MEKELLE UNIVERSITY
COLLEGE OF BUSINESS AND ECONOMICS
DEPARTMENT OF ECONOMICS

ECONOMIC ANALYSIS OF SMALLHOLDER VEGETABLE PRODUCTION IN TIGRAY, ETHIOPIA
A CASE OF IPMS'S ALAMATA WEREDA PILOT LEARNING PROJECT

BY
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A THESIS
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Declaration

This is to certify that this thesis entitled "Economic Analysis of Smallholder Vegetable Production in Tigary, Ethiopia. A Case of IPMS's Alamata Wereda Pilot learning Project" submitted in partial fulfillment of the requirements for the award of MSC in Economics (Development Policy Analysis) to the college of Business and Economics, Mekelle University, through the department of Economics, done by Mr Gebremeskel Berhane, ID.No FBE/PR0076/00 is an authentic work carried by him/her under my guidance. The matter embodied in this project work has not been submitted earlier for award of any degree or diploma to the best of my knowledge and belief.

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Abstract

To examine the determining factors on smallholder vegetable producers' adoption decision to use the new agricultural technology or not, and to interpret the smallholder's response to this new technology adoption decision in relation to the determining factors, this thesis involves the robust logit model estimation, and elasticity after logit model estimation. To see the impact of the project intervention in the pilot learning Wereda and the trend of vegetable production starting 2004 to 2009 in the area, Heckman treatment effect model and descriptive statistics are estimated (used) respectively. In the robust logit estimation, the study found that education level of the respondent, water sources accessibility, household land holding size, access to credit and households with no experience to employ man labor to their farm activity revealed positive effect while age of the household head, distance of the farm area from the local market (Alamata) and the practice of renting in land for producing vegetable output revealed negative effect on new agricultural technology adoption decisions.

The Heckman treatment effect estimation robust our principal hypothesis where our principal hypothesis is project participation has positive effect on the profitability of the project participant and in return this profitability can affect the utility of the smallholder positively which is basically assumed as impact of the project. Besides, membership of any association or farmers' cooperatives, farmer's future output market price expectation, being married or coupled and male sex variables indicates positive effect on profitability of the smallholder vegetable producer.

Keywords: new agricultural technology, adoption decision, smallholder, vegetable

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Table of content

Acronyms

CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo
CSA	Central Statistics Authority of Ethiopia
DCG	dry lands coordination group
IDB	Inter-American Development Bank
ILRI	International Livestock Research Institution
IPMS	Improving Productivity and Market Success
M.a.s.l	Meters above sea level
MoARD	Ministry of Agriculture and Rural Development
REST	Relief Society of Tigray
s/he	stands for she or he
WBoARD	Wereda Bureau of Agriculture and Rural Development

List of Tables

Chapter I: Introduction

1.1 Background of the Study

Ethiopia is a country with favorable climatic condition for growing different cereals and vegetables. But irrespective of these comfortable conditions, the country suffers through different challenges typically famine as a result of recurrent drought and food insecurity due to lack of enough domestic food consumption supply (Akalu, 2007). Vegetable production can be seen as one best solution to provide food supply to the growing food, especially vegetable consumption, demand in the country (Akalu, 2007). Because the country has promising resources like land with its comfortable climatic condition, to some extent, fertile soil contents and huge unskilled but able and till trying to produce vegetable output with backward hand tool, the country can have these comparative advantages when compared to neighboring and the rest of the world especially the middle east and Europe through producing that item at enough amount of domestic supply and of course with the orientation of export when there exist excess product than the domestic demand (Akalu, 2007)

Vegetable is a plant or part of a plant that is eaten as food; potatoes, and onions are among others. Broadly, vegetables can be categorized as Root vegetables for example carrots, Green vegetables like cabbage, and vegetables oils. Alternatively, vegetables can also grouped as leaf, root, tuber, bulb and fruit vegetables (Fekadu, Dandena, 2006).

Vegetable crops make significant contributions to the Ethiopian households and national economy. Potato and Sweet Potato are valuable food security crops for densely populated highland regions and drought prone areas respectively. Vegetable like hot pepper and onion are also used for flavoring local dishes and as well important as sources of vitamins and minerals which indicates that a considerable proportion of Ethiopians could derive their livelihood from growing vegetable (Fekadu and Dandena, 2006)

It is evident that these type of production needs large scale capital and expertise mobilization which is of course the major bottleneck for developing countries like Ethiopia. Although Vegetable production is practiced both in commercial enterprises and smallholder farmers, the later is taking the lion's share on production and its supply to the local consumers and traders.

Smallholder vegetable producers in the study area are farmers who produce and supply their vegetable produce with the traditional farming technology and traditional marketing system with incomplete market (market price) information and low price bargaining power. As a result, contrary to the expected benefits from vegetable output, smallholders are less beneficiaries of this type of production due to some reasons perhaps lack of modern farming technologies like adopting new farming system, productive organic and chemical fertilizers, extension consulting agents, knowledge of land use management, providing market information, providing transport facilities, store, infrastructure especially road. To this regard, projects aiming at solving such bottlenecks of Ethiopian smallholder vegetable producers become mandatory. The International Livestock Research Institute (ILRI) and the Ethiopian Ministry of Agriculture and Rural Development (MoARD) initiated a five year project intervention in June 2004. This project named as Improving Productivity and Market Success (IPMS) of Ethiopian farmers aims at contributing in poverty reduction of the rural poor through market oriented agricultural development (IPMS Team, 2004) is financially backed by the Canadian International Development Agency (CIDA).

This paper is intending to assess the basic motivating factors of these smallholder vegetable producers to adopt new agricultural technology introduced by the project. Besides this, the paper is also giving emphasis on some discussions whether the project is achieving its pre designed target or not will be final of this paper.

1.2 Statement of the Problem

As explained in the introductory part above, vegetable production plays the major role in food security of rural Ethiopian peasants and indeed supporting to the foreign currency earnings. As faced by capital and technology constraints and of course market access which can affect the smallholders' current and future outputs, smallholder vegetable producers farm output is insignificant compared to other producers in the nation which is contrary to the prevailing domestic as well as export demand and the need of food security.

To bring the countries smallholder vegetable producers self sufficient and beneficiaries from this area, it is commonly agreed that huge amount of capital with enough technical expertise regarding to market access like market prices information and adopting new technologies are mandatory. To this aspect, different government and non-government projects are designed and implemented and are yet on the way to be implemented though they are with their own complications and problems. These types of projects are financially backed broadly from two sources; namely, local sources including government and foreign soured projects. ILRI is one of the institutions activating in such livelihood improvements in Ethiopia. That is, it is engaged in implementing different projects in different areas or pilot learning Weredas[1] in Ethiopia. Alamata is one of the pilot learning Weredas; It is a place where fertile arable land and excess working force available. At Alamata, ILRI and MoARD are making interventions on smallholder production especially with the technical expertise starting from producing marketable output up to market search giving due emphasize to smallholder vegetable production. But, it is not surprising to raise some questions about the feasibility and impacts of these types of projects because projects are accompanied with different problems such as challenges by farmers to adopt a new agricultural technology quickly due to different circumstances probably due to household level of education, experience of farming, household asset holdings, land size, religion, price fluctuations of their produce etc. Hence, there is a need of identifying which household's characteristics is the obstacle and to what extent it hinders to accept the new agricultural technology which in turn is helpful to take actions on giving public awareness about the new technology. Because producers are motivated with better price of their output to produce more, price of the agricultural produce is the significant determinant of output but to what extent the output is affected by price response of the producers is another hindrance and of course invites for better market search. Here, the paper is going to deal with price and producers response to price in relation to their output. Finally, making interventions in a particular economic area can result either positive or negative effect to the intended beneficiaries that really needs impact assessment which indicates whether the objective of the project is achieving or not.

