adopters might disseminate the negative attributes of the practice such as its high labor requirements and this in turn might discourage some potential adopters from trying the new practice. Some of the potential adopters of the practice might also chose to delay their adoption to learn lessons from the success and failures of the pioneers. Therefore, the direction of the bias in the LPM is unpredictable. The results from comparing the LPM and 2SLS estimates suggest that the LPM has an attenuation bias.

[Insert Table 5.6 here]

The 2SLS regression estimates account for the issue of reverse causality. The values of Cragg-Donald statistics are larger than the Stock Yogo's critical value at five percent and this show rejection of the null hypotheses of weak instruments. The other requirement in the instrumental variable regression is that the instruments should be uncorrelated with the error term which is tested by the Sargan test for over identification. The computation of Sargan statistics, however, requires homoscedasticity assumption in the distribution of the error term which is too restrictive because the error term is more likely to have a spatial correlation and the reported standard errors are clustered at village level. But the p-values for the Sargan test statistics from the unreported regression without clustering are larger than 0.1 and these suggest that the null hypothesis of a zero covariance between the residuals of the structural equation and the instruments cannot be rejected.

Regarding the results, the 2SLS estimate of social learning in Column (2) shows that the weighted average of nearest neighbor adopters has strong positive impact on one's own adoption of row planting. The coefficient implies that a one standard deviation (0.39) increase in the weighted average of nearest neighbor adopters leads to an increase in the probability of row planting adoption by 8.8 percentage points. The estimate in Column (3) suggests that a one standard deviation (0.4) increase in the interaction variable increases row planting adoption by 10.4 percentage points. These show that the nearest adopters have significant influence on the dissemination of row planting practice.

The coefficient of the social learning measures in Column (5) of Table 5.6 also shows the significantly positive effects of the weighted average of homophilic adopters of row planting on one's own adoption of the practice. The coefficient of the social learning measure suggests that a one standard deviation increase in the weighted average of homophilic adopters results a 4.2 percentage point increase in one's own adoption. The coefficient of the social measure in Column (6) is also positive but not significant.

The spatial regression results in Table 5.6 are based on information from the entire cereal and legume plots. But row planting adoption is highly heterogeneous across the type of crops. The descriptive results in Table 5.2 show that most of the farmers tend to practice row planting on maize plots than other crops probably due to its large seed size advantage for row planting than the other main cereal crops. The estimates of social learning and training might be less robust if information on maize is excluded. One way to check the robustness of the variables is to run regression using subsample data. The adoption regressions conducted using plot level information for each of the four main cereal crops- barley, maize, teff, and wheat and for all cereal and legumes except maize. The definition of the social learning also changes accordingly. For example, the measures of social learning in the row planting regression in the case of maize crop are the weighted average of nearest neighbors/homophilic adopters of row planting on maize plots.

The results from the regression on the subsample data are presented in Panels A and B of Table 5.7. The measure of social learning in Panel A is the weighted average of nearest neighbor adopters whereas in Panel B it is the weighted average of homophilic adopters.

The Cragg-Donald statistic for the weak instrument test is reported in the last row of each panel. The test statistics is mostly insignificant which means the null hypothesis of weak instrument is not rejected at 5 percent except in Column (5) of Panel A. These could be due to the small sample bias problem when subsamples are used instead of the entire observations.

Even though the null hypothesis of the weak instrument is not rejected, the coefficients of the social learning and training variables are consistent in sign and significance with the coefficients obtained from the regression using data from the entire cereal and legume crop plots. For instance, the coefficients of social learning in Columns (2) and (3) of Panel A show that the weighted average of nearest neighbor row planting adopters on maize and teff are significantly associated with one's own adoption of row planting for the production of the respective crops. The result in Column (5) of Table 5.7, which is obtained from all cereal and legume plot with the exception of maize, shows that the marginal effect of the weighted average of nearest neighbor adopters is only slightly changed than the result in Table 5.6 where maize is included. These shows the weighted average of nearest neighbor adopters is a robust determinant of row planting. The coefficient of social learning in Panel B is also positive in four (out of five) regressions but none of its coefficients are significant which may be due to small sample bias. The invitation for training, on the other hand, has significant positive association with row planting adoption on maize as well as teff plots both in Panels A and B. It is also significantly associated with row planting adoption in Column (5) where all cereal and legume information with the exception of maize are used for estimation.

[Insert Table 5.7 here]

In sum, the coefficients of the social learning measures from the 2SLS regression in Table 5.6 suggest both adopter neighbors and peers have significant effects on one's own adoption of the practice. When comparing the size and level of significance of the two alternative measures of social learning, the coefficient for the weighted average of nearest neighbors has larger marginal effect and very significant than the coefficient for the weighted average of homophilic adopters. Consistent results are obtained in Table 5.7 when regressions are conducted using subsample data such as plot level regression of row planting adoption for individual crops. These suggest that that the current agricultural extension approach which focuses neighboring farmers for stimulating group learning about improved farm practices is an effective approach than other alternative extension approaches such as the facilitation of social learning between homophilics or farmers with similar demographic characteristics.

The main findings of in this chapter on the effects of social learning and extension on row planting adoption are slightly different from the findings in Todo *et al.* (2013) who reported that knowing a development agent increases the probability of knowing row planting but neither the agricultural extension nor the social networks has significant positive effects on the adoption of the practice, which may be due to small sample bias. The findings in this chapter are, however, consistent with other empirical studies on the determinants of agricultural technologies such as inorganic fertilizers, HYV seeds, and irrigation.

For example, Krishnan and Patnam (2013) found significantly positive effects of agricultural extension and weighted average of neighbors on the adoptions of inorganic fertilizers and HYV seeds in Ethiopia in the late 1990s when most of the farmers were less knowledgeable about these technologies. Their study further revealed that the role of agricultural extension declined after sometime as many farmers become aware about the technologies but the social learning from neighbors remained an important determinant of adoption. Foster and Rosenzweig (1995) and Munshi (2004) are among the studies that found significant positive effects of social learning on HYV seed adoption in India. In the case of Greece, Genius *et al*. (2013) uncovered significant positive effects of extension services, proximity to other adopters and homophilic adopters on modern irrigation technology. Using data of pineapple producing farmers from Ghana, Conley and Udry (2010) found that farmers change their farming methods after exchanging information with successful neighbors.

5.6.3.3 The other correlates of row planting adoption

This section briefly describes the other correlates of row planting adoption. The coefficients of the covariates other than the measure of social learning variable are consistent in the simple probit and spatial regressions. Therefore, the reported coefficients in Table 5.3 are interpreted in this section. Emphasis is given on the significant coefficients to save space.

The interpretation begins with the dummies of membership with social networks. The results show that there are no robust relationship between membership dummies and row planting adoption. The only significant variable from the social networks is the *senbete* dummy in Column (3). The local social network membership dummies are highly correlated with the village fixed effects because most of the farmers within the village are members of similar association. Hence, the absence of robust significant effect for these dummies could be due to their high correlation with the village fixed effects which are also included in each regression.

The years of schooling of the head has a significant positive association with row planting adoption. Its marginal effect suggests that a one percent increase in the head's years of schooling is associated with 0.03 percentage point increase in the probability of carrying out row planting. From the behavioral variables which are obtained through hypothetical games with the household heads, only the dummy for present bias is significant.[31] Its marginal effect is negative marginal is negative and this may be suggesting that farmers impatient farmers may be less likely to adopt labor demanding technologies.

From the parcel characteristics, moderately slopped parcels (compared to sloppy parcels) are associated significantly with higher likelihood of carrying out row planting probably because the return of planting in rows could be higher in parcels whose exposure to erosion is lower compared to sloppy parcels. Farm-size is negative in all the four regressions but significant only in Column (3). Its negative sign suggests that the small

[31] The hypothetical games and the variables constructed from the games are described in Annex 1.

farmers are more likely to adopt this labor intensive practice than larger farmers probably due to their larger family labor per farmland. The estimate of plot size is positive and significant which suggests that farmers prefer to carry out row planting on larger plots than the smaller plots. However, this estimate could be very sensitive to the type of crop to be planted by row planting. For instance, the regression from the subsamples of teff plots show a negative coefficient for plot size probably because planting teff in row is excessively labor demanding than in other crops and hence farmers may prefer to plant the small ones in rows in the case of teff.[32]

5.6.4 Conclusion and policy implications

This chapter investigated the determinants of row planting adoption on cereal and legume production. Special emphasis is given to the roles of training by local officers and the social learning from neighbors and peers. The result from the simple probit regression and the weighted regression on matched samples show that both invitation for training and the dummy of knowing other row planting adopters are significantly positive on the regressions for row planting adoption. The results from the 2SLS regression results which are obtained by measuring social learning using the weighted average of nearest neighbor adopters and weighted average of homophilic adopters also revealed the significant positive effects of training and social learning on row planting adoption. From the spatial based measures of social learning, the weighted average of nearest adopters is robust and its marginal effect is larger than the weighted average of homophilic adopters.

[32] The regression result is not reported to save space but can be obtained upon request.

The other finding is that adopters have reduced the seed rate (kg/ha) but they are still applying at a rate which is larger than the recommended rate by agronomist. For instance, the average seed rate on the row planted plots of teff in is 33 kg/ha, which is more than three times recommended seed rate of 5-10 kg/ha (ATA, 2013). According to the DAs, one of the factors for the discrepancy is related to implementation inefficiency because most of the farmers are new in applying the row planting method for cereal and legume production. Farmers may also tend to apply larger seed rate than recommended rate to mitigate the problem of non-germinating seeds. However, research is needed on the cause of the discrepancy for an appropriate policy suggestion to improve their efficiency.

The results of this study have important policy implications. First, the robustness of training suggests that agricultural extension is a key instrument to induce smallholders' adoption of the non-traditional planting method. Therefore, row planting related agricultural extension services should continue to increase farmers' awareness and practical knowledge about improved agronomic practices. The robust estimate for the weighted average of nearest neighbor adopters of row planting suggests that the current extension which focuses on neighboring farmers to stimulate group learning is an effective approach to disseminate new agricultural technologies and improved agronomic practices. Thus, the current neighbor based extension approach should be strengthened. Finally, increasing farm-level extension follow-ups might improve the efficient implementation of row planting for the adopter farmers.

Chapter 6

The impacts of row planting adoption on crop yield, value of crop yield, crop income, and profit

In Chapter 5, the determinants of row planting adoption were investigated. The analysis in this chapter is the continuation of the previous chapter and it focuses on the effects of row planting adoption on crop yield and related outcome measures. The discussion begins with the empirical specification in Section 6.1 followed by the discussion of the descriptive and regression results in Sections 6.2 and 6.3, respectively. Finally, Section 6.4 concludes the chapter with brief policy suggestions.

6.1 Empirical specification

The following model is specified to examine the effects of row planting adoption on the outcome variables:

$$y_{pqiv} = \alpha + \beta_1 RPAdopter_i + \beta_2 RPPlot_{pqiv} + H_i\gamma + P_{pi}\delta + C_q\theta + V_v\omega + \varepsilon_{pqiv}. \quad (6.1)$$

The subscripts *p, q, i,* and *v* denote plot, crop, household, and village respectively. y_{pqiv} represents the plot level dependent variables: crop yield, value of crop yield, crop income, and profit. Two closely related explanatory dummy variables are controlled to measure the impacts of row planting on the outcome variables of interest. The first one is $RPAdopter_i$ which takes a value one if household i implemented row planting in any one or more of her cereal or legume plot/s and zero otherwise. The coefficient of this dummy captures the average effect on the outcome variables for the adopters than the non-adopters. The other one is $RPPlot_{pqiv}$ which is a plot level dummy that takes a value one if farmer i planted crop type q on plot p by row planting method and zero otherwise. This dummy is included because most of the adopters are implementing the row planting practice only on some of their plots. Its coefficient measures the average difference in the value of the dependent variable between the row planted and broadcasted crop plots among the adopters farmers. The sum of the coefficients of these two dummies captures the average effect of row planting adoption on the row planted plots. Regarding the other covariates, H denotes the vector of household and head characteristics other than $RPAdopter_i$ and P denotes vector of plot level variables other than $RPPlot_{pqiv}$. The vectors C_q and V_v, on the other hand, denote the crop and village fixed effects; and finally ε_{pqiv} is the error term.

The specification in equation (6.1) implicitly assumes that the impact of row planting adoption is homogenous across crops. But in practice the impact of row planting could vary considerably across the type of crops depending on the crop attributes. The most important attribute of crops in relation to sowing methods is the seed size. Some crops like teff have very small seed and these crops are very difficult to efficiently allocate their seeds on the plot. Some of the crops such as maize, on the other hand, have larger seed size which is convenient to broadcast efficiently by hand than the other cereals. Hence, the productivity of row planting could be larger for the small seed crops than the larger seed ones. To account for the heterogeneities across crops, crop specific effects of row planting adoption measured by the interactions of row planted plot dummy with crop dummies are additionally controlled as seen below in equation (6.2).

$$y_{pqiv} = \alpha + \beta_1 RPAdopter_i + \beta_{2q}(RPPlot_{pqiv} * C_q) + H_i\gamma + P_{pi}\delta + C_q\theta + V_v\omega + \varepsilon_{pqiv}. \quad (6.2)$$

where $RPPlot_{pqiv} * C_q$ is the vector of the interactions between the row planted plot dummy, $RPPlot_{pqiv}$, and the crop dummies, C_q; and β_{2q} is the vector of parameter estimates that captures the crop specific impacts of planting crop type q by the non-traditional planting method. The other variables are as defined above in equation (6.1)**.**

One of the estimation issues in equations (6.1) and (6.2) when OLS is employed to measure the impact on the dependent variables is the non-randomness of the treatment variable. As discussed in Chapter 5, the adopters are the ones who have more access to agricultural extension and with many row planting adopter neighbors among others. One of the techniques to address the biases arising from the non-randomness of the treatment variables is the weighted regression on the matched samples. The first step is to estimate the propensity score, which is given below in equation (6.3), by a logit model using the row planting adopter household dummy as a dependent variable to obtain the matched groups and the frequency weights.

$$RPAdopter_i^* = \{\varphi' Z_i + u_i\}. \qquad (6.3)$$

where Z_i is a vector of household levels predetermined variables such as the age, gender, and years of schooling of the head, livestock value, asset value, and farmland. The mean differences of the covariates before the matching were significantly different between the two groups. But after matching, the significance of the differences disappeared for most of the covariates (Table A.16), which shows that the increases in the similarity between the two groups after matching. The weights for the samples in the common support region are obtained after the propensity score matching. Each observation in the treated group gets a weight of one if it is in the common support, and the weight for each control observation is the numbers of times it was used as the first nearest match for treated observations. The weights for the non-matched households are missing values. The weights for the matched households are matched with the plot level data. Then, the specifications in equations (6.1) and (6.2) are estimated by the weighted regression method. The discussion gives emphasis for the coefficients that are consistent in sign and significance in both the OLS and weighted regression on matched samples results.

6.2 Descriptive statistics

It is essential to define the dependent variables before interpreting the descriptive summary. There are four related measures of the dependent variables. The first one is crop yield, which is defined as the production quantity (in kg) per plot size (in ha). The second is the value of crop yield, which is the product of crop yield (in kg/ha) and the crop price per kg. Crop price information was elicited from farmers for each of the crop type they harvested in 2013/14. To reduce the influence of outliers in the reported prices by each farmer, the median price of each crop in the respective village is used. The third measure is crop income, which is the value of crop yield net of the cost of purchased inputs such as inorganic fertilizers, HYV seeds, and pesticides. Finally, the fourth measure is profit, which is measured by the crop income net of the imputed costs of non-purchased inputs such as family labor, own oxen, and organic fertilizers. The cost of family labor is imputed by the village level market wage rate. The rental of oxen is rare because the oxen owners fear ill treatment and exploitation of their oxen by other farmers. According to the DAs, the daily rental oxen for the pair of oxen are roughly equal to the village level daily market wage rate for an adult man and this rate is used to impute the cost of own oxen hours.

The summary of input use and the outcome variables on the row planted and broadcast plots are reported in Table 6.1. The results show that inorganic fertilizer use (in kg/ha) and HYV seed adoption are larger on the row planted than on broadcasted plots. For instance, farmers apply 20 kg/ha more dap on row planted than on broadcast plots. Organic fertilizer use (in kg/ha) and expenditures for pesticides, on the other hand, are significantly larger on the broadcast than on the row planted plots. The simple descriptive result for organic fertilizer seems less reliable due to its large variance. But the result for pesticide may be because farmers practice row planting on plots which are less susceptible to pests and insects. With regard to the outcome variables, crop yield, value of crop yield, and crop income from the row planted plots are larger than the outcomes from the broadcasted ones but significant difference is found only for crop yield.

[Insert Table 6.1 here]

Regarding profit, its computation requires very detailed information on family labor, hired labor, and oxen input on each plot for each farming activity. Since most farmers have several tiny plots, gathering the detailed input use information for each plot is time consuming for the enumerators and respondents. Instead, the details input use information was elicited only from selected largest plots of farmers which were covered by any of the four main cereal crops: barley, maize, teff, and wheat. The focus on these crops is because they account for the largest share of land under temporary crops and also in terms of the share of purchased intermediate input uses such as inorganic fertilizers. Based on the plot size and crop code information, the CAPI program automatically selects the plot/s for the input use interview. For farmers that implemented only one sowing methods (entirely broadcasting or entirely row planting), information was gathered only from one of the plot covered by the main cereals. But for farmers who applied both the traditional and non-traditional methods, information were collected from two plots (one from the row planted plot/s and the other from broadcasted plot/s).

The summary results from the selected plots are reported in Table 6.2. The results show that family labor, inorganic fertilizer, and the rate of HYV seed adoption are the highest on row planted plots than on broadcasted plots. The crop yield, values of crop yield, crop income, and profit variables are also larger for the row planted than broadcasted plots. Since the input uses may vary considerably across crops, the summary results of input uses and outcome variables in the harvesting of each crop are reported in Tables A.12-A.15. As can be seen from these tables, there are notable differences in input use across crops. The difference in family labor man hour per hectare between row planted and broadcast methods is the highest for teff production where the family labor hour employment on row planted plots is roughly twice that of the broadcast. The results in Tables A12-A.15 also show that the adoption of row planting for teff and maize production are not profitable. The regression section gives emphasis on the heterogeneous effect across crops.

[Insert Table 6.2 here]

6.3 Regression results

The results of the OLS regression results are discussed first, followed by the discussion of the results from the weighted regression on matched samples. The regressions are estimated with and without the interaction terms between the row planted plot dummy and the dummies for the type of crop harvested on the plot. The regression results with the interaction of the two dummies capture whether the effects of row planting varies across crops. The test statistics for the joint significance of these interaction terms are reported. The crop and village fixed effects are included in each regression, and the standard errors are clustered at village level.

6.3.1 The effects of row planting on the dependent variables

Table 6.3 presents the OLS regression results for crop yield, the value of crop yield, and crop income on the row planting adopter dummy, row planted plot dummy, and on several other covariates including plot characteristics, household and head characteristics, and village fixed effects. The results in Columns (1)-(3) show that the row planting adopter dummy is insignificant. But the row planted plot dummy is significantly positive and its coefficients show that row planting is associated with a 13.2 percent increases in both crop yield and the value of crop yield among the adopters, and it is associated with an increase in crop income by 1,071 Birr (which is about 10 percent increase over the crop income from the broadcast method). The sum of the estimated coefficients of the row planting adopter and the row planted plot dummy are positive in Columns (1)-(3) and the p-value show the rejection of the null hypothesis that the two coefficients are jointly zero. These suggest that row planting adoption is associated with an improvement in the agricultural productivity of farmers.

[Insert Table 6.3 here]

As discussed in the empirical specification section in Section 6.1, the effectiveness of row planting could vary considerably across crops. The estimates in Columns (4)-(7) additionally controlled for the interaction terms of the row planted plots with the crop dummies to capture the heterogeneities in the effects of row planting. The row planting adopter dummy is insignificant but many of the interaction terms between the row planted plot and crop dummies are significantly positive. The p-value in the last row of Columns (4)-(6) show the rejection of the null hypothesis that the coefficients of the interaction terms are jointly zero. These show that there are significant positive relationships between planting crops in rows and improvements in agricultural productivity but the effects of adoption are heterogeneous across crops.

For instance, the coefficient of the interaction term for barley show that row planting is significantly associated with a 31 percent increase in value of crop yield and an increase in crop income by 2,932 Birr (or about 30 percent increase) than the value of crop yield and crop income on broadcasted barley plots. For teff production, row planting is significantly associated increases in crop yield and value of yield by 24 percent and 29 percent, respectively; and significantly associated with an increase in crop income by 1,967 Birr (which is about a 20 percent larger over the crop income from the broadcasted teff plots). Similarly, the coefficient of the interaction term for wheat suggests a 26.5 percent larger value of crop yield and a 3,018 Birr (or 33 a percent) larger crop income over the broadcasted wheat plots. The result for the interaction term for millet in Table 6.3 also suggest positive association of the practice improvements in productivity but this evidence is not robust because consistent result is not obtained for this interaction term in the weighted regression on matched samples (Table 6.4) which is discussed in the next section. The lack of consistency in millet may be due to the sample bias as a result of the small number of observations for this crop.

But the interaction of the row planted plot dummy with maize crop dummy is not significant in all the regressions. The results imply that planting maize in rows may not significantly increase its yield, value of yield, and crop income. Farmers might be efficient in allocating maize seeds evenly by broadcasting method because it has large seed size than the other cereals. The descriptive result in Panel A of Table 5.2 shows that the seed rate on the broadcast plot of maize is only 12 kg/ha larger than the row planted plots, which is the smallest difference compared to the result for the other main cereal crops. In addition to the relative efficiency in allocating maize seeds by hand than the other cereal seeds, farmers who broadcast maize may also carry out transplanting the seedlings at the early growing season from the high seedling density to the low seedling parts of the plot because it has tall and thick seedling which is convenient to transplant unlike the seedlings for the other cereals. The results suggest that row planting training and extension follow-ups should focus on small seed crops where the broadcast method of sowing seeds is very inefficient.

The total effects of row planting adoption for each crop type in Columns (4)-(7) is obtained by summing the coefficients of the row planting adopter dummy and the interaction term and the respective crop dummies. For instance, the overall yield effect of planting teff in rows is -0.089+0.24, which is a 15 percent larger yield than broadcast method. Regarding the legume crops, the interaction terms between the row planted plot dummy and the corresponding crop dummies are positive except for hair coat bean and beans. The yield, value of yield and crop income effects of row planting adoption are significant for chickpea and ground nuts; and for soya bean it is significantly positive on its yield and crop income. The coefficients of the interaction terms between the row planted plot dummy and with the legume crop dummies are, however, less precise probably due to the small number of legume crop plots as farmers allocate most of their plots for cereal production.

The fourth and most important outcome variable is profit. The regression result for this dependent variable is reported in Column (7) of Table 6.3. The results for the regression of profit are discussed in this separate paragraph than the other outcome variables because the data come from selected plots and it is only for the four main cereal crops. Brief description of the data for the profit variable is offered in the descriptive statistics. The results suggest that row planting adoption is profitable only for wheat production. The results from the descriptive statistics show that the main factor which reduced the profitability of row planting is the cost of family labor which is imputed using the village level market wage rate. However, the village wage rate might understate the profitability of the practice if the shadow wage rates are smaller than the market wage rates. It is highly likely that the shadow wage rate of famers to be smaller than the market wage rate because the market wage rate reflects the rate at the peak seasons which is observed largely during the harvesting season. Thus, even though profit is the best measure of production efficiency its measurement is difficult due to lack of data on the shadow wage rates and input uses. Another alternative for policy suggestion is to look into the crop income effects of row planting because this measure takes the costs of purchased inputs into consideration. Since farmers in rural Ethiopia are predominantly subsistent producers, the yield and crop income effects of row planting would also have important policy implication. If it increases crop income which accounts for the cost of purchased inputs, it means the practice helps to decrease the number of poor below the poverty line by increasing their farm income.