1.3 Research Questions

To this regard, research questions can be designed as:

- Do smallholder farmers characteristics have an effect on adoption of new agricultural technology?

1. Wereda is an administration unit greater than Kebele where kebele is the smallest unit of administration.

- What other possible factors determines the adoption decision?
- Does this intervention by ILRI and MoARD in the name of IPMS really bring some socio-economic impact on the project participant smallholder vegetable producers?

1.4 Significance of the Study

As the researcher tried to explain the importance of project intervention above, allocating large amount of resource to such public as well as private project evolution is mandatory, that is, in order to identify the benefits and weakness thereby to enhance such intervention for the promising result and take corrective measures for the poor result of the intervention, spending an amount of money on project evaluation is crucial. This paper is going to be helpful enough to indicate some of the explanatory variables that might encourage or discourage farmers for producing more using new agricultural technology. Because much of the studies done in the area had been focusing on market chain and market related problems, this study is going to provide indications on what factors are affecting farmers agricultural technology adoption, and finally, the study will confirm the either impact of the project which will be helpful to policy making and further implementation.

1.5 Objective of the Study

1.5.1 General objectives: this study is to analyze the over all effects of the intervention by IPMS and MoARD on smallholder vegetable producers in Alamata pilot learning Wereda.

1.5.2 Specific objectives: Critically the paper is designed:

- To examine some economic and social factors that can have determining effect on decisions to adopt new agricultural technology.
- To examine the household characteristics on new agricultural technology adoption decisions.
- To see whether the intervention have socio-economic impact on smallholder vegetable producers in that particular study area.

1.6 General Hypothesis of the Study

The data which is collected from different sources, as it is explained in the data source part, is tested to the following comprehensive hypothesis.

1.6.1 Technology Adoption:

Modern farming system achieves the productivity of resources like land and labor. In this case, the intervention regarding new technology or better farming like irrigation, improved land management including soil conservation, extension agent support, using better seed are important ingredients for better output.

H_0: Smallholder's characteristics and other socio economic explanatory variables have no effect on technology adoption.

1.6.3 Impact on producers

H_0: The project intervention by ILRI and MoARD named as IPMS in Alamata pilot learning Wereda has no any economic and social impacts on project participants

1.7 Scope of the Study

Regarding time and area coverage, the study is limited to the project intervention made by ILRI and MoARD in the pilot learning Wereda Tabias of Alamata, southern part of Tigray region, Ethiopia. More over, it is restricted to the smallholder vegetable producers in that project with due emphasis to the smallholder vegetable producers technology adoption, and impact of the interventions on the smallholder producers.

1.8 Organization of the Thesis

The remaining part of the paper is containing four chapters at which the second chapter is designed to assess the related literature review mainly related to agricultural technology, adopter and adoption and main concepts of impacts. The third chapter is about the methodology and data source where the main objectives' methodologies are provided. Here, economic model for the logit and elasticity of the smallholder's to adopt the new agricultural technology are provided. The fourth chapter consists of results and discussion of the objectives designed above. In this chapter the logit estimation results and the elasticity estimation after logit are provided to the first objective which is identifying the determinants of smallholder's technology adoption decision and the response of the smallholder to these determining factors for decision. The Heckman treatment effect model for the impact of the project participation taking the net profit of the sample households as dependent variable (continuous variable) is going to be estimated and its model specification is provided in this chapter. Finally, some limitations, the concluding ideas and recommendations are provided in chapter five.

Chapter II: Review of Related Literature

2.1 Context of Peasant Production

Peasant society emerged as largely self-regulating to cope with geographic isolation, exclusion from the political system, exploitative market relations, regressive taxes, and the virtual absence of state investment in the rural sector (Smucker et al, 2006). In many of the rural society, peasants create a complex network of local institutions to ensure social security and channel access to land, labor, and capital.

Historically, peasant agriculture has been Ethiopian's primary economic activity. An estimated 83.9 percent of Ethiopia's population is living in rural areas (CSA, 2008). Most farmers in Ethiopia are peasants with farm units composed of several dispersed field plots.

Land, labor, and social relations are the most important assets of the household economy. Peasants actively manage kin ties, fictive kinship relations and other special relationships as social capital that can be leveraged for access to land, labor and capital (Smucker et al, 2006). Cash resources are extremely scarce; farm strategies tend to be labor intensive. Land is the most significant tangible asset and serves as a powerful fulcrum for access to labor and capital resources. Farmers are acutely aware of micro-site variations, such as topography and soils, and actively diversify land portfolios and cropping patterns to manage risk and spread out harvest cycles, some times they may leave a farm plot free for one harvest season to make the land more fertile locally called 'Tsigee'. As a strategy for survival, most peasants tend to focus on reducing risk rather than maximizing production. Managing a peasant household's stock of social capital is the key element of this strategy.

The agricultural sector is not significantly capitalized and there is limited public investment in rural infrastructure. A shortage of off-farm employment opportunity heightens the extent of rural poverty. Despite recent efforts to decentralize and democratize the economy and the state, reform efforts have yet to make a palpable difference in rural areas.

2.2 Agricultural Profit and Technology Adoption

Farmers' decisions to adopt a new agricultural technology in preference to other alternative (old) technologies depend on complex factors as explained above. One of the factors is farmers' perception of the characteristics of the new technology vis-à-vis that of the existing (old) technology. Other factors which influence farmers' adoption are the conventional (traditional) ones: resource endowments; socio-economic status; demographic characteristics; and access to institutional services (extension, input supply, markets, etc) (Negatua and Parikh, 1999). Studies on the effect of the conventional factors on adoption are extensive and numerous. The role of farmers' perception in adoption decision is, however, scarcely studied (Adesina, 1995). Adesina (1995) have demonstrated the impact that farmers' perceptions of the characteristics of different varieties (food quality, yield, tillering capacity, etc) have on the adoption of modern rice varieties. This is a useful dimension to look for ways of facilitating farmers' gains in perception of the real characteristics of new technologies, and to identify factors that make differences in perception formation among farmers. Awareness of the factors that influence perceptions would also facilitate the enhancement of the development and transfer of appropriate technologies.

Productivity is one of the two fundamental sources of larger income streams; the other being savings, which permit more inputs to be employed.

Here, the farmers perception yield characteristics is an indication that farmers tend to know the profits they may earn from the new varieties and the old ones.

Cost of producing vegetables and associated gains in terms of yield and profit are compared with the cross comparison group of cereals.

Important cost parameter in this calculation is the unit cost of production which determines the decision to continue production or not when it is compared to the unit revenue.

2.3 New Agricultural Technology, Adoption and an Adopter

2.3.1 New Agricultural Technology:

On the basis of different societal circumstances, the concept may be differently approached by different scholars. For instance, new agricultural technology for advanced economies connotes the concept with advanced and commercialized farming technologies, or farming machineries while the backward economies, it is usually understood as primary farming technology improvements like the uses of fertilizer, pesticides, improved seed, Cross-bred cows, and other livestock improvements, exploiting the underground and surface water potential using irrigation etc. that is, intentionally undertaken to achieve the food security through different program interventions (Yohannes, 1993). Similarly, the researcher is to mean the new agricultural technologies in the less developed economies. Specifically, the new technologies here are using fertilizers, improved seed, technical support like planting, and post harvest protection of the vegetable using chemical ingredients.

2.3.2. Adoption: Many careful analyses of adoption studies, particularly comparisons among the studies, suggest that there are a number of ways to improve micro-level analyses. Most adoption studies (Doss, 2003), use a formal analytical model. The basic approach is usually, $A=f(X)$, where A is the measure of adoption and X is the set of explanatory variables. Often the adoption of more than one technology (for instance improved variety seeds and fertilizer) and, thus, a system of adoption equations are modeled.

Here, careful attention to the variables included (and justification for both those that are included and those that are omitted) will make analyses more useful to policy makers and agricultural researchers. In this regard, the study focus on some widely used variables, alternative relationship specifications, and the interpretation of results from econometric estimations.

Finally, the study can assume that it is rare for social scientists (researchers) to have variables that exactly measure what the study most interested in: most variables the study uses are good approximations at best. Defining and interpreting results obtained from using variables that may be perfect proxies is key to obtaining useful conclusions from adoption studies (Doss, 2003)

2.3.3 Who is an Adopter?

One basic question this study brings out is defining what is meant by an “adopter” of a technology. The definition of adopter varied across different studies. What exactly is an adopter? This proves to be a complicated question with no obvious, correct answer (Doss, 2003).

In defining adoption, the first thing to be considered is whether adoption is a discrete state with binary variables (a smallholder farmer either is an “adopter” or is not) or whether adoption is a continuous measure. The appropriateness of each approach may depend on the particular context. In this concept, a smallholder farmer is defined as being an adopter if s/he is found to be growing any improved materials, which is a dummy variable. Thus, a farmer may be classified as an adopter and still grow some local materials. This approach is most appropriate when farmers typically grow either local varieties or improved varieties. If the exciting aspects of adoption are situations where farmers are increasingly planting more land to improved varieties while continuing to grow some local varieties, then a continuous measure of adoption is more appropriate. Defining adoption may be further complicated by the complexity of defining the technology being adopted. Since the definition of adoption encompasses a wide range of dissimilar practices, the results from different studies with different context of adopter are not comparable. Studies should state explicitly how terms are used. Where the full range of farmer behavior is not known *a priori*, it may make sense to ask farmers for detailed information. The researcher can then create an appropriate adoption measure using the detailed data used (Doss, 2003). Since many farmers grow more than one variety, measures of the proportion of land planted to improved materials are often used; this type of measure does not lend itself easily to more than one definition of “improved materials.” Collection of detailed data would also allow the creation of measures of adoption that are comparable across studies. Finally, in defining an adopter, researchers may also be interested in farmers’ histories of technology use. To develop such histories, researchers must ask not only whether a farmer is currently using a particular technology, but also whether he or she has ever used it. This helps to distinguish farmers who have never tried a technology from those who have tried it and discarded it.

Given the complexity of adoption measures and the potential value of having compatible measures of technology adoption across studies, it would be valuable for this study specifying the adopter as a farmer who compares her/his profits from adopting the new technologies explained above and profits from the traditional farming system. If her/his profit from producing the vegetables using the project support is greater than the profits she/he earns from the traditional farming (farming out of the supports by the project), she/he logical adopts the better farming known as adopter, while the other is considered as non adopter.

2.4 Agricultural Technology Adoption in Ethiopia

For most of the world's poorest countries, and especially those in Africa, agriculture continues to offer the leading source of employment and to contribute large fractions of national income. In many of these countries, however, agricultural productivity is extremely low. Clearly, increasing agricultural productivity is critical to economic growth and development. In many of these countries, degradation of agricultural land continues to pose a serious threat to future production potential and current livelihood of the peasant households (Beyene, 2008). Ethiopia is one of the poor countries on earth and the country is heavily dependent on peasant agriculture which is commonly produced with traditional farming system that usually results extensive agricultural land degradation and thereby causes low agricultural productivity. According to Beyene, 2008, in the last two decades, per capita food production has been lagging behind the rates of population growth, and food shortage and rural poverty have become chronic problem in the country. The challenge that Ethiopia is currently facing is to achieve food security using introducing and dissemination of yield enhancing technologies, and at the same time to slow or reverse the trend in agricultural land degradation to ensure sustainability of future agricultural production.

Besides, Ethiopian farmers have the experience of producing an output with what is called subsistence farming type. For the improvement in both the productivity and market led production in the agricultural farm, introducing new agricultural technologies had been devised and still is considered as best means of reducing the miserable poverty here in the nation.

Technology adoption has been seen as key to the development of more productive agriculture in lesser developed countries. But the adoption and adaptation of new agricultural technology occurs at the level of farm families where decisions are made based on perceived opportunity costs or risks and benefits of the new technology, and its fit within the knowledge and practices of existing agricultural system (Kebede, 1993)

Yesuf and Köhlin (2009) have tried to investigate the impacts of market and institutional imperfections on technology adoption in a model that considers adoption of fertilizer and soil conservation as joint decisions. Controlling for plot characteristics and other factors, and they found that a household's decision to adopt fertilizer does significantly and negatively depend on whether the same household adopts soil conservation. The reverse causality, however, is insignificant.

According to Yesuf and kohlin, there are also outcomes of market imperfections such as limited access to credit, plot size, risk considerations, and rates of time preference as significant factors explaining variations in farm technology adoption decisions. Relieving the existing market imperfections will most likely increase the adoption rate of farm technologies.

Other studies still focusing on traditional and new technology adoption decisions, several factors that reflect personal, physical, economic, and institutional elements were identified on an informal basis, and analyzed separately in a single equation model. From an econometric point of view, a single equation estimation approach could cause bias, inconsistency, and inefficiency in parameter estimates if simultaneity in decision is detected and/or unobserved heterogeneities are correlated for these decisions (Greene, 2000). It also obscures the possible inter-linkages and synergies that might possibly exist between the different forms of technology adoption decisions. In the context of simultaneous estimation of several adoption decisions, it becomes possible to uncover interactions that can be extremely useful in attempts to manipulate the adoption process. For example, it might be the case that a farmer is more likely to compare the traditional farming habit and the new agricultural technology and adopt the later if the traditional farming system is perceived to give less benefit. These results, if forthcoming, would suggest that extension work might concentrate more on new agricultural technology adoption, since the new technology use is more likely to follow. It might also be possible that a farmer would abandon one of the farming systems in favor of the other even if adopting both at the same time could be more beneficial in production. This could happen when the farmer faces a binding resource or liquidity constraint in his/her investment decisions. These results would suggest that resources and efforts should be geared towards relieving some of the constraints so as to reap potential gains from the new agricultural technologies and the existing farming habits (benefit from complementarities), with giving due emphasis to farmers innovation. Those smallholder farmers who produce vegetable (in this case like Tomato, Onion, Pepper) produce follows the same pattern of comparisons between the new farming system of vegetable and the way they are producing traditionally and the farming system of other cereals. But, as to the researcher's knowledge, particularly to the research area, there is no work or analysis which can indicate whether a smallholder decide to adopt or not based on the comparison of profits from both adopting and not adopting. Here, assuming all the knowledge of new farming systems and market issues appropriate, smallholder farmers can compare their benefit being producing with either of the farming technologies and thereby decide.

2.5 Agricultural Technology Adoption Constraints

As sited by Zeller et al (1998), different studies were conducted on comprehensive literature survey on adoption of agricultural innovations and they list factors that have been frequently identified as being influential in determining the adoption of an agricultural innovation. These include: (i) farm size, (ii) risk exposure and capacity to bear risks, (iii) human capital, (iv)Labor availability, (v) credit constraint, (vi) tenure, and (vii) access to commodity markets.

There are factors that hinder the production of horticultural products in the study area. The majority of the sample producers indicate pests, drought, and shortage of fertilizer and price of fuel for pumping water for irrigation as major constraints of horticulture production (Emana and Gebremedhin.H, 2006). They showed that the proportion of sample producers ranking the constraints as the top three problems affecting the production of the specified crops. The problems, according to them, are some times specific to certain vegetables. For instance, most farmers indicate that shortage of fertilizer, diseases, and frost are the most priority problems of producing Potato. On the other hand, fertilizer, pests and diseases, and shortage of pesticides are top constraints of production of Beetroots and Carrots. Furthermore, they noted that water shortage or drought on the one hand and lack of fuel for pumping irrigation water, frost and fertilizer shortage are most important problems of Onion production, which is also location and season specific.