The results in Table 6.3 do not take the non-random adoption of row planting into consideration. The regression results in Table 6.4, on the other hand, are estimated by weighted regression on the matched samples to deal with the non-randomness in row planting adoption. The coefficients of row planting adopter and row planted plot in Columns (1)-(3) are not significant. But the coefficients of the row planted plot dummy interacted with the crop dummies, which are reported in Columns (4)-(6), are positive and significant for some of the crops. These coefficients are also consistent with the OLS coefficients which are reported in Table 6.3. For instance, the interaction term for barley in Table 6.4 shows that row planting is significantly associated with a 36.2 percent increase in the value of crop yield. Likewise, planting teff in rows is significantly associated with a 26 percent increase in the value of crop yield and a 2,139 Birr increase in crop income (which is equivalent to a 23 percent increase over the crop income from broadcasted teff plots). Significant effects of row planting wheat on the value of crop yield and crop income also uncovered. The coefficients of most of the legume crops are also significantly positive except that some of the coefficients are less precise and emphasis is given for the sign and statistical significance. The less precision in the coefficients for the row planting measures for legume production may be due to small sample bias as the share of individual crops out of the total cereal and legume plots is very small because farmers in Ethiopia largely allocate their plots for one or more of the four main cereals (maize, barley, teff, and wheat).

[Insert Table 6.4 here]

6.3.2 The other correlates of the outcome variables

The discussion for the other correlates of the dependent variables is based on the reported coefficients in Table 6.3. Emphasis is given to the significant coefficients to save spaces. Form the household characteristics; the numeracy score is positively associated with the value of crop yield which suggest that educated farmers could be more knowledgeable and productive. The number of family members in the age ranges of 11-14 and 65-75 years old members, as one of the proxy for child and elderly labor, is significantly associated with larger crop yield. The values of assets and livestock are positively related with all of the dependent variables. A one percent increase in the value of livestock is associated with a 0.03 percent increases in both crop yield and value of crop yield, and 3.65 Birr increase in crop income. A one percent increase in the value of assets is associated with 0.05 percent increases in both crop yield and value of yield, and a 4.37 Birr increase in crop income. The estimates of asset and livestock values show how physical capital is important in enhancing the farmers' productivity.

Regarding the parcel and plot characteristics, the coefficient of farm-size is significantly negative and the result is consistent with the inverse farm-size productivity hypothesis that small farmers are more productive than large farmers because they have more incentive to exert family labor per unit of land than large ones. The dummy for flat slope parcel (compared to sloppy parcels) has a significant positive coefficient on crop yield, probably because flat slopes are less exposed to erosion unlike sloppy ones. Rocky surface dummy (relative to non-rock surface) has a significant negative coefficient in all regressions which may be indicating that the roots of the crop seedling could not easily find nutrients on rocky parcels. The coefficients of land quality perceptions (compared to poor quality land) have the expected positive coefficients on the outcome variables. The final category of plot level variables is the incidence of main crop damages. These dummies have negative coefficients (compared to the no damage case) and most of them are significant indicating how serious these incidences are in reducing farmers' production.

6.4 Conclusion and policy implications

In this chapter the effects of row planting adoption on crop yield, value of crop yield, crop income and profit were investigated using OLS regression and weighted regression on matched samples. The results showed that the effects of row planting adoption are heterogeneous across crops. The robust findings in this chapter include the significant positive relationships of row planting adoption with the value of crop yield and crop income for teff and wheat productions, and with crop income for barley production. But no significant positive relationships are found between row planting adoption and the outcome variables for maize production. Farmers might be efficient in allocating maize seeds evenly by broadcasting method because it has large seed size than the other cereals. In addition to relative advantage of allocating maize seeds efficiently than the other cereals, farmers who broadcast maize may also transplant seedlings from the high seedling density to the low seedling parts of the plot at the early growing season its seedling is tall and thick to do the transplanting easily unlike the seedlings for the other cereals. The relationship of row planting with the outcome variables is also positive for the legume crop.

But row planting is profitable only for wheat production. The main reason that reduced the profitability of row planting is its large family labor requirement which is imputed at the market wage rate. The use of the market wage rate also might exaggerate the true cost of family labor because it may reflect the wage rate at the peak of the harvest season. Hence, the shadow wage rate might be smaller than the market wage rate. Another alternative variable for policy suggestion is the crop income because it accounts for the costs of purchased inputs. The results suggest that row planting training should be emphasized for the small seed crops such as teff and wheat where broadcasting is very evenly by hand is very difficult. Farm level extension follow-ups might also increase farmers' implementation knowledge of row planting. For sustainable adoption of this technology, it is necessary to increase the access to affordable farm implements that help farmers in the row planting to reduce the large labor requirements.

Chapter 7

Conclusion and policy implications

The post 1991 federal and regional governments of Ethiopia have been implementing a variety of policies to reduce the widespread poverty. Special emphasis has been given to the agriculture sector because, as in other developing countries, most of the poor in Ethiopia derive their livelihood from farming. The policies aimed at increasing the production and productivity of farmers by improving their knowledge about new technologies and improved agronomic practices, improving access to land for the landless or land poor farmers, enhancing the tenure security of farmers to stimulate sustainable investments on land, and increasing their access to markets. The policies that have been carried out to achieve the objectives include the heavy investments on public agricultural extension, the redistribution of land in Amhara region in 1996/97, the issuance of landholding certifications in the early 2000, and the natural resource conservation and infrastructural development programs.

Though the federal and regional governments have carried out variety of policies, the number of empirical studies on the contributions of some of these programs on agricultural productivity, input use, and farm investment are limited. In particular, the number of studies about the 1996/97 land redistribution in Amhara region and the recently promoted row planting practice are extremely scant. In this dissertation, I attempted to fill in the knowledge gaps on the input use, investment and productivity consequences of the land redistribution and the recent row planting promotion program. The dissertation has two main parts and organized in seven chapters. The first part of the dissertation contributes to the literature in two main ways. First, it offers evidence on the short-run and long-run input use, soil conservation, and crop yield consequences of the 1996/97 land redistribution in Amhara region. The second contribution is that information about the implementation strategy was used to measure the heterogeneous tenure security of the land redistribution on the outcome variables in the long-run

The main findings of the first part of the analyses in the dissertation are the following. First, a significant negative relationship between the 1996/97 land redistribution and the crop yield was found in the short-run. The analyses of the long-term consequence of the reform, on the other hand, revealed that the reform has significant positive relationships with short-term soil conservation methods, intensive use of inorganic fertilizers, adoption of HYV seeds and improved agronomic practices such as row planting, and consequently with crop yield. The result further indicates that the reform has heterogeneous tenure security consequences within Amhara depending on how the farmers were treated in 1996/97. The most robust heterogeneous consequence is that only the land beneficiaries have a larger probability of investing in stone terraces. Support schemes for the poor beneficiaries such as credit might help to reduce short-run negative effects of land redistribution on crop yield. The other policy implication of the analyses of the land reform is that the use of non-objective criteria such as the farmer’s relationship with past political regimes might result in an increase in the tenure insecurity in the affected region. That in turn discourages farmers from carrying out long-term investments on land. The current land proclamation of Amhara region allows land redistribution if 80 percent of the village residents vote for redistribution of landholdings. Since the average farmland in the region is already small, ruling out land redistribution might increase the tenure security of farmers in the region especially to the losers.

The second part of the analyses contributes to the literature on technology adoption by rigorously investigating the roles of agricultural extension and social learning on row planting adoption using detailed plot level data of cereal and legume producing farmers in Ethiopia. There are few studies about the factors affecting the adoption of this practice and the analyses by the existing studies are household level and cannot control for key factors of adoption such as the crop fixed effects and plot attributes. Finally, the dissertation contributes to the literature by investigating the effects of row planting adoption on crop yield, value of crop yield, crop income, and profit. The earlier studies on the impact of row planting are largely about its impact on crop yield but yield alone may not be a very good indicator of productivity because it does not consider the differences in the cost of complementary inputs such as inorganic fertilizers and labor on the row planted and broadcasted plots. But the alternative measures such as the crop income and profit are better measures over crop yield because these measures take the costs of complementary inputs and labor into consideration in evaluating the productivity of the practice.

The findings in the second part of the analyses show that the technical training by local agricultural extension officers and the learning from neighbors have significant positive effects on the adoption of row planting for cereal and legume production. The seed rate by the row planting adopters is, however, much larger than the rate recommended by the agronomists. The discrepancy could be either because of inefficiency by the farmers or the high seed rate by farmers could be to compensate for non-germinating seeds. This requires empirical investigation. If the main cause is inefficiency by the farmers, then farm level extension follow-ups by farmers might help to improve their practical skill about row planting. Finally, row planting adoption is significantly associated with improvements in the value of crop yield and crop income. The results further revealed heterogeneities across the type of crops in the relationships. More specifically, row planting is significantly associated with increases in crop yield and crop income for teff and wheat productions. But it has no significant relationship with the outcome variables for maize production probably because farmers are good in broadcasting large seed crops such as maize. The results suggest that extension services on row planting training should focus on the small seed crops where broadcasting seeds evenly at a low seed rate is very difficult. Row planting is, however, not profitable at the village level market wage rate except for wheat production due to its large labor requirement. Affordable row planting farm tools should be targeted to sustain the adoption.

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Tables and Figures

Tables used in Chapter 2

Table 2.1: The number of landholders and average farm-size in some Amhara PAs by class before the 1996/97 land redistribution in the region.

Variables	Yedaguat	Agumamit	Arbce Menfesawi	Ateta Alayta
Bureaucrats and remnant feudal				
Number of holders	36	57	262	108
Average Land holding Size(ha)	2.52	3.61	1.83	1.24
Medium *(mekakelegna)*				
Number of holders.	195	47	393	71
Mean land holding Size (Ha)	1.65	2.11	1.43	1.08
Average family size	-	4.74	4.76	-
Mote-Keda				
No. of died/left with no heir)	40		111	23
Average land holding size	0.25		0.48	0.6
Poor (chequn)				
Number of holders	337	130	609	325
Average land (ha)	1	0.93	0.63	0.56
Percent of holders < 1ha	53	43	74	80
percent of holders < 0.5ha	26	36	41	45
Average family size		3.81	3.64	-
Youth				
Number of holders			285	
Average (*ha.*) pre 96/97			0	
Average age			23.63	
Percent of women youth			25.26	
Percent of son/daughter of				
Poor households			44	
Medium households			31	
Bureaucrats & remnant feudal			25	

Source: Computed based on the information on the pre land redistribution registration forms for the 1996/97 land redistribution in Amhara region. Note: Yedaguat PA is found in Enemay Woreda/district of East Gojjam zone and it has five villages. Agumamit and Arbce-Menfesawit are both in the West Gojjam zone. Agumamit is in the Jihab Tenan district and has 5 villages whereas Arbce-Menfesawit is in the Bure Wombera district and has four villages. Ateta-Alayta PA is in the Banja district of Awi zone and has seven villages.

Table 2.2: The number of landholders and average farm-size in some Amhara PAs by class after the 1996/97 land redistribution in the region.

	Woynam-yetenb	Agumamit	Ateta-Alayta			
Bureaucrats & remnant Feudal						
Number of holders	134					
Average land (ha.)	1					
Age of holder (mean)	51.9					
Percent of Female	0					
Medium						
Number of holders	89					
Average land (ha.)	2.74					
Age of holder (mean)	47.20					
Percent of Female	20					
Average land of male (ha)	2.8					
Average land of female (ha)	2.72					
Poor and Youth						
			Priority status			Youth
			1st	2nd	3rd	
Number of holders	1045	187	55	106	45	37
Average land(ha)	0.5	0.5	0.38	0.39	0.52	0.41
Average household Size			6.45	3.66	1.72	1.35
Age of holder (mean)	31.45	30.71	36.2	30.4	35.5	24.24
Percentage of female	30.7	25.6				
Average land of female (ha)	0.48	0.46				

Source: Computed based on the information on the post-redistribution registration forms after the 1996/97 land redistribution in Amhara. Note:Woynam -yetenb PA is in the Enemay district of East Gojjam and has 7 villages. In some of the PAs of the Awi administrative zone, large family size households get priority during the land allocation.

Tables used in Chapter 3

Table 3.1: The average percentage share of major cereal and legume crops in the total crop area and production volume, 1997-1999.

Crop type	E.Gojjam		West Gojjam		Awi		East Wellega	
	%area	% prod.	%area	%prodn.	%area	% prod.	% area	% prod.
Cereals								
Teff	37.41	36.83	29.07	19.57	30.75	23.54	33.7	20.52
Barley	7.36	7.7	3.96	2.53	8.88	8.51	4.04	3.4
Wheat	9.38	11.74	1.74	1.4	1.48	1.12	5.47	7.06
Maize	14.43	15.51	24.09	49.73	16.66	33.78	25.41	47.95
Sorghum	5.94		3.36	3.02	3.16		11.22	8.2
Millet	5.94		14.74	12.55	21.74	22.24	5.18	4.14
Oats	0.02		0.26		0.04		0.02	
Pulses								
Horse Bean	3.84	3.45	3.04	2.45	1.42	0.82	3.88	3.11
Field Peas	1.93	1.29	2.2	1.26	1.29	0.72	1.86	0.94
Hair coat B.	1.62	1.18	1.49				0.1	
Chick Peas	3.62	5.18	1.93	1.24	0.38		0.05	
Lentils	0.07		0.07				0.07	
Vetch	7.61	5.24	2.69	0.47				

Source: Computed based on CSA's Annual Reports (1997-1999). The elements in the table are percentage shares of land area and production volume of each crop.

Table 3.2: The summary statistics of landholders' demographic characteristics and their average landholding in the control and treated groups, 1995-1999.

Variables	East Wellega		West Gojjam versus East Wellega			West Gojjam & Awi versus East Wellega		
	Obs	mean	Obs	MD	p-value	Obs	MD	p-value
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Before the Land Redistribution								
Sex(male=1)	1038	0.777	804	-0.063	0.001	1153	-0.062	0.000
Age (years)	1037	42.351	804	2.436	0.001	1153	1.728	0.009
Age<24	1038	0.094	804	-0.005	0.715	1153	0.008	0.532
Age (24-35)	1038	0.322	804	-0.043	0.056	1153	-0.04	0.049
Age (35+)	1037	0.583	804	0.047	0.043	1153	0.032	0.134
Uneducated	1038	0.701	804	-0.069	0.001	1153	-0.071	0.001
Grade 1-3	1038	0.092	804	-0.093	0.000	1153	-0.092	0.000
Grade 3+	1038	0.206	804	0.161	0.000	1153	0.163	0.000
Household size	998	5.391	788	0.362	0.001	1131	0.3	0.003
Land (hectare)	1016	1.561	771	0.017	0.791	1105	0.095	0.095
After the Land Redistribution								
Sex(male=1)	2278	0.815	2293	-0.006	0.626	4196	-0.034	0.000
Age (years)	2278	41.998	2293	2.17	0.000	4196	1.572	0.000
Age<24	2278	0.087	2293	-0.007	0.421	4196	-0.006	0.400
Age (24-35)	2278	0.325	2293	-0.053	0.000	4196	-0.035	0.000
Age (35+)	2278	0.587	2293	0.06	0.000	4196	0.042	0.000
Uneducated	2278	0.662	2293	-0.074	0.000	4196	-0.089	0.000
Grade 1-3	2278	0.126	2293	-0.080	0.000	4196	-0.064	0.000
Grade 3+	2278	0.212	2293	0.154	0.000	4196	0.153	0.000
Household size	2211	5.05	2252	0.757	0.000	4124	0.642	0.000
Land (hectare)	2261	1.759	2264	0.365	0.000	4142	0.351	0.000

Source: Based on AGSS(1995-1999). Note: East Wellega is used as a control group whereas West Gojjam and Awi zones are the treated groups. MD means mean difference and it is computed as the mean values of variables of East Wellega less that of West Gojjam or West Gojjam and Awi combined.

Table 3.3: The summary statistics for intermediate inputs, irrigation, and crop yield, 1995-1999.

Variables	East Wellega		West Gojjam versus East Wellega			West Gojjam and Awi versus East Wellega		
	Obs	mean	Obs	MD	p-value	Obs	MD	p-value
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Before the Land Redistribution								
Inorganic total (kg/ha)	352	16.744	246	-20.2[a]	0.0000	346	-13.238	0.0000
Organic fertilizer (ha)	352	0.210	246	-0.132	0.0570	346	-0.196	0.0030
Imp. seed crop area (ha)	352	0.050	246	0.030	0.0910	346	0.030	0.0790
Pesticide applied area (ha)	352	0.027	246	0.011	0.4210	346	0.015	0.2330
Irrigated area (ha)	352	0.001	246	0.000	0.8050	346	-0.007	0.1280
Yield (100kg/ha)	241	9.69	193	-0.98	0.0900	269	-0.68	0.1860
Value of yield (Eth Birr)	125[b]	745.01	106	-234.59	0.0000	141	-171.07	0.0040
After the Land Redistribution								
Inorganic total (kg/ha)	726	11.422	673	-10.796	0.0000	1211	-5.594	0.0000
Organic fertilizer (ha)	729	0.265	680	0.013	0.7270	1227	-0.203	0.0110
Imp. seed crop area (ha)	729	0.183	680	0.079	0.1390	1227	0.104	0.0470
Pesticide applied area (ha)	729	0.038	680	0.006	0.6940	1227	0.017	0.2270
Irrigated area (ha)	729	0.005	680	0.001	0.8320	1227	-0.025	0.0000
Crop yield (100kg/ha)b	580	9.81	537	0.28	0.4550	1001	0.81	0.0100
Value of crop yield (ETB)	291	1456.3	324	37.66	0.7760	680	100.25	0.4130

Source: Based on AGSS(1995-1999). Notes: East Wellega is used as a control group whereas West Gojjam and Awi zones are the treated groups. The values of each variable are aggregated at EA level for each crop type. MD denotes the mean difference which is obtained by subtracting the average in Amhara zones from the mean in the control group (i.e., East Wellega) ***a*** - the inorganic fertilizer data of West Gojjam has some outliers for the year 1995. When values that exceed three times the standard deviations are excluded, the mean difference increased from -20 kg/ha to -10kg/ha. ***b*** - the discrepancy in the number of observations between crop yield and the value of crop yield is due to the missing crop prices in some districts in some years. ETB- Ethiopian Birr.

Table 3.4: The summary statistics of the proportion of plots affected by crop damages

Variables	East Wellega		West Gojjam vs East Wellega			West Gojjam anad Awi vs East Wellega		
	Obs	Mean	Obs	MD	p-val	Obs	MD	p-val
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Before the land redistribution								
Total damaged plots (prop.)	352	0.291	246	-0.076	0.00	346	-0.06	0.01
Disease (prop.)	352	0.029	246	-0.008	0.50	346	0.003	0.78
Frost & flood (prop.)	352	0.007	246	-0.024	0.00	346	-0.025	0.00
Insect & pest (prop.)	352	0.026	246	-0.001	0.92	346	0.004	0.62
Shortage of rain (prop.)	352	0.016	246	-0.006	0.46	346	-0.002	0.78
Much rainfall (prop.)	352	0.003	246	-0.029	0.00	346	-0.03	0.00
Wild animal (prop.)	352	0.014	246	0.003	0.59	346	0.005	0.23
Birds (prop.)	352	0.004	246	0.002	0.29	346	0.003	0.20
Other damage (prop.)	352	0.192	246	-0.013	0.01	346	-0.019	0.19
After the land redistribution								
Total damaged plots (prop.)	725	0.277	674	-0.091	0.00	1215	-0.081	0.00
Disease (prop.)	725	0.026	674	0.017	0.00	1215	0.020	0.00
Frost & flood (prop.)	725	0.007	674	-0.026	0.00	1215	-0.016	0.00
Insect & pest (prop.)	725	0.023	674	-0.008	0.19	1215	0.003	0.51
Shortage of rain (prop.)	725	0.020	674	0.001	0.90	1215	0.006	0.13
Much rainfall (prop.)	725	0.033	674	-0.034	0.00	1215	-0.032	0.00
Wild animal (prop.)	725	0.022	674	0.014	0.00	1215	0.013	0.00
Birds (prop.)	725	0.005	674	0.002	0.42	1215	0.003	0.13
Other damage (prop.)	725	0.141	674	-0.057	0.00	1215	-0.078	0.00

Source: Based on AGSS (1995-1999. Notes: East Wellega is used as a control group whereas West Gojjam and Awi zones are the affected zones by the land redistribution. The values of each variable are aggregated at EA level for each crop type. MD denotes the mean difference which is obtained by subtracting the average in Amhara zones from the mean in the control group (i.e., East Wellega)

Table 3.5: The marginal effects from the Tobit regressions for the logarithm of inorganic fertilizer (kg/ha), 1995-1999.

VARIABLES	(1)	(2)	(3)
DAmhara*T	1.018***	0.361	0.510*
	(2.715)	(1.064)	(1.681)
The proportion of male landholders	0.591	-0.948	-0.683
	(0.793)	(-1.077)	(-0.929)
ln(average hhsize)	2.451***	1.708**	1.780***
	(3.038)	(2.374)	(2.894)
The proportion of uneducated landholders	-1.077	-0.483	-0.611
	(-1.206)	(-0.564)	(-0.799)
The proportion of grade 1-3 landholders	2.872**	2.671**	2.967***
	(2.210)	(2.209)	(2.864)
Mono-crop (=1)	0.356*	0.690***	0.619***
	(1.818)	(4.111)	(4.306)
The proportion of crop plots that experienced shortage of rains	-0.857	-0.771	-0.669
	(-1.289)	(-1.096)	(-1.059)
The proportion of crop plots that experienced excessive rains	0.597	-0.294	0.283
	(1.607)	(-0.947)	(1.034)
Observations	1,384	1,984	2,616
Log-likelihood	-2218	-3175	-4144

Notes: in parenthesis are z-statistics computed using robust standard errors. Standard errors are clustered at an enumeration area level for each year. *** shows significance at 1%, ** at 5%, and * at 10%. District, crop and year fixed effects are controlled in each regression. The proportion of female landholders is the reference category for the proportion of male landholders; the proportion of grade 4 and above completed landholders is the reference group for the proportions of uneducated , and grade 1 to 3 landholder categories; mixed crop is the reference group for the mono-crop dummy; and finally the proportion of crop plots which were affected neither by shortage nor by excessive rainfall is the reference category for the proportions of crop plots affected by shortage of rainfall, and the proportion of crop plots affected by an excessive rainfall. The lower limit in the Tobit estimation was set at ln(k), where k is the minimum positive value of inorganic fertilizer (kg/ha) less a very small number. The results in Column (1) are from the “nearby group”, and in Column (2) the results obtained using the entire West Gojjam (from the affected side) and East Wellega (from the control part), and finally the results in Column (3) are obtained using the entire West Gojjam and Awi zones (from the affected) and East Wellega zone (from the control).