The horticulture production study that was conducted in the eastern part of Ethiopia is based on a tradition than on scientific recommendations (Emana and Gebremedhin.H, 2006). Similarly, the farming habit of the pilot learning Wereda (Alamata) is dominantly based on the traditional farming culture than the scientific production. Although one can associate this constraint to institutional factors, it is apparent that inadequate farmers' skill and knowledge of production and product management affects the profitability of the farmers. According to Emana and Gebremedhin.H, 2006, the traditional thinking determines the selection of varieties, crop management, adoption of technical recommendations, etc. Farmers' know-how of product sorting, grading, packing and transporting is traditional, which severely affect the quality of horticultural products supplied to the market, in fact similar to our observation in Alamata.

Besides those constraints discussed above, institutional factors such as provision of improved horticulture production technologies including supply of relevant varieties, agronomic practices and improved product management techniques are observed to be significant determining factors of vegetable production. Many studies reveal that the farmers are not getting the right varieties they wish to cultivate. Institutions failed to bring up the farmers capacity to the expected level of farmers output. Research based practical recommendations on agronomic practices and pre- and post harvest management are lacking at farmers level (Zeller et al (1998))

Institutions like the marketing agency should also make information needed for the farmers to assist planning of production for the immediate seasons. The data available at the farm level should enable forecasting of demand to adjust production planning. According to Wereda documentation, 2009, the extension system lacks highly qualified staff at *wereda* and field level which is, for example, 4 field workers (extension agents) to 1581 households in Gerjele Kebele in Alamata Wereda.

Natural factors such as rainfall, water supply, flood and pests are often beyond the control of farmers and institutions. There is a shortage of irrigation water mainly in the low land areas. Yet, contingency planning and forecasting of the events which may help to minimize the effect is not available. Moreover, appropriate management system including variety selection and diversification would reduce the effect of natural factors.

Infrastructure such as rural roads and means of communications for efficient flow of goods and market information is a limiting factor (Emana and Gebremedhin.H, 2006).

2.6 Impact Related Ideas

Public support for technology adoption in the rural sector is usually defined as an agricultural extension service. For this study extension services is define as a system and a set of functions that may induce voluntary change in the rural sector. The system includes private, public and semi-public agents and the functions could be transfer of knowledge, information, technologies or managerial capacity. Overall, the aim of these types of services is to provide technical education to farmers or foster the flow of information between farmers and technology providers.

The evaluation of the impact of this type of services in the last years can be divided in four groups (Gonzalez et al, 2009).

The first includes studies that analyze the effect of extension services by estimating production functions which include extension as an input. This approach, however, assumes that farms operate at an efficient level– which is likely due to the market inefficiencies that justify public intervention – and that there is a random assignment between controls and treated groups. The latter is rarely the case given that treated producers have, on average, different characteristics from controls. Thus, the results of this type of estimations could be biased by the observable and unobservable characteristics that might affect participation and the relevant outcome variable.

The second approach tries to overcome the problems of the production function technique by controlling for the observable variables available in the data. As Heckman (1979) explains, this correction reduces the estimation bias. One alternative would be regressed the outcome variable in a participation dummy and control for the observables (assuming they are the only ones that may affect the outcome). Other alternatives include the construction of a counterfactual of the experiment by surveying non-participant farmers and compare them with the treated through matching techniques.

For example, Gebregziabher, G. (2008) evaluated the impact of access to irrigation on household income. Gebregziabher, G. (2008) presents the non-parametric matching estimates of the average treatment effect of access to irrigation on the treated (ATT) and found a significant estimation result, that is, access to irrigation have a positive effect on the overall average household income generated.

The third body of literature utilizes a panel data approach to remove time invariant unobservable (e.g., farmers' skills or efficiency). A complete impact evaluation is offered by Gautam (2000) (as cited by Gonzalez et al, 2009) for the National Expansion Project I and II programs that were funded by the World Bank in the agricultural sector of Kenya. The extension services offered included trainings for farmers and visits. This complete impact evaluation develops a fixed effects estimation finding no evidence of a significant impact of the current extension system on farmer efficiency or crop productivity. One of the most interesting conclusions according to Gonzalez et al, (2009) is that there was a need for more efficient targeting given that many treated farmers did not need the technologies or could have implemented them without funding.

Specifically, the authors utilize a fixed effects panel model and a stochastic production frontier approach. Results from both models show that having contact with the advisory services through either a visit or a training course is significant in explaining the efficiency levels of farms.

Finally, the fourth group of studies deals with the time-variant unobservables using instrumental variables. For instance, Akobundu et al. (2004) utilize measures of access to extension services as instrument for program participation given that it is not related with the income of farmers (i.e., outcome variable). They found that the program had a positive impact on farmers' income only for the case of multiple visits from technical advisors.

Overall, two conclusions can be obtained from the revision of the literature. On the one hand, the choice for the adequate estimation technique that should be used in each case depends on the available data. Absent a well-thought experimental design, the ideal scenario would imply using panel data or a good instrument to control for biases generated by observable and unobservable. Yet, this type of data is rarely available for the agricultural sector. For cross section data the most recommended methodology is propensity matching score, however, this technique does not control for biases generated on the unobservable. On the other hand, results of the different evaluations suggest that the direction and magnitude of the impact of extension services depends of the type of intervention, on the characteristics of the market and on the producers.

Chapter III: Data Source and Research Methodologies

3.1 The Study Area Description

Alamata Wereda is located 600 km north of Addis Ababa and far 180 km south from the Tigray Regional capital Mekelle (IPMS, 2005). It is found in the southern Zone. Its broader is surrounded by Amhara region from the south and west and Afar region from the east, Korm and Mokohoni Weredas in North West and North respectively. The number of agricultural households of the Wereda is 17,597. The total population of the Wereda was 128,872 in 2003/04(IPMS. 2005). Altitude in the area ranges from 1178 to 3148 m and 75% of the woreda is low land (1500 masl or below) and only 25% is found in intermediate highlands (between 1500 and 3148 masl). The small mountains surrounding the Wereda are very steep and with low vegetation cover. These mountains cover a large area and drain to the Alamata valley. The mountains surrounding Alamata cover a large area and have a series of dissected gullies which serve as a source of runoff water to the Alamata valley. The gullies join together and form rainy season rivers down the foot of the mountains. The dissected channels slowly spread over the valley depositing silts and water down to the valley (IPMS, 2005).

The fine silt which is deposited in the low land is relatively fertile and the water becomes a source of supplementary irrigation. The Alamata valley is one of the most agriculturally potential area in the Tigray(IPMS, 2005). Farmers in the Wereda extensively cultivate cereals and vegetable; and raise mainly sheep and cattle in the valley.

Water source for these farm productions is from river diversion, flood, ponds, hand dug well, and 'Horeye'. According to the survey made by REST, the area is rich in underground water.

The 'belg' (short rains) is from January to February and 'Meher' (long rains) from July to August. In this area both the short and long rains were below average. Reliability of rainfall is increasingly becoming so low year after year so that crop production is affected significantly. The short rains are used for land preparation for the main rainy season and also for growing grass for livestock. In addition, it is also used to grow vegetable seedlings in areas where irrigation is not available. The main rains are not also reliable because the rains do not last long enough for supporting crop growth. In the old days, the big rain usually used to start in April at which time farmers would plant sorghum (which lasts for 8 months) and harvest it in November. Farmers in the area still exercise the planting of the long seasoned sorghum but with difficulties of obtaining good harvest. Even if the crop does not fail totally because of the crop's drought tolerance, yield is substantially low. On the other hand, rainfall in the midlands is slightly reliable but because of poor soil fertility and shallow soil depth, productivity is also very low (IPMS, 2005).

The lowlands of Alamata Wereda are surrounded by a chain of mountains from the east, west and partly north. As a result of this even if sufficient rainfall is not received in the valley, rainfall from the surrounding mountains become the main sources of supplementary irrigation.

Teff and sorghum are the dominant crops covering around 75% of the Wereda cultivated area.

The total area of the Wereda is estimated at 550 sq. km. However, the total area based on a digital data obtained from IPMS GIS Unit is 725.39 sq. km(as site in the IPMS, 2005).

Shortage of rainfall (moisture stress) is a major constraint of agricultural production in the Wereda. Rainfall is usually intense and short duration. The average annual rainfall for 8 years (1995 to 2002) was 831 millimeter per year (IPMS, 2005) with high variability ranging from 498 in 2001 to 1429 millimeter in 1997. Under normal conditions rain starts around the last days of June. Alamata experiences bimodal rainfall, but since recently the rain fall pattern has change in which the main rain fall starts at around the mid August and stops soon after and the small rain is very uncertain(IPMS, 2005); as a result the Wereda became one of the drought prone Weredas.

In the Wereda, there exit large population of Livestock resource mainly, Cattle, Ship, and Goats. Like in any other parts of the country, livestock productivity is low (IPMS, 2005). These livestock are of the main input factor where Oxen provide almost the entire burden of farming power.

The Wereda is located at the main road Mekelle – Addis Ababa. It has diverse road network access connected with three market potentials in the area. One to the Kobo Wereda, Amhara region which is south way from Alamata and the other two are to Korem and Mokohoni Weredas. These networks of roads make Alamata's output market more accessible than other Weredas in the Zone. The crowded of huge trucks parking and passing through the town is an evidence that the town has market access advantage.

Frankly speaking, most rural Kebeles of Tigray are very much remote in a sense they lack infrastructural facilities. Unlike these Kebeles, most of Alamata's kebeles are near the main roads and some of them have an electric power and communication access through cellophane. Transport facilities are better when compared to other kebeles; the road networks are better as explained above. And hence there is regular mini-bus and medium bus transport services to all direction from the town.

Main focus of the project by IPMS and Wereda Agriculture office is supporting the farmers of the Wereda to produce marketable agricultural output through connecting their produce to the potential markets.

The main stakeholders in this project are the Wereda office of Agriculture with its all kebele staffs, ILRI and CIDA and the farmers them selves.

3.2 Data Source and Methods of Data collection

The data which is tested against the basic hypothesis is colleted mainly through questionnaire in three Tabias in the pilot learning Wereda both from the program participants and none program participants by employing some interviewers. Besides, important information is gathered from MoARD's extension agents staff and some prior documents or collected data from the same office is the sources of the data particularly for some discussions.

The questionnaire is designed to be more closed type questions so that it enables to have specific answers to specific research objectives.

The sampling procedure is principally made based on the researcher's disposal on time and financial budget. The Wereda has fifteen Tabias. Of these, five Tabias are located in the highlands of the surroundings known as 'Dega' climate setup where the experience of vegetable production is uncommon. Ten Tabias are the low land 'Kola' climate environment part of the Wereda where vegetable production is commonly practiced.

As a result, of these ten Tabias, where this type of production is adapted by farmers in that pilot learning Wereda, the ones which are easily accessible in terms of their distance from the main road (asphalt road), distance from market, intensity of information, those three Tabias, namely, 'Gerjele', 'Tumuga', and 'Kulu Geze Lemlem' are selected. From 80796 or (17,564 household) (WBOA, 2009) total population of the rural inhabitants, 5800 households are participants in the vegetable production under the program by ILRI and WBOA and the remaining households of these rural Tabias are not participating on the program. Here, 150 population size is divided equally to the participant and non participant. See Table 1.

Table 1: Three 'Tabias'' participants and non participants population and sample taken

Name of Tabia	Non Participant household size	Sample taken	Participant Household size	Sample taken
Gerjele	1059	25	522	25
KuluGeze Lemlem	562	25	277	25
Tumuga	1411	25	695	25
Sub Total	3032	75	1494	75
Total sample population		150		
Weight	Weight of participants= 1494/75		19.92	
	Weight of non participants=3032/75		40.43	

Source: Own calculation from sample survey data (2009)

As shown in Table 1, 25 sample size from both project participants and project none participants are taken. This is non random or purposeful sample selection type. Information collected through such a system can not guarantee as being representative of the total population. Weights for both participant and non participant sample are calculated as shown in the last row in the table 1 so that Stata can correct the proportion of the sample population which can make the sample a representative one..

3.3 Econometric Models

3.3.1 Variable Identification

A) Dependent Variable*:* here, the study undertakes due calculation on incomes earned from vegetable, mainly from Tomato, Onion and Pepper, and other productions like cereal products including income from food for work. To see the profitability, the variable and fixed costs information of both the vegetable and cereals is gathered. The outputs expressed in terms of income are per 'Tsimad'[2] unit. Then, having that information, profits from vegetable and cereals are calculated separately.

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2. ' Tsimad' is a unit of land plot measurement based on the amount days it last to plough traditionally.

Finally, profit comparison is made. Then the profit difference is expressed by the variable coded as 'netprofit'. This variable is changed to dummy dependent variable coded as 'compprofit'; as if 'netprofit' is greater than zero, then 'compprofit' is assigned a value one, zero other wise.

B) Model Specification:

a). ***New Agricultural Technology*** in this particular study is defined as introducing the use of improved seeds, farm technology like planting (spacing), supporting the vegetable (for Tomato), protection from damage using chemicals, post harvest output management, training and to some extent fertilizers etc. are taken as project interventions which are assumed to have positive effect on the vegetable output and thereby increases the benefit of the smallholder vegetable producer

A particular agricultural technology comprises a number of important characteristics which may influence adoption decisions. The adoption choice on agricultural technology, which is explained above, is dependent on different set of technology preference comparisons made by smallholders (Adesina and Forson, 1995, Negatu and Panikh, 1999).

The household decision is constrained basically by two set of preferences; namely, the existing traditional farming system and the new or improved agricultural farming technology introduced by some project packages or the new innovations of the farmers themselves. The smallholder is expected to adopt or not based on the comparisons made on the benefits from farming adopting the new agricultural technology and traditional farming activities.

To come up with relational expression, let the smallholder's benefits from adopting new technology and not adopting denoted by b_m and $b_{(1)}$ respectively.

Again let the i^{th} smallholder producer's expectations of adopting new technology, that is, the new agricultural technology characteristics that are expected to influence the adoption and the factors that contributes their effect on not adopting be given as P_{im} and P_{i1} respectively and the other socio-economic, and demographic characteristics of smallholder producers affecting the adoption decision is controlled as C_i.

The relationship can be denoted as $b_{mi} = Q(P_{im}, P_{il}, C_i)$ and $b_{li} = W(P_{im}, P_{il}, C_i)$ respectively.

To express these relationships as a representative models, the researcher adopt Logit model from Pindyck and Rubinfeld (1998) as below

$$Y_j^* = \beta Xi + \in_i : ....(1)$$

$$Y_j = 0 \; if \; Y_j^* \leq 0....................(2)$$

$$Y_j = 1 \;\; if \; Y_i^* > 0..................(3)$$

Where Y_i is a limited dependent variable, is the benefit of adoption of the new agricultural technology. Y_i^* is a latent variable that indexes adoption

X_i is the vector of socio-economic demographic characteristics and technology of perception of the smallholder producer

β^T is a vector of parameters to be estimated.

$\in_i$ is the error term.

Suppose the preference comparisons of technology given as $b_{mi} - b_{1i} > 0$ that is Yi^* >0, the smallholder is observed to adopt the modern technology which is $Y_i = Y_i^* > 0, else$ if $b_{mi} - b_{li} \leq 0$ (or $Y_j^* \leq 0$), no adoption which is $Y_i = 0$

Many authors bring with or have seen the basic determining factors of the new technology adoption and regressed these determinants on the decision of adopting of farmers to particular technology sets usually fertilizer and improved seed technologies (Zeller et al (1998)).