Table 3.6: The OLS regression results for crop yield and value of crop yield, 1995-1999.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	Ln(yld)	Ln (vyld)	Ln(yld)	Ln (vyld)	Ln(yld)	Ln(vyld)
DAmhara*T	-0.30***	-0.363**	-0.163*	-0.414***	-0.146*	-0.387***
	(0.0977)	(0.152)	(0.0839)	(0.132)	(0.0794)	(0.125)
Prop. Male holders	0.0830	0.187	0.248	-0.0343	0.189	0.132
	(0.197)	(0.262)	(0.208)	(0.341)	(0.186)	(0.283)
Ln(average hhsize)	0.283	0.0403	-0.0756	-0.0346	0.0730	0.0716
	(0.209)	(0.290)	(0.174)	(0.282)	(0.157)	(0.213)
Prop. Uneducated landholders	-0.315	0.0318	-0.185	0.158	-0.218	-0.165
	(0.270)	(0.371)	(0.185)	(0.312)	(0.170)	(0.257)
Prop. Grade 1 to 3 landholders	0.0709	0.169	-0.458	0.0947	-0.202	-0.0576
	(0.367)	(0.428)	(0.311)	(0.442)	(0.266)	(0.343)
Mon crop(=1)	0.13***	0.111	0.086**	0.158**	0.111***	0.133**
	(0.0450)	(0.0775)	(0.0425)	(0.0744)	(0.0357)	(0.0615)
the proportion of crop plots affected by major crop damages types						
Crop disease	-0.519	-1.00***	-0.275	-0.507*	-0.199	-0.412
	(0.315)	(0.324)	(0.196)	(0.295)	(0.185)	(0.283)
Frost and flood	-0.373*	0.122	-0.0774	0.307	-0.0655	0.517
	(0.213)	(0.472)	(0.245)	(0.491)	(0.233)	(0.395)
Insects and pests	0.307	0.347	-0.158	-0.571*	-0.129	-0.558**
	(0.329)	(0.644)	(0.167)	(0.333)	(0.149)	(0.265)
Shortage of rain	-0.187	-0.183	-0.270	-0.146	-0.241	-0.114
	(0.287)	(0.437)	(0.228)	(0.369)	(0.215)	(0.344)
Excessive rain	-0.117	-0.252	-0.289**	-0.265*	-0.205*	-0.226
	(0.146)	(0.196)	(0.114)	(0.147)	(0.109)	(0.145)
Wild Animals	0.0838	-0.450	0.158	0.280	0.133	0.114
	(0.288)	(0.460)	(0.156)	(0.227)	(0.174)	(0.353)
Birds	-0.956	-0.213	-0.643	0.215	-0.710	0.0750
	(0.693)	(2.009)	(0.530)	(0.214)	(0.495)	(0.222)
Other damages	-0.168	-0.207	-0.181*	-0.130	-0.25***	-0.214
	(0.116)	(0.189)	(0.0962)	(0.147)	(0.0817)	(0.131)
Constant	5.80***	6.12***	6.51***	4.823***	6.309***	6.172***
	(0.623)	(0.677)	(0.291)	(0.797)	(0.267)	(0.495)

Observations	1,122	708	1,563	854	2,099	1,244
R-squared	0.410	0.352	0.484	0.449	0.411	0.345

Notes: in parenthesis are robust standard errors that are clustered at an enumeration area level for each year. *** shows significance at 1%, ** at 5%, and * at 10%. District, year and crop fixed effects are controlled in all the regression. The proportion of female landholders is the reference category for the proportion of male landholders; the proportion of grade 4 and above completed landholders is the reference group for the proportions of uneducated and grade 1 to 3 landholders categories; mixed crop is the reference group for the mono-crop dummy; and the proportion of crop plots with no crop damage is the reference category for the proportion of crop damage categories. The results in Columns (1) &(2) are obtained from the "nearby group", and in Columns (3) & (4) the results are obtained using West Gojjam (from the affected) and East Wellega (from the control), and finally the results in Column (5) &6 are obtained using the entire West Gojjam and Awi (from the affected) and East Wellega zone (from the control).

Table 3.7: The summary of the losers and beneficiaries response on how their latest land redistribution affected their input use and soil conservation in the short-run.

Variables	Increased/more employed	Decreased/less employed	No changes	Do not remember
Panel A: The response of losers				
Oxen/animal input	29	61	10	0
Family labor	42	37	18.4	2.6
Stone terraces	31	24	45	0
Check dam	34	21	45	0
Other soil conservations	42	21	34	3
Inorganic fertilizer	42	26	32	0
Panel B: The response of beneficiaries				
Oxen/animal input	79	2.6	18.4	0
Family labor	76.3	2.63	21.05	0
Stone terraces	76	24	0	0
Check-dam/drainage ditches	63	11	21	6
Other soil conservations	68	2.6	29	0
Inorganic fertilizer	71	0	29	0

Source: Computed based on the 2014 RePEAT survey in Ethiopia. The numbers in each cell refers to the percentage of respondents. The numbers of loser and beneficiary samples are 39 and 38, respectively. Farmers were asked to answer how the reform affected their input use and soil conservation practices in the first three years after the recent land redistribution.

Tables used in Chapter 4

Table 4.1: The pre-reform or 1996/97 summary statistics of farm practices and crop yield for cereal and legumes in selected Oromia and Amhara regional administrative zones.

Variables	Oromia			Amhara			Difference		
	Obs	Mean	sd	Obs	mean	sd	MD	se	p-value
Land holding (ha.)[a]	150	1.47	0.90	75	1.59	0.87	-0.118	0.124	0.343
Inorganic fert. (kg/ha)	528	14.46	38.57	204	16.10	42.40	-1.632	3.41	0.633
Improved seeds (kg/ha)	533	0.26	0.256	224	0.074	0.485	-0.048	0.034	0.162
Irrigated area (ha)	533	0.000	0.000	224	0.000	0.000	0.000	0.000	.
Organ fert. Appl. area (ha)	533	0.009	0.040	224	0.001	0.016	0.007	0.002	0.000
Pesticide appl area (ha)	533	0.019	0.087	224	0.004	0.045	0.015	0.005	0.003
Yield (100kg/ha) [b]	41	9.30	3.33	17	8.80	4.02	0.499	1.116	0.659
Yield (100kg/ha) [c]	90	10.90	6.50	161	8.496	3.997	2.39	0.663	0.000

Source: Computed based on CSA (1996)

Note: a) landholding size is at household level and the other variables are at plot level except the yield. Yield is at enumeration area level because CSA uses crop-cutting approach from some of the randomly selected samples. b) the parts of Oromia in this study are the North and East Shewa zones and North Shewa is the part zone is the one from Amara region c) The crop yield is from the districts which contain one or more of the 2014 RePEAT survey villages. d) The yield is from all the districts in North Shewa zone (Amhara) and all districts of North and East Shewa zones (Oromia).

Table 4.2: The summary statistics of household level variables by type of treatment and region, 2014.

	Amhara			Control	p-values for control versus		
	Losers	beneficiaries	Unaffected		Losers	beneficiaries	Unaffected
Age of the head	60	45	47	51	0.000	0.000	0.100
Household Size	6.42	6.10	5.32	6.36	0.920	0.490	0.000
Proportion of male head	0.90	0.86	0.82	0.87	0.680	0.980	0.430
Numbers of adults (15-64 age)	3.70	3.20	2.50	3.50	0.680	0.150	0.000
% literate heads	74	60	50	58	0.060	0.780	0.110
Years of schooling (head)	1.53	2.97	1.53	1.87	0.460	0.100	0.440
Arithmetic score (out of 6)	0.37	0.4	0.37	0.36	0.790	0.410	0.830
landholding (ha) before 1996/97	4	0.36	Na	na	na	na	Na
Landholding (ha) after the reform	2.07	2.01	Na	na	na	na	Na
% of landless before reform	0.00	76	Na	na	na	na	Na
Land holding in ha. (own)	1.67	1.61	1.63	2.45	0.000	0.000	0.000
Landholding (ha) per adult members	0.57	0.59	0.67	0.81	0.010	0.067	0.130
Total land including under temporary contract (ha.)	1.97	1.9	1.91	2.71	0.000	0.010	0.000
Total land per adult members	0.68	0.72	0.83	0.91	0.010	0.094	0.330
% who expect land redistribution in 10 years	16	13	23	22			
Total numbers of parcels	248	262	422	1198			
% of farmers who acquired fertilizers on credit scheme	13	32.4	18	0.60			
Elevation of the household compound (meter asl)		2408		2383		0.722	

Source: Computed based on the 2014 RePEAT survey.

The total numbers of losers, beneficiaries, unaffected, and farmers in the control groups are 38, 39, 69, and 164, respectively. Na means not applicable. The controls are the sample of farmers from the North and East Shewa zones of Oromia region

Table 4.3: The summary statistics of parcel and plot characteristics by treatment status and region, 2014.

Variables	Amhara			Cont.	P-value of control vs.		
	Losers	Benef.	Un-aff	group	Los.	Benf.	Un-aff.
Parcel characteristics							
Rented/sharecrop in (=1)	0.100	0.105	0.119	0.081	0.35	0.24	0.036
Sloppy parcel (=1)	0.257	0.188	0.318	0.231	0.39	0.10	0.001
Rock/stone surface (=1)	0.251	0.208	0.305	0.199	0.08	0.73	0.000
Excellent Soil (=1) [b]	0.152	0.188	0.139	0.298	0.00	0.00	0.000
Good soil (=1)	0.481	0.473	0.436	0.440	0.23	0.33	0.888
Fair soil (=1)	0.284	0.270	0.332	0.184	0.00	0.00	0.000
Poor soil (=1)	0.074	0.051	0.093	0.051	0.99	0.05	0.009
Soil conservation practices on sloppy parcels							
Stone terraces (=1)	0.12	0.320	0.075	0.160	0.43	0.02	0.046
Contour plough (=1)	0.25	0.180	0.113	0.090	0.00	0.10	0.221
Check-dam (=1)	0.21	0.080	0.165	0.160	0.28	0.10	0.524
Other soil conserve (=1)	0.07	0.020	0.070	0.000	0.05	0.41	0.002
Plot level variables							
Improved seed (=1)	0.14	0.15	0.05	0.07	0.00	0.00	0.359
Row planting (=1)	0.06	0.05	0.02	0.03	0.14	0.25	0.065
Dap (kg/ha) [b]	87.3	94.6	60.62	55.8	0.00	0.00	0.426
Urea (kg/ha)	49.5	59.23	40.86	41.84	0.22	0.00	0.849
Manure (kg/)	1064	220.77	801.8	400.4	0.06	0.27	0.108
Compost (kg/ha)	362	881.14	374.5	390.0	0.62	0.27	0.713
Other organic (kg/ha)	1.34	53.85	32.79	24.08	0.10	0.51	0.882
Exp. on insecticides	66.0	18.2	20.7	19.33	0.00	0.82	0.262
Exp. on hired labor	369	247	380.0	407.5	0.82	0.17	0.87
Crop yield (kg/ha)	1599	1607.3	1453	1394.	0.00	0.01	0.10
Value of crop yield(Birr)	13356	13355	11904	11043	0.00	0.00	0.001
Major causes of crop damages [c]							
Shortage of rain (=1)		0.027		0.036		0.309	
Flood (=1)		0.013		0.019		0.366	
Crop disease (=1)		0.043		0.046		0.791	
Insect damage (=1)		0.028		0.015		0.102	
Animal Damage (=1)		0.016		0.011		0.409	
Frost (=1)		0.055		0.118		0.000	
Others Damages (=1)		0.025		0.029		0.193	

Source: Computed based on the 2014 RePEAT survey. Note a) because of a few missing values, the proportion of soil qualities do not add up to one. b) the top 5% of the observations for urea and dap were excluded to reduce the influence of outliers on the descriptive results. c) Since the incidences of damages are outside farmers' control, the results are reported without making distinctions between losers, beneficiaries, and the unaffected.

Table 4.4: The marginal effects from the Probit regressions for the likelihood of carrying out soil conservation methods on sloppy parcels.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	Stone terraces	Cont. plough	Check Dam	Stone terraces	Cont. plough	Check Dam
Land redistribution variables						
DAmhara (=1 if Amhara region)	-0.0138	0.13***	0.0523			
	(-0.337)	(2.637)	(1.128)			
DUnaffected (=1 if neither gain nor lost land in 1996/97)				-0.0463	0.116	0.0271
				(-1.050)	(1.396)	(0.664)
DBeneficiaries (=1 if received land in 1996/97)				0.191**	0.0254	0.0356
				(2.183)	(0.357)	(0.481)
DLoser (=1 if lost land in 1996/97)				-0.0335	0.29***	0.109
				(-0.843)	(4.847)	(1.480)
ln(farm size)	-0.144*	-0.0335	-0.11***	-0.128*	-0.0285	-0.0901**
	(-1.958)	(-0.447)	(-2.668)	(-1.908)	(-0.430)	(-2.485)
Head & household level variables						
Male HHead(=1)	0.0249	-0.0464	-0.17***	0.0150	-0.0372	-0.172***
	(0.598)	(-1.422)	(-4.317)	(0.348)	(-1.267)	(-3.814)
ln(Head age)	0.101	-0.133*	0.0875*	0.107	-0.146	0.0767
	(1.055)	(-1.691)	(1.653)	(1.285)	(-1.606)	(1.355)
ln(Head's years of schooling)	0.05***	0.0163	-0.0205	0.035**	0.0259*	-0.0158
	(3.242)	(0.887)	(-1.267)	(2.260)	(1.665)	(-1.001)
The proportion of score in arithmetic test	-0.0672	-0.3***	0.288***	0.00520	-0.3***	0.278***
	(-0.534)	(-3.406)	(3.831)	(0.0464)	(-3.006)	(3.877)
ln(No. contacts with DA in main season)	0.0244	-0.008	0.0234	0.0171	-0.0122	0.0187
	(1.245)	(-0.462)	(1.100)	(0.898)	(-0.662)	(0.979)
ln(adult size, 15-64)	-0.0158	-0.0034	-0.0529	-0.0129	-0.0171	-0.0584*
	(-0.262)	(-0.08)	(-1.537)	(-0.247)	(-0.434)	(-1.671)
ln(child and elderly size)	0.0394	0.0379	-0.0190	0.0276	0.0400	-0.0233
	(1.181)	(0.996)	(-0.810)	(0.788)	(1.077)	(-0.880)
ln(assets values)	0.00650	0.0116	-0.00481	0.00235	0.0110	-0.00551
	(0.396)	(1.004)	(-0.506)	(0.182)	(0.959)	(-0.576)
ln (TLU)	0.0152	0.0123	0.032***	0.0178	0.00926	0.0326***
	(0.819)	(1.126)	(2.920)	(0.966)	(0.893)	(2.952)
ln(Number of own oxen)	0.0736	0.081**	-0.063**	0.0618	0.083**	-0.0667**
	(1.499)	(2.120)	(-2.087)	(1.382)	(2.165)	(-2.297)
land certificate (=1 if received)	0.0494	-0.271*	0.0377	0.0339	-0.218	0.0384
	(0.610)	(-1.826)	(0.976)	(0.395)	(-1.603)	(1.057)

Table 4.4 continued	Stone terraces	Cont. Plough	Check Dam	Stone terraces	Cont. plough	Check Dam
Relative farm size per capita	-0.00905	-0.0124	0.00657	-0.00532	-0.0148	0.00112
	(-0.230)	(-0.286)	(0.309)	(-0.147)	(-0.390)	(0.0518)
Parcel characteristics						
Ln(parcel size in ha)	0.05***	0.04***	0.0554**	0.05***	0.04***	0.0537***
	(2.658)	(3.309)	(2.556)	(3.290)	(3.313)	(2.692)
Ln(total number of parcels)	-0.788*	-0.272	0.542	-0.951**	-0.209	0.509
	(-1.810)	(-0.982)	(1.540)	(-2.235)	(-0.736)	(1.446)
[Ln(No. parcels)]square	0.167*	0.0680	-0.114	0.201**	0.0539	-0.108
	(1.805)	(1.036)	(-1.416)	(2.219)	(0.811)	(-1.342)
Simpson index	0.556	0.435	0.245	0.599	0.407	0.227
	(1.365)	(1.302)	(1.287)	(1.519)	(1.397)	(1.269)
Length of tenure (in years)	-0.00026	-0.0011	-0.00135	0.00024	-0.002	-0.00150
	(0.225)	(0.672)	(1.015)	(-0.184)	(1.148)	(1.207)
Leased out (=1)	0.0195	0.0503	-0.0128	-0.0193	0.0610	-0.0183
	(0.250)	(0.702)	(-0.259)	(-0.288)	(0.736)	(-0.374)
Leased in (=1)	0.0795	-0.0393	-0.0132	0.0731	-0.0412	-0.0188
	(1.261)	(-1.148)	(-0.310)	(1.181)	(-1.518)	(-0.471)
ln(parcel distance in minute units)	-0.0005	0.00036	0.00873	0.00056	-0.0002	0.0109
	(-0.036)	(0.0769)	(0.758)	(0.0432)	(-0.048)	(0.912)
Rock strewn(=1)	0.0282	-0.001	0.099***	0.0302	-0.0015	0.0972***
	(0.904)	(-0.063)	(3.89)	(1.047)	(-0.097)	(3.790)
Steep slope(=1)	0.0214	0.00229	0.107***	0.0184	0.00620	0.105***
	(0.668)	(0.0735)	(6.518)	(0.547)	(0.208)	(6.842)
Village characteristics						
Ln(distance to nearest district town)	0.0320	0.00885	0.079***	0.0411	-0.006	0.0723***
	(1.142)	(0.308)	(2.744)	(1.509)	(-0.236)	(2.694)
Transport (=1 if trans service)	0.04**	-0.0128	-0.0723	0.0304	-0.0054	-0.0718
	(1.991)	(-0.343)	(-1.548)	(1.571)	(-0.155)	(-1.513)
ln(distance to nearest market)	-0.0702*	-0.0611	-0.0908*	-0.0643*	-0.0515	-0.0816*
	(-1.905)	(-1.557)	(-1.803)	(-1.716)	(-1.487)	(-1.802)
ln(distance to the nearest FTC)	0.0345*	0.0147	0.0203	0.0330	0.00878	0.0153
	(1.652)	(0.972)	(1.104)	(1.512)	(0.664)	(0.976)
Ln(No. of landless households)	-0.00378	0.0166	0.0251**	-0.00034	0.0112	0.0233**
	(-0.272)	(1.336)	(2.097)	(-0.025)	(0.919)	(2.097)
Population density	0.008**	0.00033	-0.00152	0.0064*	0.00080	-0.00163
	(2.298)	(0.0982)	(-0.555)	(1.715)	(0.230)	(-0.537)
Observations	485	485	485	485	485	485
Log likelihood	-166	-141	-142	-159	-138	-141
Pseudo R2	0.1670	0.229	0.319	0.2012	0.2465	0.3231
P-va: DBeneficiaries'=Dlosers'				0.000	0.015	0.457
DBeneficiaries'=DUnaffected				0.007	0.408	0.925
Dlosers'=DUnaffected'				0.801	0.290	0.158

Notes: The reported results are marginal effects evaluated at the average of all variables and elements in parenthesis are z-statistics computed using robust standard errors. Standard errors are clustered at village level. *** shows significance at 1%, ** at 5%, and * at 10%. Population density is the ratio of the village population to the total land cultivated land. Distances are in kilometer units. The moderately sloppy parcel is the reference category for steep slope parcels; and the non-rocky parcel surface is the reference category for the rocky surface dummy; and owner operated parcels are the reference categories for leased-in parcels. The p-value for the equality of coefficients for the dummies of beneficiaries, losers, and unaffected are reported in the last three rows.

Table 4.5: The marginal effects from the Probit regressions for the likelihood of carrying out soil conservation methods (alternative regressions).

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	Stone terrace	Cont. plough	Check Dam	Stone terraces	Cont. plough	Check Dam
Panel A: The results using both sloppy and non-sloppy parcels						
DAmhara (=1 if Amhara region)	0.0367	0.14***	0.03***			
	(1.06)	(2.614)	(2.625)			
DUnaffected (=1 if neither gain nor lost land in 1996/97)				-0.00237	0.0803	0.050***
				(-0.063)	(1.390)	(3.095)
DBeneficiaries (=1 if received land)				0.111**	0.167**	0.0160
				(2.011)	(2.574)	(0.605)
DLoser (=1 if lost land)				0.0467	0.332***	0.0471*
				(0.872)	(3.887)	(1.861)
Ln(farm size)	-0.011	-0.0443	-0.00547	-0.00462	-0.0298	-0.00651
	(-0.32)	(-0.823)	(-0.333)	(-0.130)	(-0.638)	(-0.391)
Observations	1,964	1,964	1,964	1,964	1,964	1,964
Log likelihood	-597	-627	-333	-588	-619	-325
Pseudo R2	0.1529	0.1559	0.2576	0.1653	0.1656	0.2747
P-value, DBeneficiary=Dloser				0.4353	0.0308	0.6304
Panel B: The results with the size of land received or lost in 1996/97 (sloppy parcels only)						
DAmhara (=1 if Amhara region)				-0.0265	0.124**	0.0622
				(-0.618)	(2.352)	(1.238)
Net land received in ha.				0.07***	-0.0281	-0.0136
				(2.836)	(-0.969)	(-0.587)
Net land lost in ha.				-0.0110	0.0109	-0.00783
				(-0.430)	(0.696)	(-1.106)
Ln(farm size)				-0.14**	-0.0385	-0.10***
				(-2.191)	(-0.551)	(-2.762)
Observations				485	485	485
Log likelihood				-161	-140	-141
Pseudo R2				0.195	0.234	0.321
P-val: received land = lost land				0.000	0.08	0.776

Panel C: The weighted regression on matched samples (for losers)

DLoser (=1 if lost land)	-0.07**	0.005***	0***
	(-2.418)	(4.369)	(16.63)
Ln(farm size)	-0.0410	0.00190*	-0***
	(-0.970)	(1.675)	(-5.037)
Obs	413	508	482

Notes: The reported results are marginal effects evaluated at the average of all variables and elements in parenthesis are z-statistics computed using robust standard errors. Standard errors are clustered at village level. *** shows significance at 1%, ** at 5%, and * at 10%. The regression in panel C is based on the entire parcel information. Head and household level, parcel and village level variables are included in the regressions in Panels A-C but estimates not reported to save spaces.

Table 4. 6: The marginal effects from the Tobit for fertilizer use (kg/ha) and from Probit regressions for the adoptions of HYV seeds and row planting.

VARIABLES	(1) Ln (Dap kg/ha)	(2) Ln (Urea kg /ha)	(3) Ln(Organic kg/ha)	(4) HYV seeds (=1)	(5) Row planting (=1)
Land redistribution variables					
DUnaffected (=1 if neither gain nor lost land in 1996/97)	0.536	-0.0706	-0.189	0.00718	0.0195
	(1.502)	(-0.205)	(-1.066)	(0.239)	(1.365)
DBeneficiaries (=1 if received land)	1.148***	0.432	-0.133	0.0849***	0.0423***
	(3.351)	(1.432)	(-0.432)	(3.568)	(2.827)
DLoser (=1 if lost land)	1.318***	0.255	-0.166	0.0955**	0.0482***
	(3.903)	(0.693)	(-0.949)	(2.521)	(3.171)
Ln(farm size)	0.0414	-0.293	-0.896***	0.0351	-0.0223
	(0.200)	(-1.486)	(-4.779)	(0.949)	(-1.265)
Head and household level variables					
Male HHead(=1)	-0.0228	-0.0902	0.154	-0.0157	0.0647***
	(-0.173)	(-0.609)	(0.857)	(-0.478)	(8.193)
Ln(Head age)	-0.83***	-0.477**	-0.618*	-0.0421	-0.0394*
	(-3.735)	(-2.116)	(-1.657)	(-1.007)	(-1.823)
ln(Head's years of schooling)	0.00785	0.00260	0.0343	0.0190	0.00740
	(0.147)	(0.0339)	(0.434)	(1.430)	(1.213)
Proportions of correct score in arithmetic test	0.312	0.704	-0.0419	-0.0350	-0.0261
	(1.182)	(1.445)	(-0.104)	(-0.566)	(-0.710)
ln(No. of contacts with the DAs in main farming season)	0.0337	0.107	-0.0707	0.0465***	0.0140***
	(0.374)	(1.262)	(-0.773)	(4.611)	(3.415)
ln(adult size, 15-64)	-0.110	-0.0668	0.235	-0.0134	-0.0362***
	(-0.766)	(-0.347)	(1.325)	(-0.392)	(-3.545)
ln(children and elderly size, 11-14&65-75)	-0.00295	-0.161	0.0756	-0.00871	-0.00833
	(-0.0167)	(-1.193)	(0.453)	(-0.435)	(-0.599)
ln(assets values)	0.0166	0.0283	-0.0261	0.00798	0.00644*
	(0.191)	(0.370)	(-0.506)	(1.275)	(1.693)
ln (TLU)	-0.0280	0.00841	0.134*	-0.00169	0.0162***
	(-0.451)	(0.139)	(1.837)	(-0.143)	(8.749)
ln(total numbers of own oxen)	0.0762	0.206	0.561*	0.00702	-0.00378
	(0.754)	(1.415)	(1.902)	(0.214)	(-0.177)
Fertilizer credit (=1 if received fertilizer on credit)	0.678**	0.890***	-0.856***	-0.0406*	-0.0148
	(2.492)	(3.195)	(-3.156)	(-1.822)	(-0.999)

Table 4.6 Continued	Ln (Dap kg/ha)	Ln (Urea kg /ha)	Ln(Organic kg/ha)	Improved seed (=1)	Row planting (=1)
Land certificate (=1)	0.0640	0.179	-0.417***	0.0357	0.0125
	(0.329)	(1.024)	(-2.782)	(0.673)	(0.985)
Relative farm size per capita	0.00311	0.107	0.268***	-0.0113	0.00407
	(0.0229)	(0.729)	(3.108)	(-0.410)	(0.362)
Parcel and plot characteristics					
ln(plot size)				0.0716***	-0.0429*
				(2.985)	(-1.864)
ln(total numbers of parcels)	-0.129	0.0820	3.980***	0.0168	-0.152*
	(-0.116)	(0.0659)	(3.606)	(0.104)	(-1.697)
[ln(No. parcels)]square	0.0337	-0.00264	-0.753***	-0.0119	0.0481**
	(0.129)	(-0.009)	(-3.128)	(-0.319)	(2.573)
Simpson index	-0.657	-0.477	-0.507	-0.153	0.0274
	(-0.957)	(-0.710)	(-0.365)	(-1.334)	(0.422)
Length of tenure (in years)	0.00635	0.0105*	0.00824	0.00101	-0.000391
	(1.374)	(1.894)	(1.257)	(1.300)	(-0.792)
Leased in (=1)	0.145	0.0518	-0.758***	0.0136	0.000954
	(0.992)	(0.309)	(-2.907)	(0.417)	(0.0709)
ln(parcel distance in minute)	0.121**	0.188***	-0.602***	-0.00345	-0.00537
	(2.351)	(3.027)	(-9.725)	(-0.401)	(-0.975)
Excellent soil (=1)	0.147	0.209	0.754**	0.00398	-0.0534**
	(0.671)	(0.805)	(2.306)	(0.122)	(-2.470)
Good soil (=1)	0.0399	0.153	0.647*	-0.00901	-0.0664***
	(0.184)	(0.616)	(1.873)	(-0.268)	(-4.009)
Fair soil (=1)	0.0370	0.0376	0.315	-0.0115	-0.0403***
	(0.192)	(0.162)	(1.008)	(-0.339)	(-3.162)
Moderate slope (=1)	-0.0823	-0.310	-0.0153	0.0222	0.0253
	(-0.582)	(-1.544)	(-0.0720)	(1.283)	(1.546)
Steep slope (=1)	-0.516**	-0.533**	0.274	-0.0423	-0.0226
	(-2.461)	(-2.362)	(0.989)	(-1.373)	(-1.274)
Rock strewn(=1)	-0.28***	-0.143	0.263**	-0.047***	-0.0469**
	(-2.680)	(-1.063)	(2.141)	(-2.984)	(-2.382)
Shortage of rain (=1)	0.0481	-0.558	-0.242	-0.00233	0.0233*
	(0.146)	(-1.454)	(-0.688)	(-0.0448)	(1.878)
Village characteristics					
ln(distance to nearest district town)	0.343	0.327*	-0.286**	0.0113	0.343
	(1.520)	(1.674)	(-2.366)	(0.633)	(1.520)
Transport (=1 if trans service)	-0.0364	-0.129	0.0631	-0.080***	-0.0364
	(-0.183)	(-0.743)	(0.469)	(-3.773)	(-0.183)
ln(distance of nearest market)	-0.126	-0.124	0.173	0.0752***	-0.126
	(-0.430)	(-0.456)	(1.176)	(2.601)	(-0.430)

ln(distance in km to the FTC)	0.426**	0.261	0.0315	-0.0162	0.426**
	(2.007)	(1.234)	(0.412)	(-1.269)	(2.007)
Ln(No. of landless households)	0.119*	0.0830	-0.318***	0.00513	0.119*
	(1.710)	(0.940)	(-7.741)	(0.660)	(1.710)
Population density	0.0434	0.0400	0.00792	-0.00159	0.0434
	(1.338)	(1.456)	(0.502)	(-0.867)	(1.338)
Observations	1,400	1,400	1,405	1,274	1,305
Log-likelihood	-1681	-1610	-890	-305	-121
Pseudo R2	0.2803	0.2593	0.2002	0.2273	0.382
P-val,DBeneficiaries'=Dlosers'	0.325	0.573	0.869	0.755	0.629
DBeneficiaries'=DUnaff'	0.010	0.078	0.769	0.001	0.014
DLosers'=DUnaffected	0.000	0.185	0.867	0.056	0.017

Notes: The reported results are marginal effects evaluated at the average and elements in parenthesis are z-statistics computed using robust standard errors. Standard errors are clustered at village level. *** shows significance at 1%, ** at 5%, and * at 10%. %. Organic fertilizer is the sum of manure and compost. The lower limit in the Tobit estimation is set at ln(k), where k is the minimum positive values of respective values of the censored dependent variables less a very small number. HYV seed and row planting adoption are estimated by Probit regression. The non-sloppy parcel is the reference category for steep and moderately steep slope parcels; and the non-rocky parcel surface is the reference category for the rocky surface dummy, and owner operated parcels are the reference categories for leased-in parcels. Crop fixed effects are included in each regression.

Table 4.7: The marginal effects from the Tobit for fertilizer use (kg/ha) and from Probit regressions for the adoptions of HYV seeds and row planting (further results).

VARIABLES	(1) Ln (Dap kg/ha)	(2) Ln (Urea kg /ha)	(3) Ln(Organic kg/ha)	(4) HYV seed (=1)	(5) Row planting (=1)
Panel A. The results without the heterogeneous tenure security measures					
DAmhara (=1 if Amhara region)	0.913***	0.131	-0.175	0.0600**	0.0398***
	(2.657)	(0.411)	(-1.021)	(2.254)	(2.708)
Ln(farm size)	-0.0370	-0.322*	-0.903***	0.0318	-0.0252
	(-0.189)	(-1.690)	(-4.891)	(0.845)	(-1.506)
Observations	1,400	1,400	1,405	1,274	1,305
Panel B: with the sizes of land received and lost					
DAmhara (=1 if Amhara region)	0.848**	0.0750	-0.140	0.0445*	0.0341**
	(2.428)	(0.225)	(-0.804)	(1.734)	(2.032)
Net land received (ha)	0.131*	0.144	-0.0417	0.00979	0.00686
	(1.711)	(1.282)	(-0.363)	(1.021)	(0.779)
Net land lost (ha)	0.0563	0.0279	-0.0487	0.0149	0.00574
	(1.442)	(0.446)	(-1.131)	(1.441)	(1.251)
Ln(farm size)	-0.0864	-0.370*	-0.901***	0.0228	-0.0269
	(-0.454)	(-1.880)	(-4.774)	(0.598)	(-1.522)
Observations	1,400	1,400	1,405	1,274	1,305
Panel C: Weighted regression on matched samples (for the losers)					
DLoser (=1 if lost land in 1996/97)	1.524***	0.485	-0.0662	0.0998	
	(3.240)	(0.906)	(-0.166)	(1.000)	
Ln(farm size)	0.462	-0.0600	-0.858*	0.251***	
	(0.934)	(-0.161)	(-1.795)	(3.862)	
Obs	369	369	374	293	
Panel D. Village fixed effects (only Amhara samples)					
DBeneficiaries' (=1 if received land in 1996/97)	0.111 (0.544)	0.361 (1.555)	-0.0704 (-0.584)	0.0774* (1.790)	0.0275 (0.612)
DLoser (=1 if lost land in 1996/97)	0.563***	0.269	-0.319*	0.0916*	0.166**
	(3.500)	(1.230)	(-1.831)	(1.694)	(2.043)
Ln(farm size)	-0.294**	-0.62**	-0.831***	-0.0082	-0.220**
	(-2.259)	(-2.573)	(-2.680)	(-0.126)	(-2.136)
Observations	597	597	601	541	354

Panel E: Village fixed effects (only Amhara samples)

Net land received in ha in1996/97	0.0356	0.229**	-0.00132	0.0148	0.00776
	(0.448)	(2.464)	(-0.0199)	(1.051)	(0.346)
Net land lost in 1996/97	0.130**	0.0861	-0.180***	0.03***	0.0414*
	(2.318)	(1.393)	(-3.230)	(3.134)	(1.729)
Ln(farm size)	-0.372***	-0.7***	-0.779***	-0.0452	-0.237**
	(-4.208)	(-3.199)	(-3.115)	(-0.746)	(-2.031)
Observations	597	597	601	541	354

Panel F: Village fixed effects (only Oromia samples)

Ln(farm size)	0.299	0.119	-0.386	0.0688	0.0212
	(1.297)	(0.565)	(-1.112)	(1.092)	
Observations	805	805	806	661	393

Notes: The reported results are marginal effects evaluated at the average of all variables and elements in parenthesis are z-statistics computed using robust standard errors. Standard errors are clustered at village level. *** shows significance at 1%, ** at 5%, and * at 10%. Organic fertilizer is the sum of manure and compost. The lower limit in the Tobit estimation is set at ln(k), where k is the minimum positive values of respective values of the censored dependent variables less a very small number. HYV seed and row planting adoption are estimated by Probit regression. Head and household level, parcel level variables, and Crop fixed effects are included in each regression both in Panels **A** –F but their estimates are not reported to save space.

Table 4.8: The plot level regression results for crop yield and value of crop yield in cereal and legume production.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
	Ln(yld)	Ln(vyld)	Ln(yld)	Ln(v yld)	ln(yld)	ln(vyld)
Land redistribution variables						
DAmhara (=1 if Amhara region)	0.42***	0.53***	0.29**	0.40***		
	(3.544)	(4.164)	(2.671)	(3.544)		
DUnaffected (=1 if neither gain nor lost land)					0.26**	0.351***
					(2.19)	(3.001)
DBeneficiaries(=1 if received land in 1996/97)					0.32**	0.446***
					(2.591)	(3.484)
DLoser (=1 if lost land in 1996/97)					0.319*	0.466**
					(2.083)	(2.714)
Ln(farm size)			-0.5***	-0.57***	-0.5***	-0.56***
			(-5.428)	(-6.289)	(-5.11)	(-5.999)
Head and household level variables						
Male HHead(=1)	-0.0347	-0.0373	0.0249	0.0241	0.0229	0.0192
	(-0.364)	(-0.358)	(0.289)	(0.256)	(0.262)	(0.203)
Ln(Head age)	-0.45***	-0.45***	-0.4***	-0.37***	-0.4***	-0.39***
	(-5.630)	(-5.444)	(-4.042)	(-3.842)	(-4.05)	(-3.929)
ln(Head's years of schooling)	0.115***	0.094***	0.10***	0.0847**	0.1***	0.0846**
	(3.786)	(3.309)	(3.212)	(2.658)	(3.208)	(2.620)
Proportion of correct answers in arithmetic test	0.117	0.205	0.0575	0.148	0.0649	0.160
	(0.503)	(0.868)	(0.250)	(0.655)	(0.276)	(0.689)
ln(No. of contacts with DA in the main season)	0.0581	0.0546	0.0455	0.0415	0.0423	0.0352
	(1.117)	(1.259)	(0.973)	(1.075)	(0.873)	(0.865)
ln(adult size, 15-64)	-0.24**	-0.27***	-0.0814	-0.101	-0.0902	-0.119*
	(-2.618)	(-3.522)	(-0.911)	(-1.566)	(-1.03)	(-1.874)
Ln(children and elderly size, 11-14 & 65-75)	0.0973	0.0929	0.152*	0.148*	0.148*	0.142*
	(1.248)	(1.125)	(1.966)	(1.797)	(1.947)	(1.780)
Ln(assets values)	0.0517*	0.0488*	0.078**	0.076***	0.07**	0.073***
	(1.834)	(2.064)	(2.687)	(3.058)	(2.620)	(3.008)
Ln (Tropical livestock unit	0.0171	0.0162	0.0255	0.0247	0.0264	0.0260
	(0.755)	(0.643)	(1.271)	(1.047)	(1.305)	(1.088)
Ln(total number of own oxen)	0.208*	0.231**	0.30***	0.32***	0.3***	0.319***
	(2.054)	(2.378)	(3.470)	(3.964)	(3.626)	(4.091)
Fertilizer credit (=1 if received on credit)	0.157	0.145	0.197*	0.185**	0.18**	0.172**
	(1.302)	(1.507)	(2.078)	(2.431)	(2.107)	(2.224)
Land certificate (=1)	0.0567	0.0711	0.00488	0.0181	0.001	0.0114
	(0.712)	(0.947)	(0.062)	(0.255)	(0.012)	(0.163)
Relative farm size	-0.0057	0.00182	0.217**	0.23***	0.21**	0.229***
	(-0.097)	(0.0337)	(2.585)	(3.045)	(2.609)	(3.117)

Table 4.8 Cont'd	ln(yld)	ln(vyld)	ln(yld)	ln(vyld)	ln(yld)	ln(vyld)
<u>**Parcel and plot characteristics**</u>						
Ln(total number of parcels)	0.707	0.296	1.239	0.831	1.243	0.846
	(0.839)	(0.422)	(1.336)	(1.078)	(1.329)	(1.080)
Ln(No. of parcels)square	-0.121	-0.00616	-0.191	-0.0763	-0.192	-0.0809
	(-0.614)	(-0.039)	(-0.909)	(-0.461)	(-0.90)	(-0.478)
Simpson index	-0.981*	-1.085**	-0.793	-0.891*	-0.781	-0.871*
	(-1.943)	(-2.524)	(-1.522)	(-2.074)	(-1.50)	(-2.062)
Length of tenure (in years)	-0.005	-0.00446	0.00394	0.00340	0.0039	0.00328
	(-1.009)	(-1.046)	(-0.839)	(-0.841)	(-0.82)	(-0.791)
Leased in (=1)	-0.272*	-0.253*	-0.198	-0.179	-0.201	-0.186
	(-2.064)	(-1.822)	(-1.461)	(-1.244)	(-1.48)	(-1.296)
ln(parcel distance in minute)	-0.0404	-0.0231	-0.0496	-0.0329	-0.0499	-0.0336
	(-1.274)	(-0.921)	(-1.546)	(-1.309)	(-1.56)	(-1.350)
Excellent soil (=1)	0.50***	0.52***	0.49***	0.50***	0.5***	0.487***
	(4.038)	(5.521)	(3.358)	(4.354)	(3.110)	(3.920)
Good soil (=1)	0.319**	0.33***	0.315*	0.329**	0.305*	0.311**
	(2.102)	(2.877)	(1.920)	(2.585)	(1.787)	(2.311)
Fair soil (=1)	0.247	0.231**	0.250	0.231*	0.243	0.217*
	(1.722)	(2.165)	(1.614)	(1.993)	(1.493)	(1.739)
Moderate slope (=1)	-0.0468	-0.0158	-0.0708	-0.0423	-0.0669	-0.0355
	(-0.473)	(-0.219)	(-0.739)	(-0.602)	(-0.70)	(-0.510)
Steep slope (=1)	0.137	0.208**	0.0505	0.122*	0.0507	0.123*
	(1.488)	(2.739)	(0.551)	(2.040)	(0.553)	(2.051)
Rock strewn(=1)	0.0111	0.0180	0.0396	0.0473	0.0399	0.0472
	(0.163)	(0.278)	(0.633)	(0.824)	(0.644)	(0.820)
Shortage of rain (=1)	-0.97***	-0.261*	-0.92**	-0.215	-0.92**	-0.201
	(-2.892)	(-1.854)	(-2.698)	(-1.389)	(-2.67)	(-1.272)
Flood (=1)	-0.191	-0.202	-0.244	-0.256	-0.243	-0.257
	(-1.287)	(-1.318)	(-1.617)	(-1.641)	(-1.58)	(-1.629)
Crop disease (=1)	-0.69***	-0.52***	-0.7***	-0.53***	-0.7***	-0.54***
	(-4.188)	(-4.150)	(-4.273)	(-4.182)	(-4.21)	(-4.149)
Insect damage (=1)	-0.390	-0.361	-0.339	-0.309	-0.340	-0.310
	(-1.431)	(-1.323)	(-1.184)	(-1.084)	(-1.18)	(-1.080)
Animal damage (=1)	-0.643	-0.661	-0.691	-0.710	-0.689	-0.707
	(-1.002)	(-0.996)	(-1.081)	(-1.076)	(-1.07)	(-1.070)
Theft on crop field (=1)	-0.151	-0.228	-0.159	-0.236	-0.168	-0.259
	(-0.889)	(-1.293)	(-0.885)	(-1.245)	(-0.92)	(-1.340)
Frost (=1)	-0.68***	-0.65***	-0.7***	-0.67***	-0.7***	-0.67***
	(-3.588)	(-3.229)	(-3.723)	(-3.356)	(-3.71)	(-3.338)
Other damage (=1)	-1.9***	-1.6***	-2.0***	-1.8***	-2.0***	-1.78***
	(-3.456)	(-3.168)	(-3.828)	(-3.487)	(-3.84)	(-3.544)

Table 4.8 continued	ln(yld)	ln(vyld)	ln(yld)	ln(vyld)	ln(yld)	ln(vyld)
Village characteristics						
Ln(distance to nearest district town)	0.185**	0.23***	0.157**	0.20***	0.16**	0.202***
	(2.657)	(3.003)	(2.624)	(2.913)	(2.579)	(2.910)
Transport (=1 if trans service)	0.0384	0.0422	0.0191	0.0225	0.0172	0.0186
	(0.538)	(0.504)	(0.268)	(0.284)	(0.238)	(0.232)
ln(distance of nearest market)	-0.18**	-0.28***	-0.144	-0.23**	-0.144	-0.232**
	(-2.377)	(-3.626)	(-1.655)	(-2.675)	(-1.63)	(-2.608)
ln(distance in km to the FTC)	-0.0005	0.0331	-0.005	0.0275	-0.006	0.0243
	(-0.008)	(0.516)	(-0.105)	(0.519)	(-0.12)	(0.417)
Ln(No. of landless households)	0.0627	0.0761	0.0447	0.0587	0.0453	0.0603
	(1.488)	(1.719)	(1.248)	(1.509)	(1.251)	(1.532)
Population density	-0.0147	-0.0173	-0.0111	-0.0135	-0.0117	-0.0147
	(-1.257)	(-1.398)	(-1.082)	(-1.267)	(-1.10)	(-1.339)
Constant	17.69*	18.80**	14.28	15.34*	14.34	15.23*
	(1.783)	(2.217)	(1.501)	(1.908)	(1.489)	(1.851)
Observations	1,415	1,407	1,415	1,407	1,415	1,407
R-squared	0.226	0.295	0.248	0.319	0.249	0.320
p-va,DBenef.=Dlosers'					0.9665	0.8974
DBenef.=DUnaff'					0.5231	0.1386
Dlosers=Dunaffected.					0.7441	0.4903

In parenthesis are t-statistics computed using robust standard errors. Standard errors are clustered at village level. *** shows significance at 1%, ** at 5%, and * at 10%. The non-sloppy parcel is the reference category for steep and moderately steep slope parcels; and the non-rocky parcel surface is the reference category for the rocky surface dummy, and owner operated parcels are the reference categories for leased-in parcels. Crop fixed effects are included in all of the regressions.

Tables used in Chapter 5

Table 5.1: The summary statistics of access to agricultural extension, social networking, and other household level variables by row planting adoption status, 2014.

	Non adopters		Adopters		Mean Diff.	
	Mean	sd	mean	Sd	MD	p-value
Panel A. Extension & social learning						
Heard about Row Planting (=1)	0.958	0.202	0.997	0.057	-0.039	0.0000
Knowing other RP adopters (=1)	0.675	0.469	0.933	0.251	-0.258	0.0000
Invitation for RP training (=1)	0.546	0.498	0.792	0.406	-0.246	0.0000
Know how to implement RP (=1)	0.637	0.481	0.973	0.163	-0.336	0.0000
No. of DA she knew	0.884	0.722	1.154	0.729	-0.27	0.0000
Discussed with DA (=1)	0.577	0.494	0.736	0.441	-0.159	0.0000
No. contacts with DA(main season)	4.572	8.924	12.08	28.76	-7.506	0.0000
No. of contacts with DA (off-farm)	1.766	5.505	3.9	8.655	-2.134	0.0000
No. of cereals & legumes by RP	0.00	0.00	1.39	0.68	-1.39	0.0000
No. of harvested cereals& legumes	2.66	1.25	2.67	1.28	-0.01	0.8700
Proportion of crops by RP out of total	0.00	0.00	0.61	0.29	-0.61	0.0000
Prop. of cereal & legume land by RP	0.00	0.00	0.60	0.32	-0.60	0.0000
Panel B. Time preference and risk						
Myopic	0.731	0.862	0.661	0.881	0.07	0.156
Present bias	0.721	0.449	0.762	0.426	-0.041	0.095
Prop. that played risk game	0.967	0.179	0.981	0.138	-0.014	0.125
Risk (number of risky choices)	0.872	0.84	0.859	0.879	0.014	0.777
Panel C. Social Networking						
Iddir (=1)	0.945	0.229	0.894	0.308	0.051	0.001
Mahber (=1)	0.55	0.498	0.413	0.493	0.138	0.000
Senbete (=1)	0.287	0.453	0.244	0.43	0.043	0.084
farmer union (=1)	0.491	0.5	0.424	0.495	0.067	0.017

Table 5.1 Continued

Panel D. Demographic characteristics						
Male head(=1 for male)	0.863	0.344	0.923	0.267	-0.06	0.0010
Age of the head	50.34	16.32	46.87	14.4	3.476	0.0000
Literacy status of the head (=1)	0.515	0.5	0.632	0.483	-0.117	0.0000
Years of schooling of the head	2.496	3.465	3.493	3.607	-0.997	0.0000
Max. years of schooling in the family	7.036	3.376	6.931	3.432	0.105	0.5840
Numeracy score (out of 6)	0.397	0.13	0.417	0.124	-0.02	0.0040
Household size	6.487	2.525	7.063	2.847	-0.576	0.0000
Male adults (15-64)	1.657	1.1	1.844	1.209	-0.188	0.0040
Female adults (15-64)	1.611	1.054	1.687	1.027	-0.076	0.1960
Child (11-14) and elderly (65-75)	0.573	0.489	0.583	0.497	-0.01	0.7130
Panel F. Income & wealth indicators (12months)						
Income from self-employment	3507	12367	6124	20865	-2617	0.0070
Income from non-labor activities	1965	6320	2106	9884	-141	0.7640
Total value of assets	8712	25020	15860	93581	-7148	0.0660
Total value of livestock	28393	33823	21735	23722	6659	0.0000
Tropical livestock unit (TLU)	4.223	4.201	3.681	3.4	0.543	0.0120
Total farmland land (in hectare)	2.23	1.78	2.01	2.02	0.22	0.0370

Source: Computed based on the 2014 RePEAT survey. Total number of non-adopters and adopters are 639 and 627, respectively. MD means the mean difference values of variables of adopters from non-adopters.