After calculating the profit differences and setting a dummy variable as explained above, the important explanatory variables which are assumed as to have either effect on the adoption are listed in the table.

Table 2: Explanatory variables and their description

Variable code	Variable Type	Variable description
Vage	continuous	Age of the household head(Demographic characteristics) continuous variable
Vedu	continuous	Level of education of the household respondent
Vwsourced	Binary	Yes or No answer for the question asked if the respondent has an access for water source like river diversion, pond, spring, bore hole etc.
Vlsize	continuous	Land size of the household
expectation1	Binary	Market price expectation of the respondent
Dalamata	continuous	Distance from the local market-Alamata
credit1	Binary	Credit access of the respondent from any institution, mainly from Dedebit Credit and saving institution.
Landsource	Binary	An access to hire land from the market

b) Hypotheses

The hypotheses attached to each of the independent variables included in the model were based on the following hypothesizes**.**

I. Age of the respondent: here, for the reason that young aged farmers are close to information and have easy access to technology, the younger the respondent, the more s/he adopts the technology.

II. Level of education of the respondent: as it is all known, education has positive contribution to compare circumstances based on heir advantage, the same for comparing the new and traditional farming systems. That is, the more the education level of the respondent the more s/he will adopt the new technology. Positive relationship between participation (compprofit) dummy and the education level (continuous variable 'Vedu') is observed.

III. Water source: one of the main factors of agricultural production is obviously water. And hence, it becomes a main factor for comparison between to adopt and not to adopt. This can be the case because, unlike the traditional farming which needs seasonal rain fall, the project intervention on producing the vegetables requires the availability of enough water from different sources like from borehole, spring, river diversion, hand dug well etc. Here, the one who have water access for producing the vegetables is likely to adopt the technology (positive relationship).

IV. Household land size: farmers with large land size holdings allocate their plots to different farming activities, that is, they can produce varieties of crops apportioning their own land based on different circumstances like the urgency a crop for food, risk minimization, profitability of the variety etc. Similarly, if the farmer has enough land size holding, s/he can easily decide to participate (adopt) in the modern farming system. Farmers owning large land size for farming are likely to adopt new ideas.

V. Price expectation for vegetable output: future vegetable price expectation is one of the factors that motivate farmers to produce more. For this reason, the farmers seek to adopt or introduce new farming mechanisms which bring them with better productivity and thereby enjoy the higher profit margin of the expected price rise. Based on these facts any one can say a farmer who can expect an increase in future price of these produce adopts new farming technology.

VI. Credit: farming inputs are important for the productivity of both the land and the labor force. But, these farming inputs like seed purchase, chemical for different purposes, fertilizer, labor employment etc. need cash liquidity which is beyond the capability of farmers. Then arises the need for financial institutions purposely established to supplement the productivity of the farmers. Though there are different ways of getting loan, Dedebit Credit and Saving institution is the sole institution providing loans with no or minimum collateral base in the study area. Here, the more the farmer is getting an access to credit the more s/he has liquid cash which enables her/him to purchase the farming inputs so that adopt the new agricultural technology.

VII. Distance from the nearest market Alamata: markets are important for the farmer to produce more or not. Besides the transport infrastructure, distance from the nearby market has its own negative effect to technology adoption. In this case, the more the farmer is living or the more the farm plot is located at a distant place the less is the probability of the farmer to adopt the new agricultural technology.

Finally, the functional relationship of these dependent and explanatory variables can be denoted as:

$Y_i = B_1$vage $+B_2$vedu $+B_3$vlsize + B_4vwsourced + B_5vexpectatin1 + B_6credit1 + B_7dalamat +… where **Yi** is the dummy dependent variable expressed as 'compprofit' and Bi are the parameters to be estimated.

This model in equation1 allows the identification of the decision of whether or not to adopt and the conditional level of use of the technology if the initial adoption decision was made (Adesina and Forson, 1995). Here Logit Model will be used for its advantage in that its coefficients can be disaggregated to determine the effect of a change in the i^{th} variable on changes in the probability of adopting the modern technology and the expected use intensity of the modern technology. It can be depicted as:

$E(Y_i) = \phi_{(z)} E(Y_i^*)$..........................(4)

Where $E(Yi^*)$, the expected value of Yi for those smallholder who are already made the adoption decision and $\varnothing$ is the cumulative normal distribution function at Z, where Z is $XB/\delta\ (\delta\ is \operatorname{var} iaance)$.

Apart from their signs, the coefficients in the binary choice models are not easy to interpret directly. One way to interpret the parameters (and to ease comparisons across different models) is to consider the partial derivatives of the probability that 'Yi 'equals one with respect to continues explanatory variable Xi (Verbeck, 2004).

Hence, differentiating equation (4) with respect to x is

$$\partial E(Y_i) \big/ \partial X_i = \phi_{(z)} \left\{ \partial E(Y_i^*) \big/ \partial\ xi \right\} + E(Y_j^*) \left\{ \partial\phi(z) \big/ \partial xi \right\} \text{................(5)}$$

Multiplying equation (5) by Xi/E (Yi) converts the relationship into elasticity form.

That is

$$\left(\partial E(Yi) / \partial xi\right) Xi \big/ E(Yi) = \left\{\partial E(Yi) / \partial xi\right\} Xi \big/ E(Yi) + E(Y_i^*)\left\{\partial\phi(z) / \partial xi\right\} Xi \big/ E(ui) \text{..........(6)}$$

By rearranging equation (6) it results.

$$\left\{\partial E(Yi) / \partial xi\right\} Xi \big/ E(Yi) = \left\{\partial E(Y_i^*) / \partial xi\right\} Xi \big/ E(Yi) + \left\{ \partial\varphi_{(z)} \big/ \partial xi \right\} Xi \big/ \phi(z) \text{.......................(7)}$$

The total elasticity in equation (7) indicates the change in the probability of the expected level of use intensity of the modern technology for the already adaptor smallholder vegetable producers and the change in the elasticity of the probability of being an adopter where the main focus here is the later one. Here since the observations are of individual and are not grouped, the elasticity estimation after logit estimation is estimated and hence it is possible to interpret the marginal effect of the explanatory variable on the dependent variable which was not possible taking the only the coefficients of the logit estimation results.

3.4. Impacts on Producers

In many of the less developed agrarian economies the agricultural productivity is extremely low. Clearly, increasing agricultural productivity is critical to economic growth and development.

One important way to increase agricultural productivity is through the introduction of improved agricultural technologies and management systems. National research programs are activating in most countries, in Ethiopia named as Ethiopian institute of agricultural research, working with a network of international centers operating under the auspices of different international and local research institutions. These research institutions have worked to develop new agricultural technologies and management practices. A challenge for agricultural researchers, however, is to understand how and when new technologies are used by farmers in developing countries.

Over the years, researchers have worked to answer challenging questions about agricultural technology adoption. Initially, policy makers and researchers sought simple descriptive statistics about the use and diffusion of new seed varieties and associated technologies such as fertilizer and irrigation (Yohannes 1993, Doss, 2003). Concerns arose later about the impact of technology adoption mainly focusing on commodity production, on poverty and malnutrition, on farm size and input use in agriculture, on genetic diversity, and on a variety of social issues.

For further decision whether to introduce and diffuse new technology or not, impact assessment is important/mandatory then. In this study, smallholder vegetable production is undertaken by household where the necessary supply like labor and capital come from.

Basically the project's aim is to transform the smallholder producers through helping to produce marketable output thereby increase their income (IPMS, 2005). The smallholder maximizes utility given the income at which income is the profit of the smallholder's production activities (own production) and off-farm employment (Ravalion, 2001)

Here, the study adopt smallholder profit maximization with the assumption that utility is an increasing function of profit with fixed capital and labor resources. For this concept, the researcher express the following functional relationships between utility and profit as below:

$$\pi_i(P_j, V_j, C_{iy,} C_{jx}, C_{it}) = \underset{xi \quad yi}{Max}\left(P_i V_i - W_i X_i - C_{iy} Y_i - C_{ix} X_i - C_{it} : T_j(X_i, Y_i, Z_i), P_j > 0, V_j > 0\right)$$

…… (1)

Where P_i vector of output prices of smallholder i, V_i vector of variable input prices of smallholder, and C_{iy}, C_{ix}, C_{it} are vectors of transaction costs for output, variable inputs and fixed transaction costs respectively.