Table 5.2: The summary of plot and parcel level variables by row planting adoption status.

Panel A. Seed rate (kg/ha) by the method of sowing/planting								
Variables	Broadcasted			Row planted			Mean diff.	
	Obs	Mean	Sd	Obs	Mean	Sd	MD	P-val
All cereal and legumes	3796	109.3	108.8	1100	47.6	70.8	61.7	0.00
Teff	1177	49.99	38.5	84	33.0	32.8	16.9	0.00
Barley	513	172.8	91.9	27	116.9	76.8	55.8	0.00
Maize	315	40.21	36.0	722	28.0	40.9	12.2	0.00
Wheat	691	168.9	98.6	95	140.5	98.5	28.4	0.01
Panel B. Parcel characteristics by row planting adoption status								
Variables	Non-adopters			Adopters			Mean Diff.	
	Obs	Mean	Sd	Obs	Mean	Sd	Obs	Mean
Distance to parcel (min)	3045	16.34	24.2	2052	16.5	28.3	-0.17	0.829
Soil conservation (=1)	3041	0.24	0.43	2050	0.43	0.50	-0.19	0.000
Leased-in land (=1)	3044	0.09	0.29	2052	0.11	0.31	-0.02	0.021
Length of tenure in years	3036	24.54	13.1	2040	23.5	13.3	1.07	0.005
Flat slope (=1)	3045	0.74	0.44	2052	0.65	0.48	0.08	0.000
Steep slope (=1)	3045	0.12	0.32	2052	0.14	0.35	-0.03	0.002
Moderate slope (=1)	3045	0.15	0.35	2052	0.20	0.40	-0.05	0.000
Rock strewn surface (=1)	3034	0.16	0.37	2044	0.09	0.28	0.07	0.000
Excellent soil (=1)	2993	0.22	0.42	2030	0.24	0.43	-0.01	0.240
Good soil (=1)	2993	0.54	0.50	2030	0.56	0.50	-0.02	0.168
Fair soil (=1)	2993	0.19	0.39	2030	0.16	0.36	0.03	0.002
Poor soil (=1)	2993	0.05	0.21	2030	0.05	0.21	0.00	0.936
Number of parcels	3060	7.03	3.85	2058	5.22	3.46	1.81	0.000

Source: Computed based on the 2014 RePEAT survey. Note: Panel A shows the differences in seed rate between broadcasted and row planted plots. The results in the first three Columns are from broadcast methods, and the results in Columns 4-6 are seed rate on row planted plots. Panel B, on the other hand, compares the characteristics of parcels owned by the non-adopters and adopters of row planting.

Table 5.3: The average marginal effects from the Probit regressions for the determinants of plot level row planting adoption in cereal and legume production.

VARIABLES	(1) All farmers	(2) Aware farmers	(3) Knowhow farmers	(4) Probit on matched
Invitation for RP training (=1)	0.0681***	0.0633***	0.0764***	0.0755***
	(3.000)	(2.746)	(2.672)	(2.796)
Knowing other RP adopters (=1)	0.0964***	0.0905***	0.109***	0.0566**
	(3.914)	(3.472)	(3.394)	(2.047)
# of DAs the farmer know	0.0123	0.0141	0.0129	-0.00546
	(1.106)	(1.241)	(1.016)	(-0.376)
Ln(#contacts with DAs-Meher)	0.0277***	0.0272***	0.0257**	0.0373***
	(3.111)	(3.037)	(2.430)	(2.688)
Ln(#contacts with DAs -Belg)	-0.00356	-0.00234	-0.00874	-0.00471
	(-0.433)	(-0.289)	(-1.037)	(-0.534)
Maize (=1)	0.297***	0.297***	0.354***	0.243***
	(8.757)	(8.713)	(9.544)	(7.865)
Teff (=1)	-0.0548	-0.0551	-0.0506	-0.0400
	(-1.383)	(-1.383)	(-1.150)	(-1.163)
Wheat (=1)	0.0631**	0.0635**	0.0710**	0.0708***
	(2.187)	(2.188)	(2.209)	(2.640)
Farm union (=1 if member)	0.00776	0.00994	-0.00457	-0.00707
	(0.487)	(0.628)	(-0.298)	(-0.363)
Iddir (=1 if member)	0.00461	0.00122	-0.0142	0.0466
	(0.160)	(0.0422)	(-0.451)	(1.055)
Mahber (=1 if a member)	-0.00338	-0.00485	-0.0260	0.00267
	(-0.207)	(-0.295)	(-1.396)	(0.118)
Senbete (=1 if a member)	0.0198	0.0208	0.0545***	0.0225
	(1.214)	(1.271)	(2.704)	(0.932)
HHsex (male=1)	-0.0237	-0.0190	-0.0372	-0.0123
	(-1.102)	(-0.874)	(-1.343)	(-0.518)
Ln(head age)	-0.0101	-0.0102	-0.00838	-0.0156
	(-0.625)	(-0.614)	(-0.412)	(-0.994)
Ln(years of school)	0.0301***	0.0286***	0.0312***	0.0293***
	(3.953)	(3.718)	(3.493)	(2.888)
Numeracy score (out of 6)	-0.00788	-0.00533	0.00248	0.0574
	(-0.146)	(-0.0992)	(0.0411)	(0.923)
Ln(adult members, 15-64)	0.0116	0.00822	0.00520	0.0104
	(0.710)	(0.499)	(0.254)	(0.526)
Ln(child & elderly labor)	0.0182	0.0202	0.0266*	0.00239
	(1.328)	(1.481)	(1.652)	(0.145)

Table 5.3 Cont'd	All farmers	Aware farmers	knowhow farmers	probit on matched
Participate in in risk game (=1)	-0.0561	-0.0577	-0.0648	-0.0761
	(-1.100)	(-1.133)	(-1.252)	(-1.494)
Degree of risk taking (0, 1 or 2)	0.00358	0.00379	0.00835	-5.32e-05
	(0.499)	(0.533)	(0.956)	(-0.00579)
Participate in time preference game	-0.0275*	-0.0298*	-0.0281*	-0.0191
(=1)	(-1.795)	(-1.940)	(-1.694)	(-1.015)
Present bias (=1)	-0.0340**	-0.0356**	-0.0393**	0.0119
	(2.309)	(2.401)	(2.248)	(0.651)
Myopic	0.00638	0.00722	0.00460	0.000500
	(0.876)	(0.982)	(0.519)	(0.0599)
Ln (distance to plot, min)	-0.00670	-0.00759	-0.00412	-0.00430
	(-1.211)	(-1.335)	(-0.632)	(-0.619)
Leased-in land (=1)	0.000902	-0.000304	-0.0121	-0.0155
	(0.0489)	(-0.0160)	(-0.505)	(-0.684)
Flat parcel (=1)	0.0104	0.00767	0.00933	0.0484
	(0.404)	(0.306)	(0.359)	(1.394)
Moderately slope (=1)	0.0469*	0.0447	0.0353	0.0705**
	(1.666)	(1.574)	(1.248)	(2.022)
Rocky surface (=1)	-0.00154	-0.00159	0.00170	0.0256
	(-0.0622)	(-0.0621)	(0.0542)	(1.005)
Excellent soil (=1)	-0.000852	0.000797	-0.00366	0.00774
	(-0.0287)	(0.0273)	(-0.115)	(0.212)
Good soil (=1)	-0.0339	-0.0332	-0.0380	-0.0272
	(-1.188)	(-1.189)	(-1.303)	(-0.823)
Fair soil (=1)	-0.0363	-0.0368	-0.0404	-0.0404
	(-1.141)	(-1.163)	(-1.220)	(-1.157)
Ln (farm size)	-0.0169	-0.0159	-0.0262*	-0.00868
	(-1.219)	(-1.128)	(-1.710)	(-0.446)
Ln (plot size)	0.0193**	0.0179**	0.0226**	0.0144
	(2.311)	(2.127)	(2.441)	(1.637)
Observations	4,105	4,066	3,398	4,535
Pseudo-R2	0.4937	0.4938	0.4839	0.5218
Log pseudo likelihood	-1188	-1179	-1074	-1112
Maize=Teff (P-val)	0.000	0.000	0.000	0.000
Maize=Wheat (P-val)	0.000	0.000	0.000	0.000
Wheat=Teff (P-val)	0.000	0.000	0.000	0.000

z-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Standard errors clustered at village level. Crop and village fixed effects are included in each regression. The regressions in the 2nd & 3rd Columns are based only on the aware and knowledgeable subsamples about row planting. The regression in Column 4 implemented by weighted regression on the matched samples. The reference group for the crop dummies is barley and only the marginal effects for maize, teff, and wheat are reported to save space.

Table 5. 4: The average marginal effects from Probit regressions for the plot level determinants of row planting adoption in teff production.

VARIABLES	(1)	(2)	(3)	(4)
	All farmers	Aware farmers	knowhow farmers	Probit reg. on matched
Invitation for RP training (=1)	0.142***	0.138***	0.223***	0.125***
	(3.551)	(3.364)	(3.115)	(5.096)
Knowing other RP adopters (=1)	-0.00402	-0.00644	0.0215	-0.0388
	(-0.0853)	(-0.137)	(0.213)	(-1.056)
#DAs that the farmer know	0.0510*	0.0525**	0.0660*	0.0328*
	(1.952)	(1.985)	(1.751)	(1.753)
Ln(#contacts with DAs -Meher)	-0.000463	-0.000697	-0.00342	0.00777
	(-0.0358)	(-0.0538)	(-0.211)	(0.776)
Ln(#contacts with DAs -Belg)	-0.00888	-0.00806	-0.0205	-0.0118
	(-0.692)	(-0.621)	(-1.157)	(-1.142)
Observations	667	664	495	913
Pseudo-R2	0.2550	0.2545	0.2117	0.421
Log pseudo likelihood	-173	-173	-163	-134

Notes: z-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Standard errors clustered at village level. The observable plot, parcel, household, and head level variables and the village fixed effects are included in each regression. The estimates in Columns 2 and 3 are based only on the aware and knowhow farmers, only. The regression in Column 4 is estimated by a weighted regression on the matched samples.

Table 5.5: The effects of agricultural extension and social learning on row planting adoption (using alternative measures of row planting adoption).

VARIABLES	(1)	(2)	(3)	(4)
	All farmers	Aware farmers	Knowhow farmers	Regression on matched
Panel A: The results from the OLS regressions for the logarithm of seed rate (kg/ha)				
Invitation for RP training (=1)	-0.00869	0.000888	-0.0281	0.0160
	(-0.246)	(0.0255)	(-0.621)	(0.391)
Know other RP adopters in village (=1)	-0.0489	-0.0322	-0.0768	-0.0450
	(-1.172)	(-0.770)	(-1.282)	(-1.021)
#DAs that the farmer know	0.0265	0.0230	-0.000879	0.0270
	(0.869)	(0.752)	(-0.0301)	(0.785)
Ln(#contacts with DAs -Meher)	-0.0216	-0.0209	-0.00250	-0.0622**
	(-0.914)	(-0.897)	(-0.101)	(-2.573)
Ln(#contacts with DAs -Belg)	-0.0179	-0.0195	-0.0363	0.00149
	(-0.917)	(-1.015)	(-1.656)	(0.0538)
Observations	4,815	4,716	3,867	5,303
Panel B: The average marginal effects for the household level Probit regression of row planting adoption (=1 if the household adopted row planting in one or more plots)				
Invitation for RP training (=1)	0.166***	0.162***	0.170***	0.150***
	(3.965)	(3.658)	(3.230)	(3.782)
Knowing other RP adopters (=1)	0.218***	0.214***	0.223***	0.186***
	(4.654)	(4.204)	(3.471)	(3.906)
Observations	934	888	689	1,017
Panel C: The average marginal effects from the Tobit regressions for proportion of crops planted by row planting method (out of the total harvested cereal and legume crop types)				
Invitation for RP training (=1)	0.0935***	0.0895***	0.0915***	0.0920***
	(3.538)	(3.288)	(2.790)	(3.395)
Knowing other adopters in village (=1)	0.151***	0.147***	0.165***	0.119***
	(4.276)	(3.877)	(3.381)	(3.011)
Observations	1,262	1,233	1,013	1,355
Panel D: The average marginal effects from the Tobit regressions for the proportion of crop land under row planting				
Invitation for RP training (=1)	0.0807***	0.0791***	0.0791**	0.080***
	(3.27)	(3.12)	(2.56)	(3.31)
Knowing other RP adopters (=1)	0.155***	0.155***	0.178***	0.115***

	(4.63)	(4.30)	(3.84)	(3.24)
Observations	1,258	1,230	1,010	1,349

Robust t-statistics (clustered at village level) in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The observable plot, parcel, household, and head level variables that are shown in Tables 5.3 as well as the crop and village fixed effects are included in each regression in Panel A-D. The regression in Panel ***A*** is at plot level but those in B-D are at household level. The estimates in Columns 2 and 3 are based only on the subsample of farmers who are aware and knowledgeable about the row planting method. The estimation in Column 4 is estimated by a weighted regression on matched samples.

Table 5.6: The spatial regression results for the determinants of plot level row planting adoption in cereal and legume production.

VARIABLES	Using nearest neighbor adopters			Using homophilic adopters		
	LPM	2SLS	2SLS	LPM	2SLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)
W* RPk	-0.0246	0.237***		-0.0476*	0.0946*	
	(-0.660)	(3.069)		(-1.674)	(1.686)	
W RPk*KnowAdopter			0.26***			0.0788
			(2.74)			(1.291)
Invitation for RP training (=1)	0.050***	0.051***	0.038**	0.0566**	0.0579***	0.0535**
	(2.876)	(3.289)	(2.30)	(2.603)	(2.691)	(2.485)
#DAs that the farmer know	0.00434	0.00375	0.0066	0.00464	0.00490	0.00499
	(0.457)	(0.382)	(0.658)	(0.360)	(0.399)	(0.405)
Ln(#contacts with DAs -Meher)	0.026***	0.0252**	0.026***	0.0303**	0.0287**	0.0295***
	(2.938)	(2.570)	(2.731)	(2.607)	(2.531)	(2.643)
Ln(#contacts with DAs -Belg)	0.00250	0.00105	-0.0006	0.00589	0.00446	0.00446
	(0.260)	(0.103)	(-0.070)	(0.518)	(0.404)	(0.419)
Observations	4,854	4,854	4,854	3,469	3,469	3,469
R-squared (centered)	0.520	0.505	0.512	0.519	0.511	0.517
Cragg-Donald Wald F		40.82	21.43		35.98	26.48

Notes: Robust z-statistics in parentheses*** p<0.01, ** p<0.05, * p<0.1, standard errors clustered at village level. The Stock-Yogo weak instrument test critical values for the 2SLS estimates are 21.41 at 5% maximal IV critical values and 11.41 at 10% maximal IV relative bias. LPM is the linear probability regression model. The observable plot, household, and head level variables that are shown in Tables 5.3 as well as the crop and villages fixed effects are controlled in all the Columns 1-6. The dependent variable is a dummy that takes 1 if the farmer implemented the non-traditional planting method in the plot and zero otherwise. *W* is the standardized weighting matrix, and *W**RPk is the weighted average of nearest neighbor adopters (Columns 1-3)/homophilic adopters (Columns 4-6) and W RPk*KnowAdopter is its interaction knowing other adopters.

Table 5.7: A spatial 2SLS regression results for the determinants of plot level row planting adoption using the subsample data of the main cereal crops.

VARIABLES	(1)	(2)	(3)	(4)	(5)
	Barley	Maize	Teff	Wheat	All cereal & legumes but maize
Panel A: Using nearest neighbor adopters					
W *RPk	0.173	0.370*	0.25***	0.313	0.185***
	(0.700)	(1.768)	(3.156)	(1.156)	(2.930)
Invitation for RP training (=1)	-0.0118	0.124***	0.0360*	0.0143	0.0351**
	(-0.749)	(2.748)	(1.652)	(0.411)	(2.420)
#DAs that the farmer know	0.0165	0.00168	0.0303*	0.0191	0.0130
	(0.865)	(0.0923)	(1.695)	(0.537)	(1.227)
Ln(#contacts with DAs -Meher)	0.031**	0.047***	0.0011	0.0306	0.0165
	(2.153)	(2.880)	(0.0715)	(1.003)	(1.640)
Ln(#contacts with DAs -Belg)	-0.00252	-0.0206	-0.0002	-0.0021	0.00711
	(-0.132)	(-1.110)	(-0.012)	(-0.104)	(0.747)
Observations	540	1,024	1,241	767	3,830
R-squared (centered)	0.402	0.444	0.229	0.230	0.291
Cragg-Donald Wald F	9.84	7.11	13.59	5.86	36.87
Panel B: Using homophilic adopters					
W *RPk	0.107	0.0149	0.178	-0.151	0.0280
	(0.687)	(0.161)	(1.564)	(-0.728)	(0.487)
Invitation for RP training (=1)	-0.0110	0.110**	0.07***	0.00930	0.0510**
	(-0.368)	(2.143)	(2.863)	(0.216)	(2.534)
#DAs that the farmer know	-0.0007	-0.00330	0.0234	0.0368	0.0109
	(-0.027)	(-0.151)	(1.275)	(0.757)	(0.724)
Ln(#contacts with DAs -Meher)	0.07***	0.0391*	0.00221	0.0340	0.0229*
	(2.940)	(1.888)	(0.163)	(1.025)	(1.869)
Ln(#contacts with DAs -Belg)	-0.0131	0.00107	-0.0006	0.00864	0.00362
	(-0.579)	(0.0499)	(-0.040)	(0.406)	(0.333)
Observations	372	700	899	568	2,769
R-squared (centered)	0.453	0.494	0.290	0.294	0.312
Cragg-Donald Wald F	7.1	6.47	4.41	3.7	20.74

Notes: Robust z-statistics in parentheses*** p<0.01, ** p<0.05, * p<0.1, standard errors clustered at village level. The observable plot, household, and head level variables used in Tables 5.3 and the village fixed effects are included in each regression in both Panels A and B. The term *W**RPk denotes the weighted average of nearest neighbor adopters in Panel A and the weighted average of homophilic adopters in Panel B.

Tables used in Chapter 6

Table 6.1: The summary statistics of plot level variables by the sowing/planting method.

Variable	Broadcasting method			Row planting method			Mean diff.	
	Obs	Mean	Sd	Obs	Mean	Sd	MD	P-val
HYV seeds (=1)	3827	0.09	0.28	1135	0.54	0.50	-0.45	0.00
Dap (kg/ha)	3791	61.31	80.21	1095	81.2	99.75	-19.87	0.00
Urea (kg/ha)	3791	36.04	64.02	1096	50.9	74.30	-14.89	0.00
Organic fert. (kg/ha)	3797	604.74	3076	1097	436.0	2048	168.7	0.03
Cost of pesticide (Br.)	3829	22.95	72.97	1135	8.66	48.95	14.28	0.00
Cost of seeds (Br.)	3798	96.33	274.1	1133	156.7	256.7	-60.39	0.00
Yield (kg/ha)	3789	1384.5	1329	1092	2217.1	8658	-832.6	0.00
Value of yield (ETB)	3738	11207	9790	1063	12554	36676	-1346	0.23
Crop income (ETB.)	3721	9869.3	9471	1058	10777	36456	-908.3	0.422

Source: Computed based on the 2014 RePEAT survey. Note: ETB stands for local currency Ethiopian Birr.

Table 6.2: The summary statistics of detailed input use data on selected major cereal crop plots by the sowing/planting method, 2014.

Variable	Broadcast Plots			Row planted plots			Mean diff.	
	Obs	Mean	Sd	Obs	Mean	Sd	md	p-val
Man hours per hectare								
Adult male	981	564.26	730.23	569	601.82	786.08	-37.56	0.352
Adult female	981	192.73	885.44	569	287.47	770.84	-94.74	0.028
Children	981	158.60	537.28	569	235.94	613.98	-77.34	0.013
Oxen	981	260.03	344.47	569	205.42	374.14	54.61	0.004
Hired labor (Birr)	981	380.29	1142.5	569	236.80	629.02	143.5	0.001
Rental oxen(Birr)	981	63.65	444.08	569	74.00	424.06	-10.35	0.649
Other inputs (Birr)	981	2.76	59.89	569	3.83	48.08	-1.07	0.700
Dap (kg/ha)	977	75.61	71.62	569	83.21	91.82	-7.60	0.090
Urea (kg/ha)	977	43.79	65.06	569	53.81	65.96	-10.03	0.004
HYV seeds (=1)	981	0.13	0.34	572	0.61	0.49	-0.48	0.000
Seed (kg/ha)	975	89.07	82.45	569	41.73	57.31	47.34	0.000
Org fert. (kg/ha)	977	395.31	2202.5	568	443.72	1918.7	-48.41	0.651
Yield (kg/ha)	968	1227.80	967.22	563	1939.9	1772.5	-712.2	0.000
Value of yield(Birr)	950	10064.9	6683.5	550	10994.4	9556.5	-929.5	0.044
Crop income (Birr)	947	8186.8	6226.3	550	9047.8	9184.3	-860.9	0.051
Profit (Birr)	945	3132.7	7119.5	549	4501.3	9267.9	-1368	0.003

Source: Computed based on the 2014 RePEAT survey. Note: The results for this section are elicited only from selected barley, maize, teff, and wheat plots because it is time consuming to ask the detailed input uses in each of the farmers plots.

Table 6.3: The OLS regression results for the plot level determinants of crop yield, value of crop yield, crop income, and profit.

VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	ln(yld)	ln(vyld)	Crop inc.	ln(yld)	ln(vyld)	Crop inc.	Profit
RPAdopter hh (=1)	-0.0833	-0.0395	-269.2	-0.0899	-0.0461	-312.3	-1,096**
	(-1.333)	(-0.73)	(-0.663)	(-1.43)	(-0.864)	(-0.779)	(-2.372)
RPPlot(=1)	0.132*	0.13***	1,071*				
	(1.671)	(2.707)	(1.849)				
RPPlot*Barley				0.257	0.310**	2,932**	-302.0
				(0.500)	(2.230)	(2.518)	(-0.243)
RPPlot*Maize				0.177	0.0864	192.4	283.6
				(1.343)	(1.226)	(0.260)	(0.314)
RPPlot*Millet				0.61**	0.833**	8,761**	
				(2.393)	(2.014)	(2.069)	
RPPlot*Sorghum				0.414	0.435	5,098	
				(1.064)	(0.833)	(0.942)	
RPPlot*Teff				0.24**	0.288***	1,967**	-1,016
				(2.084)	(2.955)	(2.149)	(-0.439)
RPPlot*Wheat				0.114	0.265***	3,018***	2,036**
				(0.579)	(3.124)	(2.988)	(2.038)
RPPlot*Hair coat bean				-0.275*	-0.287**	-2,553	
				(-1.76)	(-2.116)	(-1.627)	
RPPlot*Bean				-0.0643	-0.0469	-887.6	
				(-0.39)	(-0.332)	(-1.074)	
RPPlot*Chickpea				0.9***	0.849***	7,508***	
				(7.779)	(7.935)	(6.404)	
RPPlot*Field pea				0.50**	0.109	-134.1	
				(2.150)	(0.292)	(-0.0224)	
RPPlot*Groundnut				0.823*	0.633*	20,046***	
				(1.697)	(1.978)	(3.386)	
RPPlot*Soya bean				0.77**	0.488	6,352***	
				(2.202)	(0.951)	(3.457)	
Hhsex (male=1)	0.00446	0.0369	509.1	-0.0012	0.0326	438.4	-123.5
	(0.0649)	(0.641)	(1.034)	(-0.02)	(0.568)	(0.885)	(-0.210)
Ln(head age)	-0.0180	-0.0113	-97.21	-0.0209	-0.0145	-121.9	-133.8
	(-0.572)	(-0.380)	(-0.335)	(-0.67)	(-0.491)	(-0.421)	(-0.301)
Ln(years schooling-head)	0.0436*	0.0135	60.54	0.0427	0.0116	42.97	98.79
	(1.703)	(0.731)	(0.357)	(1.642)	(0.625)	(0.251)	(0.379)
Numeracy score (out of 6)	0.186	0.351**	1,024	0.196	0.357***	1,074	1,134
	(1.090)	(2.620)	(1.042)	(1.145)	(2.672)	(1.094)	(0.736)

Table 6.3 Cont'd

VARIABLES	ln(yld)	ln(vyld)	Crop inc.	ln(yld)	ln(vyld)	Crop inc.	Profit
Ln (adult members,15-64)	-0.0323	-0.0489	-527.1	-0.0340	-0.0524	-553.2	-451.6
	(-0.569)	(-1.066)	(-1.204)	(-0.60)	(-1.149)	(-1.286)	(-0.787)
Ln(child. & elderly 11-14&65-75)	0.098**	0.0412	317.5	0.09**	0.0400	310.8	484.9
	(2.086)	(1.054)	(0.975)	(2.074)	(1.026)	(0.960)	(0.954)
Ln(tot. self-emp. income)	0.0151	0.0101	114.2	0.0150	0.00983	108.2	-66.56
	(1.592)	(1.151)	(1.568)	(1.584)	(1.139)	(1.507)	(-0.659)
Ln(tot non-labor income)	-0.00873	-0.0093	-23.54	-0.0081	-0.00895	-17.82	-154.1*
	(-0.905)	(-1.164)	(-0.389)	(-0.83)	(-1.101)	(-0.294)	(-1.683)
Ln(livestock value)	0.036***	0.03***	386.***	0.03**	0.035***	375.3***	70.39
	(2.635)	(3.015)	(3.997)	(2.574)	(2.940)	(3.980)	(0.603)
Ln(tot asset value)	0.0429*	0.051**	437***	0.04**	0.053***	461.5***	485.8**
	(1.971)	(2.516)	(2.983)	(2.003)	(2.634)	(3.176)	(2.447)
Risk game (=1 if take part)	0.108	0.0646	475.7	0.107	0.0596	421.0	-250.7
	(0.818)	(0.577)	(0.435)	(0.790)	(0.523)	(0.383)	(-0.185)
Degree of risk taking (0,1,2)	0.0192	0.0196	216.5	0.0180	0.0192	206.8	0.0991
	(0.853)	(0.931)	(1.111)	(0.790)	(0.918)	(1.090)	(0.00032)
Time pref. game (=1 if take part)	0.0598	0.0115	6.314	0.0619	0.0151	55.90	637.9
	(1.135)	(0.277)	(0.0141)	(1.180)	(0.361)	(0.124)	(1.163)
Present bias (=1)	-0.0433	-0.0229	51.77	-0.0399	-0.0214	71.66	-13.56
	(-0.812)	(-0.527)	(0.133)	(-0.75)	(-0.492)	(0.183)	(-0.0215)
Myopic	-0.0333	-0.0286	42.93	-0.0339	-0.0287	47.01	-435.2
	(-1.327)	(-1.266)	(0.277)	(-1.36)	(-1.282)	(0.308)	(-1.361)
Ln(distance to plot, min)	0.0291	0.034**	7.063	0.0297	0.0338**	3.152	144.1
	(1.636)	(2.165)	(0.0401)	(1.644)	(2.182)	(0.0184)	(0.652)
Soil conservation (=1)	0.0264	0.0388	115.0	0.0300	0.0418	167.5	-871.1*
	(0.525)	(0.905)	(0.328)	(0.599)	(0.979)	(0.485)	(-1.902)
Leased-in land (=1)	-0.0226	-0.0693	-437.1	-0.0220	-0.0656	-365.3	866.0
	(-0.381)	(-1.274)	(-0.954)	(-0.37)	(-1.225)	(-0.815)	(1.080)
Ln(farm size)	-0.111**	-0.1***	-1,182***	-0.108*	-0.13***	-1,143***	-684.5
	(-2.027)	(-3.021)	(-3.535)	(-1.98)	(-2.963)	(-3.467)	(-1.634)
Flat slope (=1)	0.126*	0.0777	465.5	0.121*	0.0756	417.9	1,944***
	(1.727)	(1.225)	(0.865)	(1.669)	(1.175)	(0.754)	(2.775)
Moderate slope(=1)	0.0901	0.0734	384.3	0.0885	0.0761	353.4	-974.2
	(0.953)	(1.001)	(0.678)	(0.953)	(1.028)	(0.610)	(-1.144)
Rocky surface(=1)	-0.126*	-0.1***	-1,018*	-0.128*	-0.16***	-1,004*	-78.87
	(-1.835)	(-2.71)	(-1.889)	(-1.88)	(-2.761)	(-1.859)	(-0.100)
Excellent soil (=1)	0.0384	0.0371	346.1	0.0419	0.0386	354.7	-924.5
	(0.276)	(0.311)	(0.455)	(0.299)	(0.320)	(0.450)	(-0.878)
Good soil(=1)	0.114	0.129	799.8	0.115	0.126	757.9	707.9
	(0.867)	(1.164)	(1.179)	(0.874)	(1.129)	(1.082)	(0.708)

Table 6.3 Cont'd

VARIABLES	ln(yld)	ln(vyld)	Crop inc.	ln(yld)	ln(vyld)	Crop inc.	Profit
Fair soil(=1)	0.0182	0.0640	433.3	0.0170	0.0608	423.8	-922.4
	(0.136)	(0.525)	(0.606)	(0.126)	(0.498)	(0.581)	(-0.825)
Short. of rain(=1)	-0.43***	-0.2***	-2,149***	-0.4***	-0.22***	-2,156***	-2,207**
	(-3.395)	(-2.850)	(-3.840)	(-3.34)	(-2.833)	(-3.901)	(-2.859)
Flood(=1)	-0.9***	-0.4***	-3,491***	-0.9***	-0.45***	-3,610***	-5,532**
	(-4.158)	(-4.254)	(-6.273)	(-4.28)	(-4.425)	(-6.559)	(-4.676)
Crop disease(=1)	-0.38***	-0.2***	-2,984***	-0.4***	-0.27***	-3,019***	-4,027**
	(-4.092)	(-4.019)	(-6.217)	(-4.14)	(-4.117)	(-6.137)	(-4.427)
Insects (=1)	-0.29***	-0.2***	-2,002***	-0.3***	-0.26***	-2,086***	-982.7
	(-3.217)	(-3.566)	(-3.215)	(-3.32)	(-3.660)	(-3.302)	(-0.744)
Animal damag (=1)	-0.577*	-0.102	-1,455*	-0.573*	-0.0985	-1,415*	-1,311
	(-1.749)	(-0.924)	(-1.752)	(-1.74)	(-0.895)	(-1.737)	(-0.813)
Bird damage (=1)	-0.740	-0.423	-2,638	-0.737	-0.419	-2,637	602.4
	(-1.333)	(-1.108)	(-1.419)	(-1.35)	(-1.110)	(-1.468)	(0.124)
Thefts (=1)	-0.56***	-0.3***	-4,992***	-0.5***	-0.39***	-5,059***	-4,648**
	(-2.888)	(-3.399)	(-5.618)	(-2.83)	(-3.411)	(-5.367)	(-3.392)
Frost (=1)	-0.42***	-0.3***	-2,968***	-0.4***	-0.37***	-3,028***	-4,653**
	(-4.672)	(-7.347)	(-8.367)	(-4.70)	(-7.614)	(-8.383)	(-4.839)
Other damages(=1)	-1.07***	-0.4***	-3,631***	-1.0***	-0.47***	-3,785***	-3,364**
	(-6.227)	(-5.35)	(-6.445)	(-6.31)	(-5.485)	(-6.844)	(-4.413)
Constant	5.691***	7.08***	-5,565***	5.7***	7.128***	-5,134**	-700.0
	(17.98)	(25.10)	(-2.730)	(18.03)	(25.23)	(-2.547)	(-0.206)
Observations	4,734	4,644	4,629	4,734	4,644	4,629	1,454
R-squared	0.272	0.350	0.296	0.275	0.354	0.305	0.358
P-values	0.059	0.025	0.066	0.0000	0.0000	0.000	0.3586

Notes: Robust t-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1. The crop and village fixed effects are included in each regression. The profit regression is only for barley, maize, teff, and wheat plots because the detailed input information was collected only for selected plots covered by these crops. The dependent variables ln(yld), ln(vyld) and crop inc. represents the natural logarithms of crop yield, value of crop yield and crop income respectively. Crop income and profit are not logarithmic transformed. The p-value in the last row in Columns 1-3 if for the null hypothesis that the RPAdopter and RPPlot are jointly zero, and in Columns 4-7 it is the joint test for the null hypotheses that the interactions of row planted plot dummies with crop dummies are zero.

Table 6.4: The OLS regression results on matched samples for the plot level determinants of crop yield, value of crop yield, and crop income.

VARIABLES	(1) ln(yield)	(2) ln(vyield)	(3) Crop inc.	(4) ln(yield)	(5) ln(vyield)	(6) Crop inc.
RPAdopter hh (=1)	-0.115	-0.0753	-381.8	-0.103	-0.0612	-332.7
	(-1.185)	(-0.915)	(-0.709)	(-1.099)	(-0.758)	(-0.607)
RPPlot (=1)	-0.00420	0.0581	560.4			
	(-0.0518)	(0.967)	(0.961)			
RPPlot*Barley				0.0531	0.362**	1,983
				(0.130)	(2.118)	(1.311)
RPPlot*Maize				-0.115	-0.134	-568.6
				(-0.705)	(-1.145)	(-0.592)
RPPlot*Millet				0.0931	-0.455**	-3,689**
				(0.361)	(-2.414)	(-2.208)
RPPlot*Sorghum				0.162	0.405	4,827
				(0.288)	(0.635)	(0.705)
RPPlot*Teff				0.192	0.259**	2,139**
				(1.452)	(2.626)	(2.288)
RPPlot*Wheat				0.0258	0.245**	3,654***
				(0.116)	(2.633)	(3.414)
RPPlot*Haircoat b.				-0.443*	-0.274	-6,019**
				(-1.873)	(-1.476)	(-2.490)
RPPlot*Bean				0.390*	0.184	1,286
				(1.798)	(0.852)	(1.282)
RPPlot*Chickpea				0.770***	0.914***	6,720***
				(3.352)	(4.912)	(3.577)
RPPlot*Field pea				0.748*	0.00866	-3,185
				(1.860)	(0.0224)	(-0.836)
RPPlot*Groundnuts				0.968**	1.570***	13,279**
				(2.037)	(2.666)	(2.417)
HHsex(Male=1)	-0.0266	0.00204	-518.6	-0.0564	-0.0187	-620.9
	(-0.199)	(0.0172)	(-0.655)	(-0.437)	(-0.157)	(-0.800)
Ln(head age)	-0.0295	-0.0398	-149.4	-0.0453	-0.0512	-269.6
	(-0.441)	(-0.741)	(-0.233)	(-0.655)	(-0.962)	(-0.455)
Ln(years schooling-head)	0.00198	-0.0268	-36.81	0.00329	-0.0271	-99.80
	(0.0407)	(-0.701)	(-0.111)	(0.0685)	(-0.729)	(-0.308)
Numeracy score (out of 6)	0.0378	0.373	-51.58	0.0456	0.363	331.9
	(0.121)	(1.436)	(-0.0276)	(0.146)	(1.400)	(0.190)
Ln (adult size,15-64)	0.0354	-0.0446	-154.9	0.0356	-0.0476	-164.4
	(0.378)	(-0.552)	(-0.254)	(0.378)	(-0.593)	(-0.281)

Table 6.4 Continued

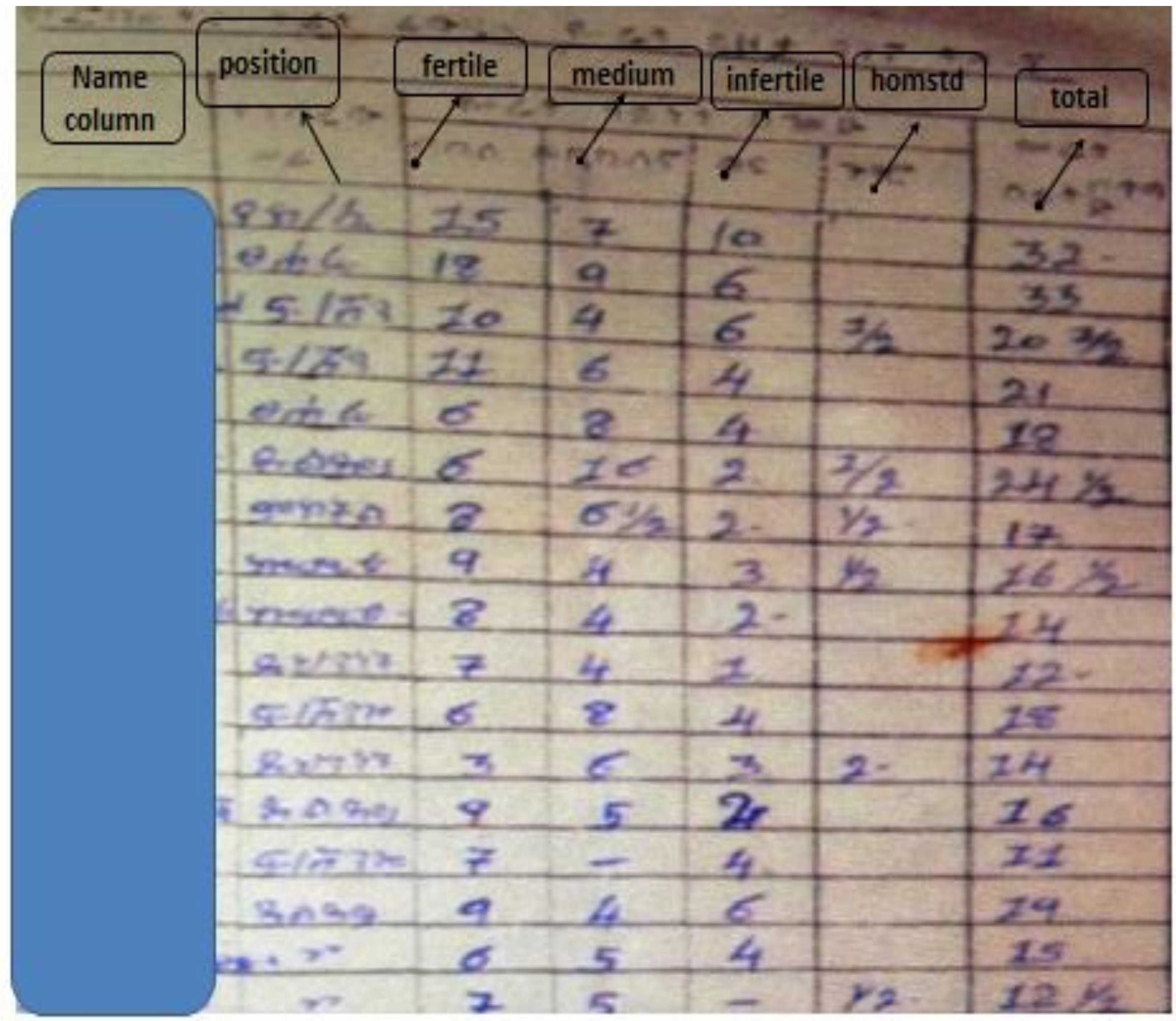
VARIABLES	ln(yield)	ln(vyield)	Crop inc.	ln(yield)	ln(vyield)	Crop inc.
Ln(child. &elderly, 11-14&65-75)	0.0769 (0.781)	0.143* (1.702)	91.97 (0.175)	0.0817 (0.833)	0.142* (1.703)	136.5 (0.268)
Ln(Income from self emp.)	0.0278* (1.765)	0.0142 (1.139)	50.89 (0.458)	0.0276* (1.755)	0.0126 (1.033)	43.40 (0.405)
Ln(income from non-labor)	-0.0228 (-1.408)	-0.0303* (-1.968)	-118.3 (-1.232)	-0.0230 (-1.425)	-0.0300* (-1.958)	-112.0 (-1.215)
Ln(livestock value)	0.0405* (1.668)	0.0486** (2.434)	375.6*** (2.823)	0.0376 (1.508)	0.0467** (2.267)	329.7** (2.545)
Ln(asset value)	0.102** (2.352)	0.101*** (2.684)	736.7*** (2.762)	0.105** (2.363)	0.107*** (2.832)	801.2*** (3.195)
Risk game (=1 if take part	0.0486 (0.145)	-0.104 (-0.409)	-126.9 (-0.0773)	0.0468 (0.143)	-0.110 (-0.450)	-249.6 (-0.162)
Degree of risk taking (0,1,2)	0.0221 (0.495)	0.0259 (0.871)	390.6 (1.107)	0.0213 (0.477)	0.0244 (0.820)	390.9 (1.125)
Time pref. game (=1 if take part)	0.147 (1.280)	-0.00665 (-0.0693)	1,241** (2.302)	0.146 (1.299)	0.00617 (0.0680)	1,255** (2.376)
Present bias (=1)	-0.0703 (-0.714)	-0.0943 (-0.985)	-502.0 (-0.803)	-0.0733 (-0.752)	-0.0947 (-1.009)	-520.9 (-0.847)
Myopic	-0.00161 (-0.0315)	-0.0161 (-0.396)	31.54 (0.118)	-0.00144 (-0.0278)	-0.0165 (-0.409)	12.05 (0.0476)
Ln(distance to plot, minute)	0.0544* (1.928)	0.0283 (1.000)	161.8 (0.733)	0.0505* (1.792)	0.0244 (0.884)	128.6 (0.612)
Soil conservation (=1)	-0.00109 (-0.0115)	0.0402 (0.533)	-378.6 (-0.662)	0.00997 (0.109)	0.0514 (0.713)	-183.9 (-0.346)
Leased-in land (=1)	0.0576 (0.547)	0.0522 (0.568)	-481.1 (-0.641)	0.0721 (0.677)	0.0770 (0.839)	-292.9 (-0.422)
Ln(farm size)	-0.162* (-1.791)	-0.180** (-2.352)	-1,704*** (-2.857)	-0.152* (-1.687)	-0.170** (-2.218)	-1,565*** (-2.802)
Flat slope (=1)	0.558*** (4.035)	0.296** (2.511)	1,379* (1.756)	0.567*** (4.222)	0.304** (2.539)	1,551* (1.981)
Moderate slope(=1)	0.360** (2.280)	0.168* (1.672)	728.0 (1.024)	0.361** (2.313)	0.173* (1.676)	947.3 (1.314)
Rocky surface(=1)	-0.148 (-1.150)	-0.240** (-2.030)	-932.1 (-1.157)	-0.135 (-1.044)	-0.236** (-2.033)	-813.8 (-1.031)
Excellent soil (=1)	-0.0962 (-0.702)	0.0990 (0.802)	-1,263 (-1.062)	-0.0888 (-0.647)	0.101 (0.821)	-1,109 (-0.941)
Good soil(=1)	0.214* (1.801)	0.323*** (3.127)	503.6 (0.554)	0.210* (1.778)	0.318*** (3.082)	476.3 (0.503)
Fair soil(=1)	0.0901 (0.572)	0.255** (2.269)	1,036 (0.945)	0.0864 (0.543)	0.255** (2.244)	1,126 (1.016)

Table 6.4 Continued

VARIABLES	ln(yield)	ln(vyield)	Crop inc.	ln(yield)	ln(vyield)	Crop inc.
Shortage of rain(=1)	-0.574**	-0.212	-1,308	-0.579**	-0.214*	-1,529
	(-2.536)	(-1.633)	(-1.380)	(-2.584)	(-1.696)	(-1.584)
Flood(=1)	-1.184***	-0.441***	-3,655***	-1.18***	-0.431***	-3,684***
	(-3.223)	(-3.600)	(-5.807)	(-3.236)	(-3.444)	(-5.755)
Crop disease(=1)	-0.233**	-0.0753	-1,634*	-0.235*	-0.0669	-1,659*
	(-2.002)	(-0.606)	(-1.933)	(-1.972)	(-0.543)	(-1.844)
Insects (=1)	-0.109	-0.0499	-1,166	-0.0934	-0.0557	-1,434
	(-0.869)	(-0.337)	(-1.180)	(-0.760)	(-0.422)	(-1.381)
Animal damag (=1)	-0.694*	0.253	-495.9	-0.683	0.261	-457.5
	(-1.675)	(1.221)	(-0.362)	(-1.635)	(1.319)	(-0.364)
Bird damage (=1)	-1.411*	-0.856**	-4,648***	-1.415**	-0.856**	-4,580***
	(-1.990)	(-2.291)	(-2.850)	(-1.995)	(-2.254)	(-2.884)
Thefts (=1)	-0.601***	-0.290	-2,591	-0.62***	-0.339	-3,131*
	(-3.446)	(-1.239)	(-1.463)	(-3.858)	(-1.585)	(-1.767)
Frost (=1)	-0.256***	-0.153*	-1,682**	-0.27***	-0.168*	-1,886***
	(-2.891)	(-1.857)	(-2.570)	(-3.032)	(-1.883)	(-2.756)
Other damages(=1)	-1.089***	-0.429***	-3,444***	-1.08***	-0.440***	-3,635***
	(-6.263)	(-4.247)	(-5.175)	(-6.081)	(-4.289)	(-5.504)
Constant	4.788***	6.700***	-5,879*	4.858***	6.712***	-5,744**
	(9.919)	(15.48)	(-1.866)	(9.919)	(15.33)	(-2.006)
Observations	2,922	2,877	2,819	2,922	2,877	2,819
R-squared	0.310	0.386	0.325	0.315	0.395	0.342
P-values	0.3909	0.2016	0.2462	0.0012	0.0000	0.0000

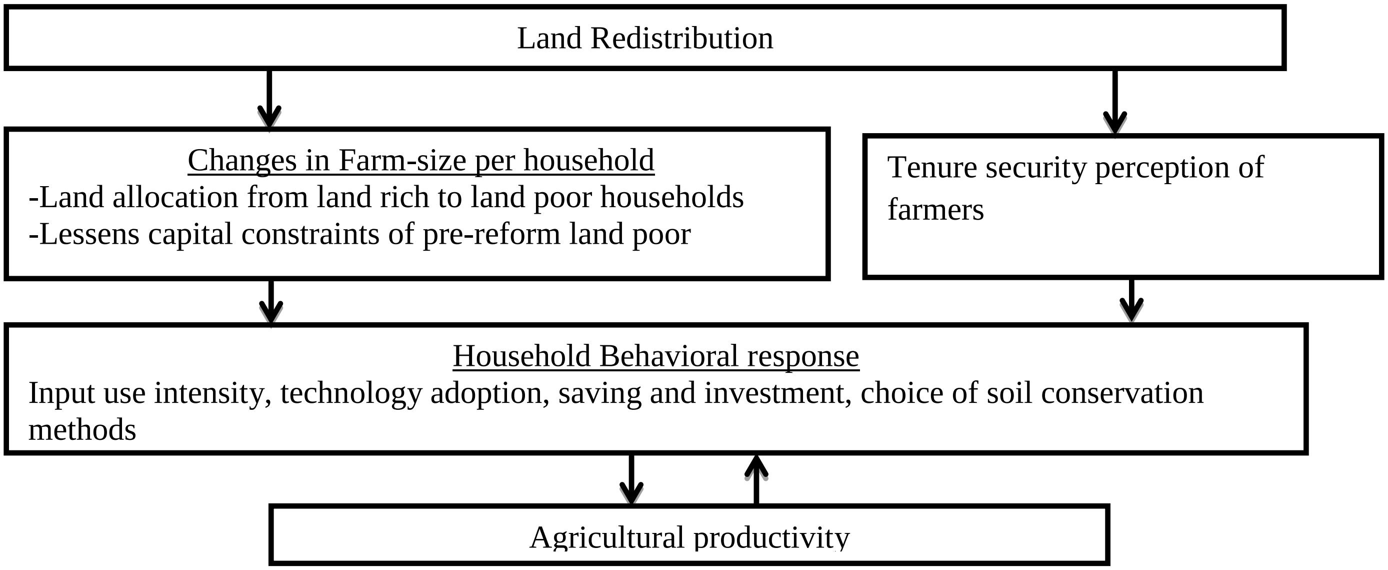
Robust t-statistics in parentheses,*** p<0.01, ** p<0.05, * p<0.1. The households were matched using the predetermined household level characteristics. The crop and village fixed effects are included in each regression. The p-value in the last row in Columns 1-3 if for the null hypothesis that the RPAdopter and RPPlot are jointly zero, and in Columns 4-6 it is the joint test for the null hypotheses that the interactions of row planted plot dummies with crop dummies are zero.

Figures



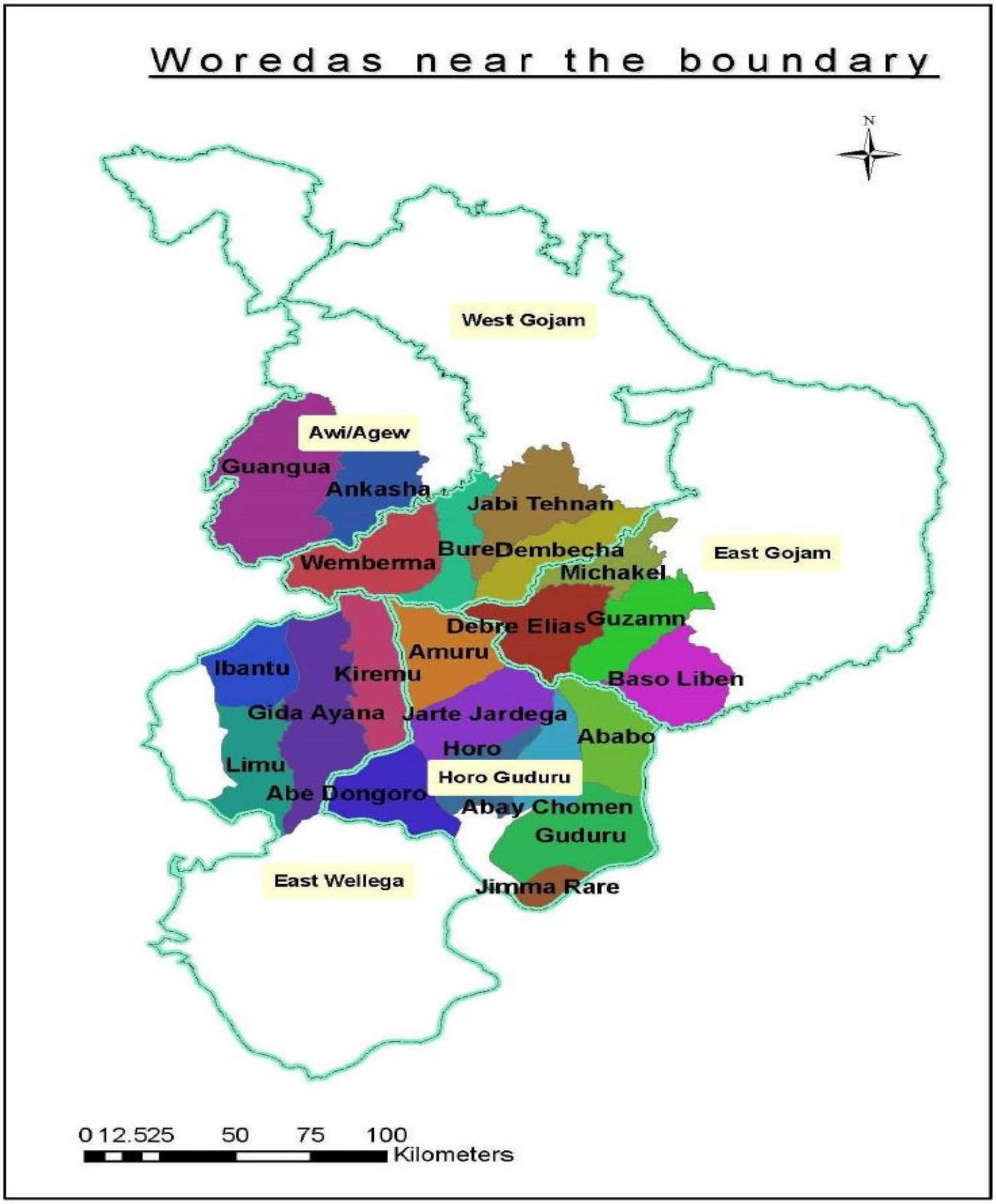
Source: Obtained from EPLUA offices (Digital picture). Column (1) shows the name of the farmers. Column (2) shows the type of position the farmers was in charge during the previous political regimes. Columns (3)-(5) shows the total farmland by degree of fertility (very fertile, medium, and poor), and Column (6) homestead land size. Finally, Column (7) shows the total landholding which is the sum of the figures in Columns (2)-(6) in *timad* unit (note 1 *timad*=0.25 hectare).

Figure 2. 1: A sample pre land redistribution registration form for past bureaucrats and remnant feudal farmers in West Gojjam.



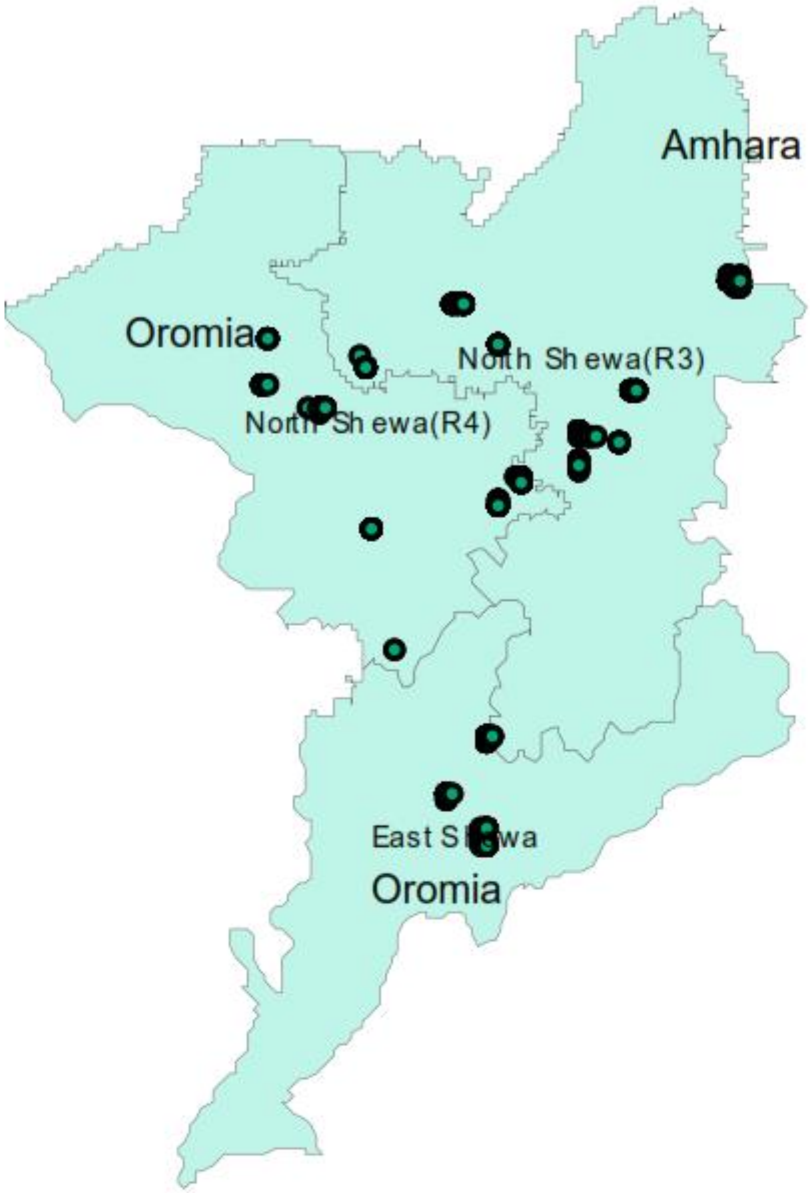
Source: Based on Otsuka and Place (2014) and Hagos *et al.* (2012)

Figure 2. 2: The link between land redistribution, tenure security, farm investments, and agricultural productivity through two pathways.



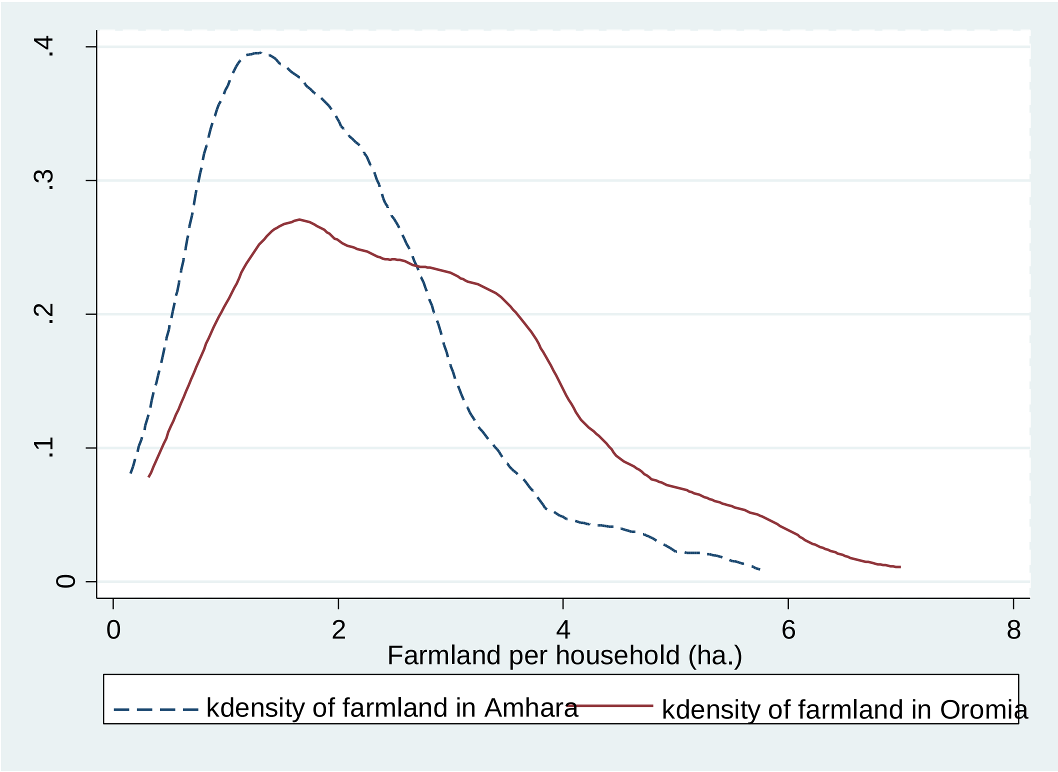
The solid lines are the administrative zone and the enclosed shaded areas are the boundaries of the respective woredas/districts close to the Amhara-Oromia border)

Figure 3. 1: The treated and control administrative zones.



Note: the dots represent the sample households in the 2014 RePEAT survey. Note: the solid lines separate the administrative zones.

Figure 3. 2: The North Shewa zone of Amhara region vis-a-vis border sharing zones of Oromia (North and East Shewa zones).



Source: Computed based on the 2014 RePEAT survey

Figure 3.3 The kernel density of farmland in hectares in Amhara and Oormia regions, 2014.

Source: Vandercasteelen et al. (2014). Note: the graph in the left is under the traditional or broadcast method of sowing whereas the one in the right is planted by row planting method.

Figure 5.1: A figure which shows teff crop under the broadcast and row planting methods.

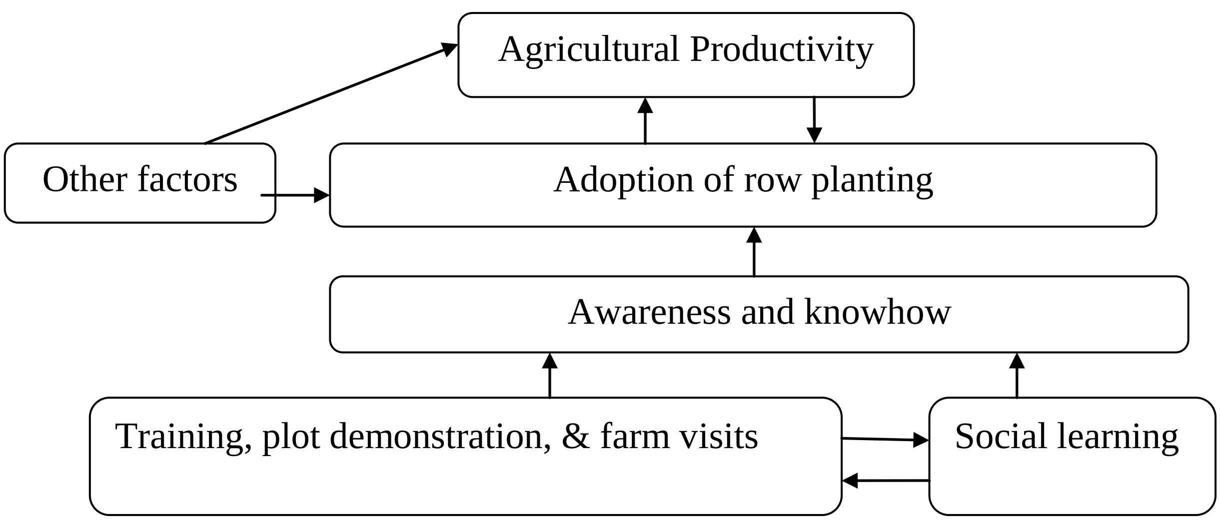


Figure 5. 2: The pathways of agricultural extension, social learning, and the other factors on the adoption of row planting and productivity.

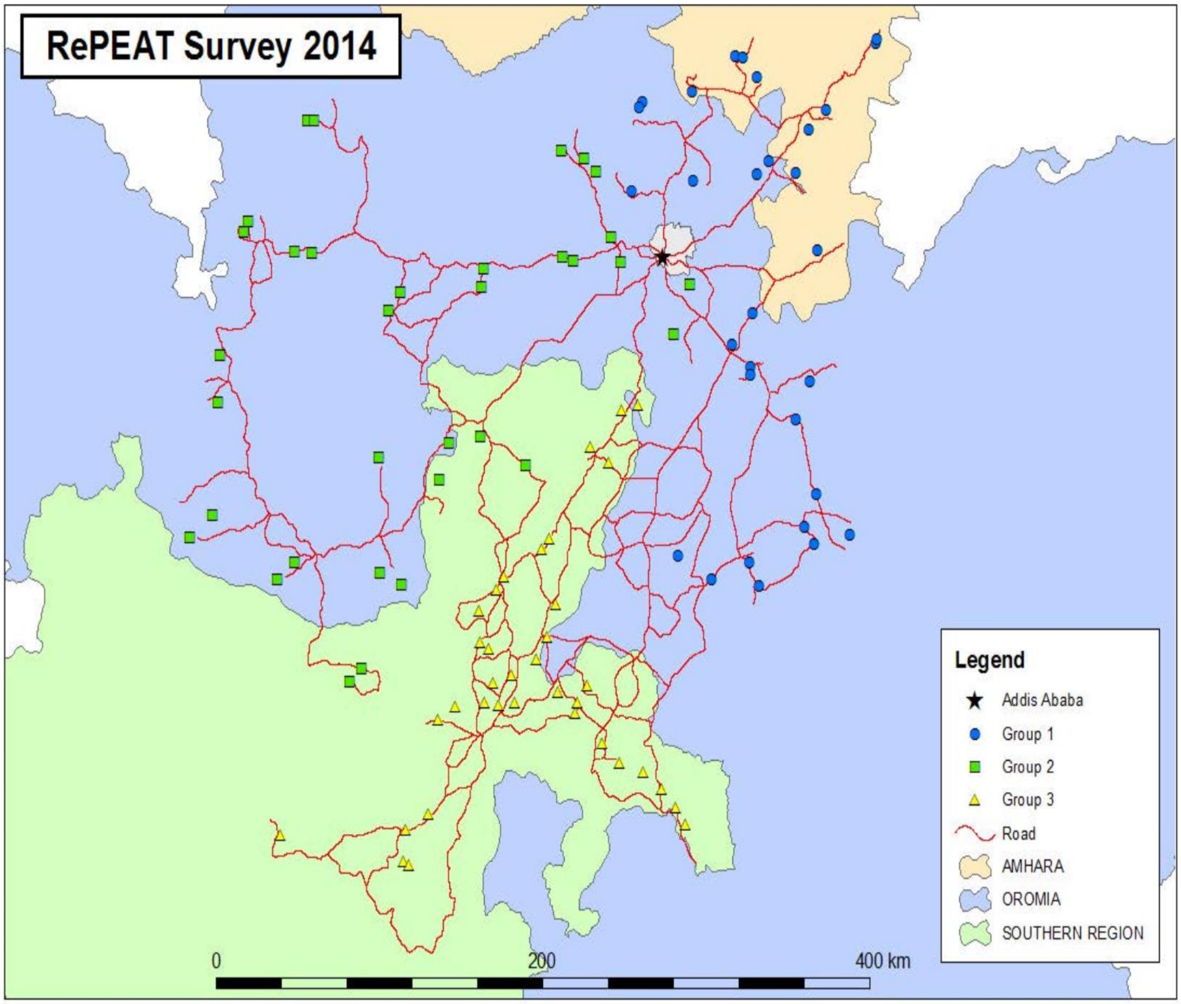


Figure 5.3: The distribution of study villages covered in the 2014 RePEAT survey in Ethiopia

Appendices

Appendix Tables used in Chapter 3

Table A.1: The marginal effects from the Tobit regression for the inorganic fertilizer use (kg/ha) and OLS regression results for crop yield and value of crop yield in Shewa zones.

	Log (inorg. Fertilizer kg/ha)	Ln (yield)	Ln(value of yield)
DAmhara*T	0.249***	-0.0865	-0.209*
	(3.385)	(0.0810)	(0.109)
Prop. Male landholders	0.652***	-0.0187	0.201
	(4.429)	(0.183)	(0.238)
Ln(average hhsize)	-0.0597***	0.136	-0.270
	(-8.259)	(0.164)	(0.225)
Prop. Uneducated holders	-1.303***	-0.67***	-0.778**
	(-6.906)	(0.253)	(0.333)
Prop. Grade 1-3 holders	-1.880***	-0.570*	-0.757*
	(-9.069)	(0.334)	(0.435)
Mon crop(=1)	0.827***	0.0763*	0.112
	(4.886)	(0.0450)	(0.0745)
<u>The proportions of crop plot damage incidences</u>			
Crop disease (prop.)		-0.256	-0.526*
		(0.216)	(0.318)
Frost and flood (prop.)		0.117	-0.494
		(0.295)	(0.402)
Insects and pests (prop.)		-0.156*	0.0546
		(0.0874)	(0.176)
Shortage of rain (prop.)	-0.385***	-0.50***	-0.57***
	(-8.717)	(0.0923)	(0.133)
Excessive rain (prop.)	0.612***	-0.48***	-0.51***
	(4.084)	(0.106)	(0.128)
Wild Animals (prop.)		-0.414	-0.739
		(0.412)	(0.684)
Birds (prop.)		0.0959	-0.168
		(0.242)	(0.312)
Other damages (prop.)		-0.26***	-0.0603
		(0.0987)	(0.137)
Constant		7.07***	7.440***
		(0.406)	(0.567)
Observations	2862	2,170	1,205

R-Squared		0.334	0.336

Notes: in parenthesis are robust z statistics in Column 1 and robust standard errors in Columns 2 and 3. Standard errors clustered at an enumeration area level for each year. *** shows significance at 1%, ** at 5%, and * at 10%. District, year and crop fixed effects are controlled in each regression. The log-likelihood for the Tobit regression of inorganic fertilizer use is -3679. The treated part is the North Shewa zone of Amhara whereas the control groups are from the North and East Shewa zones of Oromia region.

Table A.2: The marginal Effects from the Tobit regressions for the plot level determinants of inorganic fertilizer use in kg/ha (log).

VARIABLES	(1) Near demarcation (Gojjam province vs E.Wellega)	(2) W.Gojjam vs E.Wellega	(3) W. Gojjam & Awi vs E.Wellega	(4) N.Shewa (Amhara) vs N & E Shewa (Oromia)
DAmhara*T	0.419**	0.0853	0.166	0.175***
	(2.240)	(0.527)	(1.182)	(4.209)
Observations	13,626	20,160	26,108	27,394

Notes: in parenthesis are z-statistics computed using robust standard errors. Standard errors are clustered at enumeration area level for each year. *** shows significance at 1%, ** at 5%, and * at 10%. District, crop and year fixed effects, gender of the landholder, household size, dummies of illiteracy and grade 1 through years of schooling, dummy of mono-crop, and dummies of shortages and excessive rains are also controlled but not reported to save space. The lower limit in the Tobit estimation is set at ln(k), where k is the minimum positive value inorganic fertilizer (kg/ha) less a very small number.