Again, Y_i, X_i and Z_i are vectors of output, variable inputs, labor and capital for smallholder j. T(.) is the state of technology smallholder j.

From equation (1) the study can show the following terms as:-

$$P_i = P_i(K, H, L) \text{.......................}(2)$$

$$V_j = V_i(K, H, L) \text{......................}(3)$$

$$C_{jy} = C_{iy}(K, H, L) \text{....................}(4)$$

$$C_{jx} = C_{jx}(K, H, L) \text{...................}(5)$$

$$C_{jt} = C_{jx}(K.H, L) \text{....................}(6)$$

Where K_j, H_j, L_j Represents vectors of smallholder characteristics, vectors of project intervention by IPMS and MoARD and aggregate benefit accrued to smallholder j due to access to markets, credit, and transport services respectively. From those identifications, it can be written equation (1) as:

$\pi_i(K, H, L)$...........................(7) , which represents the reduced form of the profit equation.

3.4.1 Heckman treatment effect on Impact Analysis: For the sake of capturing the impacts as on smallholder profit through increasing income as a result of IPMS's intervention by ILRI and the Wereda Bureau of Agriculture(WBOA) at Alamata pilot learning Wereda, the study have used Heckman treatment effect estimation method.

Justification: the study is applying the treatment effect model which is similar to Heckman two step model because Heckman two step model overcomes the problems of linear regression (OLS) model of selection bias. Because the data the study has is a cross sectional primary data collected from 150 sample population which was drawn purposely (nonrandom sampling) from both the total participant and non-participant population size in these three Kebeles. And hence, the participation decision may be affected through self selection bias where the estimation of linear regression model can not correct this self selection bias and there by the estimated parameters become inconsistent and wrongly interpreted.

Further, the study chooses this model than the propensity score matching where again the sample size matters. Propensity score matching have the ability to correct the self selection bias by searching and matching the best matches of the respondents with having common support observable characteristics which may need, if not lucky enough, large amount of sample size; most of the time above 200 sample size.

The Heckman treatment effect model is applied by using two groups as smallholders participating in the project (treatment) and smallholders not participating in the project while both sharing similar observable characteristics. The mean effect (profit) of treatment is calculated (Ravalion, 2001) as the average difference in profitability between the treated and control group.

Let $D_j \in (0,1)$ indicates whether the smallholder j is participating in IPMS's and WBOA project or not; that is, 1 if participating, 0 otherwise.

The profit can also be defined as $\pi_{(D_j)}$ for smallholder at which j=1, 2….N where N is indicating the total population (Sample size), in this case, 150 number of respondents

The effect (profit) of smallholder j participation then is going to be calculated as:

$$E_i = \pi_{i(1)} - \pi_{i(0)} \text{.............................} (8)$$

However equation (8) cannot observe the smallholder's j profitability has s/he not participating in the project (Ravallion, 2001) and selection bias can result inconsistent parameter coefficient estimation.

Selection problems are pervasive in applied micro econometric research. For instance, profits of a project participation, in this case, is observed only for those individuals who participates in the project while the profit of the non-participants is not. Here the selection problem can be viewed as a problem of missing observations.

Since the data employed is not collected with procedure of random sampling, there may exist selection bias. To the matched estimation, there are different methods of estimation models. Of these, propensity score matching is more celebrated than Heckman two step selection models. But since the data the study have is small (150 household sample), Heckman treatment effect model is used.

Heckman's approach to the selection problem is closely linked to economic theory. His key insight is that observations are often missing because of conscious (self-selection) choices made by economic agents (the decision to participate in the project).

In the regression context, self-selection bias occurs when one or more explanatory variables are correlated with the residual term of outcome equation or selection bias arises because the "treatment" was correlated with the error term in the outcome equation because the residual captures the effects of all omitted and imperfectly measured variables. Thus any explanatory variables that are correlated with the unmeasured or incorrectly measured factors will end up proxying for them where if any explanatory variable ends up proxying for those factors, it cannot be directly interpreted its estimated coefficient as the effect of that explanatory variable for each, since it also captures part of the effect of the omitted or incorrectly measured variables.

The well-known Heckman correction (also called the two-stage method) has become part of the standard toolbox in applied micro-econometric work. The method may be described by means of the following two equations.

Profit equation:

$$\pi_{1i} = X_{1i}\beta_1 + \varepsilon_{1i} \quad \text{---} (9)$$

Participation equation:

$$e^* = X_{2i}\beta_2 + \varepsilon_{2i} \quad \text{---} (10)$$

Where Equation (9) determines the individual $i's$ profit (output equation), where as (10) is a "participation selection equation" describing the individual's propensity to participate in the project. Hence, π_i is the observed profit for participant individual i if s/he participates and e^* is a latent variable that captures the propensity to participate X_{1i} and X_{2i} are vectors of observed explanatory variables, such as age and education, household size, distance from the market, etc; ε_{1i} and ε_{2i}, are mean-zero stochastic errors representing the influence of unobserved variables affecting π_i and e^*_i. The parameter (vectors) of interest are β_1 and β_2. Although the latent variable e^*_i is unobserved, it can be defined as dummy variable $e_i = 1$ if $e_i^* > 0$ and $e_i = 0$ otherwise; it thus can be observed the positive net profit only if $e_i = 1$, that is, if the individual participates in the project. Here it is likely that the unobserved terms ε_{1i} and ε_{2i} are negatively correlated; that is, individuals with higher propensity to participate, given the characteristics X_{1i} and X_{2i}, are presumably also more likely not to participate in the project. If this is true, the sample of individuals observed as participants will not accurately represent the underlying population, even in a large sample. Failure to correct or recognize this selectivity problem generally produces inconsistent estimates of the parameters in the net profit equation.

Here assuming the basic assumptions, specifically saying that, $\varepsilon_{1i} \sim \mathrm{N}(0,1)$ and $\varepsilon_{2i} \sim \mathrm{N}(0, \delta^2)$, that is, the error terms, ε_{1i} and ε_{2i}, are assumed to be bivariate, normally distributed with correlation coefficient (ρ), the conditional mean of ε_{1i} can be written as:

$$E(\varepsilon_{1i} / e_1^* > 0) = E(\varepsilon_{1i} / \varepsilon_{2i} > -X_{2i}\beta_2) \text{......... ....} (11)$$

Where equation (11) is indicating the mean error term given the farmer is participating.

And hence it can be put as:

$$E(\pi_i \mid \mathrm{X}_{1i}; \mathrm{e}_i = 1) = \mathrm{X}_{1i}\beta_1 + \mathrm{E}(\varepsilon_{1i} \mid \varepsilon_{2i} > -\mathrm{X}_{2i}\beta_2) \text{..} (12)$$

Where Equation 12 shows the average treatment effect (average profit of participation); which is the result of the differences in profits when the farmer is participating and s/he is not. Thus, the regression equation on the selected sample depends on both X_{1i} and X_{2i}. Omitting the conditional mean of ε_{1i} biases the estimates of β_1 (unless ε_{1i} and ε_{2i} are uncorrelated, in which case the conditional mean of ε_{1i} is zero). Selection bias can thus be regarded as a standard problem of omitted-variable bias. The problem is to find an empirical representation of the conditional mean of ε_{1i} and include this variable in the profit equation.