Table A.3: The marginal effects from the Placebo Tobit regression results for the EA level determinants of inorganic fertilizer use (kg/ha) in logarithm, 1995-1999.

VARIABLES	(1) Gojjam provinces (Highlighted part of the province in Fig. 3.1=PTG)	(2) West Gojjam versus Awi (WGojjam=PTG)	(3) East Wellega (districts in the highlighted part of Fig. 3.1 =PTG)
PlaceboGroup* T	0.0619	-0.779	-0.364
	(0.180)	(-1.624)	(-1.113)
Observations	2,500	1,544	1,072

Note: Gojjam province includes East Gojjam, West Gojjam, and Awi administrative zones. PTG denotes the Placebo Treated group. In parenthesis are robust standard errors that are clustered at an enumeration area level for each year. *** shows significance at 1%, ** at 5%, and * at 10%. District, crop and year fixed effects, the proportions of male holders, average household size, the proportions of illiterate, and those through 1-3 years of school, mono-crop dummy, and the vectors of crop damage indicators are controlled but not reported to save space. The lower limit in the Tobit estimation is set at ln(k), where k is the minimum positive values of inorganic fertilizer (kg/ha) less a very small number.

Table A.4: The placebo regression results for the EA level determinants of crop yield and value of crop yield, 1995-1999.

VARIABLES	Gojjam provinces (Highlighted part of the province in Fig. 3.1=PTG)		West Gojjam versus Awi (WGojjam=PTG)		East Wellega (districts in the highlighted part of the zone in Fig. 3.1 =PTG)	
	(1)	(2)	(3)	(4)	(5)	(6)
	Ln(yld)	Ln(vyld)	Ln(yld)	Ln(vyld)	Ln(yld)	Ln(vyld)
PlaceboGroup*T	-0.0787	0.0142	0.0632	-0.149	0.108	0.141
	(0.0974)	(0.109)	(0.109)	(0.120)	(0.169)	(0.197)
Observations	1,286	1,286	825	825	419	419
R-squared	0.316	0.370	0.327	0.283	0.576	0.522

Notes: Gojjam province includes East Gojjam, West Gojjam, and Awi administrative zones. PTG means the Placebo Treated group. In parenthesis are robust standard errors that are clustered at an enumeration area level for each year. *** shows significance at 1%, ** at 5%, and * at 10%. District, crop and year fixed effects, the proportions of male holders, average household size, the proportions of illiterate, and those through 1-3 years of school, mono-crop dummy, and the vectors of crop damage indicators are controlled but not reported to save space.

Appendix Tables used in Chapter 4

Table A.5: The percentage share of individual crop in the total cereal and legume crop plots in the treated and control areas by region, 2014.

Crop name	Amhara	Oromia
Barley (Gebis)	25.55	17.81
Maize (bekolo)	1.03	5.82
Sorghum (Mashla)	4.11	0.11
Teff (white)	10.13	20.66
Teff (red/mixed)	8.81	4.68
Wheat	22.47	19.18
Haricot beans (Adengware)	0.00	2.85
Bean (Bakela)	14.83	18.04
Chick peas (Shenbere)	1.91	4.45
Field pea (Ater)	3.52	1.83
Lentils (Misir)	7.64	4.22
Soybeans (Akuri ater)	0.00	0.34

Source: Computed based on the 2014 RePEAT survey

Table A.6: The marginal effects from the Probit regression for the parcel level determinants of soil conservation methods (with village effects).

VARIABLES	(1)	(2)	(3)
	Stone Terraces	Contour plough	Check Dam/ drainage ditch
Panel A: Amhara (using dummies)			
DBeneficiaries (=1 if received land in 1996/97)	0.194**	-0.0181	-0.111
	(1.984)	(-0.182)	(-0.493)
DLoser (=1 if lost land in 1996/97)	-0.007	-0.110	-0.00821
	(-0.098)	(-1.539)	(-0.0497)
Ln(farm size)	-0.173	-0.193	-0.0704
	(-0.913)	(-1.240)	(-0.687)
Observations	213	180	145
Log likelihood	-45	-50	-52
Pseudo R2	0.4693	0.4434	0.3578
P-value for Beneficiary=loser	0.0005	0.3770	0.3571
Panel B: Amhara (using land received/lost)			
Net land received in ha in 1996/97	0.08***	0.0373	-0.0640
	(2.661)	(0.951)	(-1.249)
Net land lost in ha in 1996/97	-0.0175	-0.059*	-0.030**
	(-0.587)	(-1.672)	(-2.123)
Ln(farm size)	-0.165	-0.137	-0.0919
	(-1.064)	(-1.113)	(-0.650)
Observations	213	180	145
Log likelihood	-46	-49	-51
Pseudo R2	0.4684	0.4583	0.3709
P-value for received land = lost land	0.0000	0.0088	0.4158
Panel C: Oromia (Control)			
Ln(farm size)	-0.40***	-0.0978	-0.0439*
	(-3.297)	(-0.637)	(-1.721)
Observations	218	211	243
Log-likelihood	-78	-47	-68
Pseudo-R2	0.2436	0.3874	0.3577

Notes: The reported results are marginal effects evaluated at the average of all variables and elements in parenthesis are z-statistics computed using robust standard errors. Standard errors are clustered at village level. *** shows significance at 1%, ** at 5%, and * at 10%. The p-value for the equality of coefficients of tenure security measures for beneficiaries and losers are reported in the last row. Head and household level, parcel level variables are included in each regression in Panel **A-B** but the coefficients of these variables are not reported to save space.

Table A.7: The regression results for the plot level determinants of crop yield and value of crop yield.

Variables	(1)	(2)
	ln(yield)	ln (value yield)
Panel A: with size of land received and lost		
DAmhara (=1 if Amhara region)	0.254**	0.359***
	(2.120)	(3.153)
Net land received in ha in1996/97	-0.000	0.0155
	(-0.0086)	(0.497)
Net land lost in 1996/97	0.0661*	0.0695*
	(1.966)	(1.784)
Ln(farm size)	-0.56***	-0.579***
	(-4.911)	(-6.125)
Observations	1,415	1,407
R-squared	0.249	0.320
Panel B: Weighted regression on matched samples (for losers)		
DLoser (=1 if lost land in 1996/97)	0.318	0.491**
	(1.133)	(2.114)
Ln(farm size)	-0.300	-0.528**
	(-1.169)	(-2.458)
Observations	374	370
R-squared	0.359	0.396
Panel C: with village fixed effects (Amhara)		
DBeneficiaries (=1 if received land in 1996/97 in Amhara region)	0.0659	0.0853*
	(1.106)	(1.974)
DLoser (=1 if lost land in 1996/97)	0.119	0.170
	(1.004)	(1.135)
Ln(farm size)	-0.382	-0.462**
	(-1.75)	(-2.3)
Observations	611	607
R-squared	0.230	0.331
Panel D: with village fixed effects (Amhara)		
Net land received in ha in1996/97 (for beneficiaries)	-0.0223	-0.0140
	(-0.589)	(-0.460)
Net land lost in 1996/97 (for losers)	0.0462	0.0597*
	(1.784)	(2.037)
Ln(farm size)	-0.423*	-0.514**
	(-2.075)	(-2.896)
Observations	611	607

R-squared	0.231	0.331
Panel E: with village fixed effects (Control/Oromia)		
Ln(farm size)	-0.559***	-0.552***
	(-3.584)	(-3.672)
Observations	806	802
R-squared	0.349	0.409

Notes: in parenthesis are t-statistics computed using robust standard errors. Standard errors are clustered at village level. *** shows significance at 1%, ** at 5%, and * at 10%. Head and household level, parcel level variables, and crop fixed effects are included in the regressions in Panels ***A-E***

Table A.8: The regressions results for the determinants of plot level crop yield and value of crop yield (with intermediate inputs and village fixed effects).

	(1)	(2)
Variables	ln(yield)	ln (value yield)
Panel A: with beneficiaries and losers dummies (Amhara)		
DBeneficiaries' (=1 if received land in 1996/97)	0.0817	0.0807
	(1.090)	(1.378)
DLosers' (=1 if lost land in 1996/97)	0.118	0.149
	(0.860)	(0.807)
Ln(farm size)	-0.287	-0.337*
	(-1.573)	(-1.955)
Observations	595	591
R-squared	0.266	0.359
Panel B: with size of land received and lost (Amhara)		
Net land received in ha in1996/97	-0.0267	-0.0241
	(-0.700)	(-0.913)
Net land lost in 1996/97	0.0437	0.0544
	(1.830)	(1.539)
Ln(farm size)	-0.340	-0.396*
	(-1.797)	(-2.215)
Observations	595	591
R-squared	0.267	0.360
Panel C: Control groups (Oromia)		
Ln(farm size)	-0.551**	-0.554***
	(-3.250)	(-3.787)
Observations	805	801
R-squared	0.375	0.427

Notes: in parenthesis are t-statistics computed using robust standard errors. Standard errors are clustered at village level. *** shows significance at 1%, ** at 5%, and * at 10%. Head and household level, parcel level variables, and crop fixed effects are included in the regressions under Panels ***A-C.*** The logarithms of dap/ha, urea/ha, organic fertilizer/ha, and dummies of improved seed, and row planting are also additionally controlled.

Table A.9: The marginal effects from the Probit regressions for the household level determinants of tenure insecurity.

VARIABLES	(1)	(2)
DAmhara (=1 if Amhara region)	0.0195	
	(0.366)	
DUnaffected (=1 if neither gain nor lost land in 1996/97)		0.0411
		(0.563)
DBeneficiaries (=1 if received land)		-0.0272
		(-0.296)
DLoser (=1 if lost land)		0.0258
		(0.358)
Observations	285	285

Notes: z-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1. The household level variables such as age, gender, years of education, and livestock value, and village characteristics like the number of landless households and distance from district towns are controlled both in Columns (1) and (2). The dependent variables is a dummy variable which takes a value 1 if the farmers expects or uncertain about land redistribution in the region in the next 10 years and zero otherwise.

Appendix Tables used in Chapter 6

Table A. 10: The reason for not adopting row planting for those who are having knowledge about row planting.

Variables	Obs	mean	sd
Tedious and time demanding (=1)	249	0.65	0.48
lack of skilled extension(=1)	249	0.10	0.30
Financial constraint (=1)	249	0.02	0.14
want to see from others (=1)	249	0.07	0.25
other reasons (=1)	249	0.09	0.28

Source: Computed based on the 2014 RePEAT survey. The sum of mean does not add up 1 because of non-response.

Table A.11: The balancing test results before and after matching by invitation to training.

	Before Matching				After matching			
Variables	Control	Treated	Mean Diff.	P-val.	Control	Treated	Mean Diff.	P-val.
Head sex (=1)	0.84	0.92	-0.08	0.000	0.91	0.91	0.00	0.849
Ln(head age)	3.87	3.82	0.05	0.090	3.81	3.82	-0.01	0.789
Ln(head years of schooling)	0.78	1.02	-0.23	0.000	0.90	0.95	-0.05	0.294
Prop. of correct answers in arithmetic test	0.39	0.42	-0.03	0.001	0.38	0.41	-0.03	0.000
Ln(adult members size)	1.34	1.44	-0.10	0.000	1.48	1.45	0.04	0.095
Ln (child and elderly labor)	-0.09	-0.01	-0.08	0.005	0.00	-0.02	0.02	0.559
Farm union (=1)	0.38	0.50	-0.12	0.000	0.43	0.49	-0.06	0.021
Iddir (=1)	0.92	0.92	0.01	0.724	0.95	0.92	0.03	0.021
Mahber (=1)	0.60	0.42	0.17	0.000	0.35	0.44	-0.09	0.001
Senbete (=1)	0.31	0.24	0.06	0.018	0.24	0.25	-0.01	0.612
Ln(farmland)	0.29	0.56	-0.27	0.000	0.59	0.47	0.12	0.013

Source: Computed based on the 2014 RePEAT survey

Appendix Tables used in Chapter 7

Table A.12: The summary statistics for input use and yield for barley production by the sowing/planting method.

Variable	Broadcast Plots			Row planted plots			Mean diff	
	Obs	Mean	Sd	Obs	Mean	Sd	MD	P-val
Family labor hours/hectare								
Adult male	169	521.41	605.61	19	861.39	1026.7	-339.9	0.17
Adult female	169	128.77	321.78	19	444.41	1014.9	-315.6	0.19
Children	169	131.84	310.27	19	227.11	463.43	-95.27	0.39
Oxen	169	305.38	508.89	19	239.70	360.98	65.68	0.48
Hired labor (Birr)	169	197.55	781.71	19	106.08	443.39	91.47	0.44
Rental oxen(Birr)	169	153.15	824.79	19	105.26	458.83	47.89	0.70
Other inputs (Birr)	169	0.71	9.23	19	0.00	0.00	0.71	0.32
Dap (kg/ha)	168	66.19	63.95	19	88.45	70.42	-22.26	0.20
Urea (kg/ha)	168	25.78	51.55	19	20.97	27.21	4.81	0.52
Imp. seed (=1)	169	0.08	0.27	19	0.53	0.51	-0.45	0.00
Seed (kg/ha)	166	165.01	97.50	19	104.63	72.64	60.38	0.00
Org fert. (kg/ha)	168	686.96	2502.3	19	284.90	1206.0	402.05	0.24
Yield (kg/ha)	166	1277.9	834.33	19	1533.9	953.5	-256.1	0.27
Value of yield(Birr)	159	7829.3	4989.8	18	9480.3	6149.1	-1650	0.28
Crop income	158	6537.4	4799.6	18	7821.1	5901.5	-1283	0.38
Profit	158	1173.9	5641.4	18	2001.4	6715.8	-827.4	0.62

Source: Computed based on the 2014 RePEAT survey

Table A.13: The summary statistics for input use and yield for maize production by the sowing/planting method.

Variable	Broadcast Plots			Row planted plots			Mean diff	
	Obs	Mean	Sd	Obs	Mean	Sd	MD	P-val
Family labor hours/hectare								
Adult male	127	572.70	896.45	447	512.46	684.3	60.24	0.484
Adult female	127	212.73	321.26	447	283.86	813.3	-71.1	0.138
Children	127	176.69	304.69	447	219.41	627.2	-42.7	0.288
Oxen	127	196.13	349.58	447	162.53	348.8	33.60	0.340
Hired labor (Birr)	127	239.43	1329.8	447	181.33	556.5	58.10	0.632
Rental oxen(Birr)	127	59.36	468.02	447	64.16	383.3	-4.81	0.916
Other inputs (Birr)	127	0.00	0.00	447	4.50	53.64	-4.50	0.077

Dap (kg/ha)	127	26.87	57.01	447	71.35	79.20	-44.4	0.000
Urea (kg/ha)	127	9.80	32.16	447	52.00	66.56	-42.2	0.000
Imp. seed (=1)	127	0.15	0.36	450	0.65	0.48	-0.50	0.000
Seed (kg/ha)	126	34.31	23.71	447	25.38	18.76	8.93	0.000
Org fert. (kg/ha)	127	690.97	1901.8	446	416.15	1800	274.8	0.148
Yield (kg/ha)	125	2007.85	1650.4	442	2023.5	1897	-15.7	0.928
Value of yield(Birr)	122	9384.7	7591.9	431	10167.7	9314	-783	0.341
Crop income	122	8947.77	7473.9	431	8447.2	9027	500.5	0.534
Profit	122	5096.49	7613.8	430	4848.9	8624	247.5	0.759

Source: Computed based on the 2014 RePEAT survey

Table A.14: The summary statistics for input use and yield for teff production by the sowing/planting method.

Variable	Broadcast Plots			Row planted plots			Mean diff.	
	Obs	Mea n	Sd	Obs	Mean	Sd	MD	P-val
Family labor hours/hectare								
Adult male	471	609.68	781.23	42	1241.5	1308.1	-631.9	0.004
Adult female	471	235.45	1218.5	42	375.21	611.62	-139.7	0.207
Children	471	186.20	721.57	42	340.22	599.10	-154.0	0.123
Oxen	471	268.48	301.52	42	443.51	513.55	-175.0	0.035
Hired labor (Birr)	471	486.14	1301.8	42	503.37	954.43	-17.23	0.914
Rental oxen(Birr)	471	39.24	232.39	42	40.00	259.23	-0.76	0.985
Other inputs (Birr)	471	5.27	86.11	42	4.05	26.23	1.22	0.830
Dap (kg/ha)	469	76.72	65.85	42	159.66	163.76	-82.94	0.002
Urea (kg/ha)	469	44.00	55.55	42	70.16	80.84	-26.16	0.046
Imp. seed (=1)	471	0.11	0.31	42	0.45	0.50	-0.34	0.000
Seed (kg/ha)	469	44.69	30.74	42	30.76	25.85	13.93	0.002
Org fert. (kg/ha)	469	163.05	1750.7	42	190.48	1032.9	-27.43	0.878
Yield (kg/ha)	465	883.14	545.84	41	1180.0	802.16	-296.9	0.025
Value of yield(Birr)	458	10466	6573.7	41	14395.	10077.5	-3929	0.018
Crop income	457	8403.2	6086.5	41	11157	9834.23	-2754	0.085
Profit	456	3245.5	7010.0	41	784.98	12655.4	2460.5	0.226

Source: Computed based on the 2014 RePEAT survey

Table A.15: The summary statistics for input use and yield for wheat production by the sowing/planting method.

Variable	Broadcast Plots			Row planted plots			Mean difference	
	Obs	Mean	Sd	Obs	Mean	Sd	MD	P-val
Family labor hours/hectare								
Adult male	213	494.64	576.12	59	748.13	713.84	-253.49	0.014
Adult female	213	137.99	422.10	59	202.49	354.42	-64.50	0.239
Children	213	107.53	208.58	59	289.22	575.71	-181.68	0.020
Oxen	213	243.63	254.13	59	348.80	363.06	-105.18	0.040
Hired labor (Birr)	213	377.00	822.87	59	517.42	790.78	-140.42	0.235
Rental oxen(Birr)	213	49.47	338.64	59	165.15	712.53	-115.68	0.231
Other inputs (Birr)	213	0.51	6.86	59	0.00	0.00	0.51	0.282
Dap (kg/ha)	212	110.16	78.74	59	117.13	84.53	-6.97	0.571
Urea (kg/ha)	212	78.16	88.70	59	65.75	52.54	12.41	0.177
Imp. seed (=1)	213	0.21	0.41	59	0.44	0.50	-0.23	0.001
Seed (kg/ha)	213	160.36	74.99	59	149.99	106.60	10.38	0.485
Org fert. (kg/ha)	212	502.78	2876.0	59	771.52	2977.4	-268.74	0.538
Yield (kg/ha)	211	1487.8	893.41	59	1976.9	1344.4	-489.08	0.01
Value of yield(Birr)	210	11287	7085.1	58	15203	10474	-3916.7	0.009
Crop income	209	8517.2	6526.5	58	12405	10009	-3888.4	0.007
Profit	208	3248.4	7727.7	58	5410.2	11193	-2161.9	0.171

Source: Computed based on the 2014 RePEAT survey

Table A.16: The balancing test results before and after matching by row planting adoption status.

Variables	Before matching				After matching			
	Control	Treated	Mean Diff.	P-val.	Control	Treated	Mean Diff.	P-val.
Head sex (=1)	0.86	0.92	-0.06	0.000	0.90	0.92	-0.01	0.471
Ln(head age)	3.86	3.81	0.06	0.042	3.82	3.80	0.02	0.484
Ln(head years of schooling)	0.78	1.10	-0.32	0.000	0.98	1.18	-0.21	0.002
Prop. of correct answers in arithmetic test	0.40	0.42	-0.02	0.003	0.45	0.42	0.03	0.000
Ln(#adult or 15-64 age size)	1.38	1.44	-0.06	0.005	1.45	1.44	0.01	0.756
Ln (half of the# 11-14 & 65-75)	-0.04	-0.03	-0.01	0.627	0.08	-0.02	0.11	0.003
Ln(self emp incom)	5.58	5.76	-0.19	0.166	5.90	5.82	0.07	0.668
Ln(income from remittance, aid,)	4.96	4.91	0.06	0.680	5.29	5.01	0.28	0.105
Ln(livestock value)	9.52	9.12	0.40	0.001	9.41	9.18	0.23	0.103
Ln(assets value)	7.92	8.17	-0.26	0.002	8.16	8.29	-0.12	0.235
Ln(farmland)	0.57	0.36	0.22	0.000	0.97	0.97	0.00	0.691

Source: Based on the 2014 RePEAT survey in Ethiopia.

Annex 1 <u>Definition of behavioral variables</u>

The risk and time preference measures, which are obtained from hypothetical games, are controlled because farmer's attitudes towards risk and time value are found to be important factors affecting farmers' choices (Tanaka and Munro, 2014). Multiple price list questions were asked for respondents to make choices. The hypothetical game for time value was between choosing different size money at present and future periods: between today and a month later. The first game was to ask farmers to choose either the amount of money today or a month later for each of the three alternatives. The lists were 200 birr today versus 200 birr a month latter; 200 birr today vs 300 birr a month later; and finally, 200 birr today versus 400 birr a month later. The myopic takes a value "1" for farmers that that always choose to receive the money today in all of the three alternatives, takes a value

"0.75" if the head chooses to wait a month only after the size increases to 400 birr, and it takes a value "0.25" if the head accepts 300 or more to wait for 1 month, and "-1" if the farmer waits to choose 200 birr after one month than receiving 200 birr today.

They were also asked a similar hypothetical game but with different timing for the payment. Instead of the today versus one month later option, the game was changed into receiving money after 6 months versus receiving money after 7 months. This is used to capture present bias. Some may be impatient to receive money today than any time in the future but they may be less impatient if both options are in the future. These differences are captured by using a dummy variable that takes a value "1" if the heads wait 7 months and receive larger money than waiting 6 month for small money and “0’ otherwise. Some households did not participated in the time preference game and a binary variable that takes "1" if she participated in the game and "0" otherwise is controlled to account for this issue. The time impatience (higher time value) is expected to have a negative coefficient on row planting adoption because impatient heads might be more concerned about present leisure and consumption that the returns after some period with more expenditure and labor efforts.

The risk attitude of heads is also captured through hypothetical risk games. The respondents were confronted with three set of 50-50 gamble (one sure outcome and two risky outcomes). The sure outcome is 100 versus 100 Birr, the first risky outcome is 200 versus 50 Birr, and the third risky is 300 versus 0 Birr. Each respondent was asked to select the most she preferred from the three gambles. I followed Engle-Warnick, Escobal and Laszlo (2006) strategy to construct a risk measure variable. The risk-lover variable gets a value “2” if the farmer chose the most risky choice (300 vs. 0), and a value “1” if the farmer chose the second risky (200 vs. 50), and it takes a value "0" if she go for the sure pay off (100 vs. 100). There are some farmers who were not willing to play the game, and a variable which take a value “1” for participants of the gamble and which takes value “0” for the non-participants of the gamble was controlled to account for the differences between participants and non-participants. Finally, the heads numeracy skill is measured by the proportion of correctly answered questions out of six numeracy skill test questions.