Assuming that ε_{1i} and ε_{2i} are drawn from a bivariate normal distribution, the regression equation can be derived:

$$E(\pi_i \mid \mathrm{X}_{1i}, \mathrm{e}_i = 1) = \mathrm{X}_{1i}\beta_1 + \rho\delta_1\lambda_i \text{..(13)}$$

In equation (13) ρ is the correlation coefficient between ε_{1i} and ε_{2i}, δ_1 is the standard deviation of ε_{1i}, and, λ_i – the inverse of Mill's ratio(hazard lambda), sometimes called a "control function" or estimated expected error - literally a function that controls for selection bias , can be also given as by

$$\lambda_i = \frac{\phi(X_{2i}\beta_2 \mid \delta_2)}{\Phi(X_{2i}\beta_2 \mid \delta_2)} \text{.......... ....(14)}$$

Where λ_i is derived from the partial derivation of the inverse mills ratio with respect to, δ_2, the standard deviation of ε_{2i}, where ϕ and Φ are the density and distribution functions of the standard normal distribution respectively.

As shown in the Scientific Contributions of James Heckman and Daniel McFadden (Bank of Sweden, 2000), Heckman treatment effect procedure is conceptually as follows:

The first step involves estimating the parameters in equation (10) or the participation equation by the probit method, using the entire sample. These estimates can then be used to compute λ_i, for each individual farmer in the sample. Once λ_i is computed, the study can estimate equation(13) over the sample of participating farmers by ordinary least squares (OLS) regression, treating $\rho\delta_1$ as the regression coefficient for λ_i. Here STATA provide the potion that calculates the treatment effect procedure at a time using the 'two-step treat' syntax. The sign of the selection bias depends on the correlation between the errors in the profit (out come equation) and participation equations 'ρ' and the correlation between λ_i and the variables in the profit equation X_{1i}. Since λ_i is a decreasing function of the probability of sample selection, it follows that the β-coefficient on variables in X_{1i} that are likely to raise both profits and participation, such as education, will be biased downwards if the Heckman selection correction technique is not applied(provided $\rho > 0$).

Variables employed: here, as it is explained in part 3.3.1 above, the smallholder farmer may adopt the new agricultural technology if net profit is greater than zero, not adopt other wise. The impact of the technology adoption the study defined is explained by the utility maximization function explained in equation (1). Utility of the smallholder according to this functional relationship is an increasing function of profit basically the net profit which is gained as a result of technology adoption. Hence, net profit (‘netprofit’ which is continuous dependent variable) is calculated as the difference between the vegetable and cereal or other crops profits where the positive sign for the net profit is net indicator of the impact of producing vegetable being participating in the project. That is, profit from vegetable is greater than the profit from cereals. Then, in the following, the study set some of the explanatory variables that have an individual effect on the continuous dependent variable (net profit) where the ceteris paribus assumption is held true and some additional variables which are assumed to create some self selection bias in the selection equation.

Accordingly, age of the respondent(vage), the household head, respondent’s level of education(vedu),, smallholder’s experience in the vegetable farming activity both with and with out participation in the program(vexper), land size of the household(vlsize), market information by the extension agents(from both IPMS and Wereda agricultural office extension agents) (mktinfo3), any membership basically farmers’ cooperative membership of the smallholder farmer(cooprativem), having an access of employing labor from the local labor market for the purpose of the farm activity(employedin1), household oxen ownership(oxen), smallholder’s farm output market price expectation(expectation1), marital status which was asked whether the farmer is coupled or single(dummy) (marriage1), sex of the farmer, male(msex), and project participation(participation1) are taken as explanatory variables in the out come variable equation. Here, it is assumed that all these variables have positive impact on the profitability of the smallholder.

To control the self selection bias, here the study estimates the selection equation with certain explanatory variables.

Age of the respondent, education level of the respondent, marital status of the respondent, access to water source for irrigation from different sources(vwsourced), comparison of technology sets(tcompare), equal accessibility of the project to all farmers(access1),, household land holding size, and oxen ownership are the explanatory variables taken as selection bias factors where the participation(participation1) variable which is included in the out come equation is the dummy dependent variable.

Chapter IV: Results and Discussion

4.1 A Descriptive Analysis:

4.1.1 Sample Socioeconomic information

The main socioeconomic data characterizing the respondents' situation is given in Table 4 expressed as a summary statistics. The result in these tables shows that participants and non participant respondents included in the sample were from all age groups, ranging from the minimum age of 24 to the maximum age group of 68 years old, with an average age of 41 years. The majority (nearly 60%) of the respondents included in the survey is male (see Table 3).

Table 3: Some demographic characteristics expressed in terms of frequency and percent

Variable		Freq.	Percent	Cum
Marital Status	single	55	36.67	36.67
	married	81	54.00	90.67
	divorced	7	4.67	95.33
	widowed	7	4.67	100.00
Religion,	Orthodox	125	83.33	100.00
	Moslem+ others	25	16.67	16.67
Gender,	female	60	40.00	40.00
	male	90	60.00	100.00
Techno comparison,	No	4	2.67	2.67
	Yes	116	77.33	80.00
	I don't know it	30	20.00	100.00
Are you using only your own land?				
	Yes	93	62.00	62.00
	No	57	38.00	100.00
Fertilizer use	Yes	52	34.67	34.67
	No	98	65.33	100.00
Education,	Illiterate (0)	10.67	10.67	
	Primary level I (1-4)		36.66	
	Primary levelII(5-8)		46	
	Secondary (>=9)		6.67	

Source: Own Survey (2009)

As it can be seen in Table 3, Orthodox religion amounts at 83 percent of the sample population, the remaining sample population belongs to Moslem and other religions in the locality.

Marital status of the sample respondents indicate that married respondents dominate the sample by 54% while 36.67 % of the sample population are single or originally unmarried, the rest accounts for the divorced, widowed respondents.

The tabulated results also shows that 46% of the respondents' education level is between Grade (including) five and grade eight (including), 36.66% are in Grade range of grade 1 to grade 4. Among the remaining amount 10.67% are illiterate respondents (see Table 3).

Of the 150 household respondents, 73%(see Table 3) compare the new agricultural technology with the agricultural farming system, while 20% do not know what the technology package intervention is, and though they know the new and old farming practice, 2.67% of the respondents did not compare the benefits and drawbacks of these comparison technology sets. 62% of the respondents do not use rented in land, that is, they use only their own household land holding while 38% of the 150 sample population size use rented in land for the vegetable production.

Unlike most other areas of the region, only 34.67% (see Table 3) of the respondents are just using fertilizer for their own produce while the majority of the sample population amounting 65.33% do not use fertilizer for their agricultural produce. This number is a supportive indication for the oral responses of the respondents that they said is the land around the Raya Valley is fertile enough and possible to produce the local crop and vegetable varieties with out any chemical fertilizer support; it only needs enough rain fall or water sources.

The average respondents' household size is approximately around 4.73(see Table 4) which is slightly above the regional average rural household size which is 4.6(CSA, 2008). Average number of children who can't participate in the farming activity in a household is approximately 2, where a family can have minimum one child and maximum 6. Average schooling of children of these sample population indicates that a family on average send 3 children to school.

A family in this sample survey has an average land size of 3.48 'Tsimad' where this family land rages 0.5 to 9 'Tsimad', basically this household farm size is assumed to a factor for the decision made for technology adoption in the pilot learning Wereda.

Of the household size, on average, approximately 3 members can participate in the farm production (see Table 4).

Table 4: Summary statistics of household respondents

Variable	Obs	Mean	Std. Dev.	Min	Max
Respondent's Age	150	41.31333	11.44472	24	68
Respondent's					
Religion	150	.8333333	.3739265	0	1
Eductaion	150	4.313333	2.819245	0	11
Household size	150	4.726667	1.455822	3	11
Number of children	150	1.986667	1.023133	1	6
Children schooling	150	2.546667	1.065548	1	6
Household land size	150	3.48	1.39976	.5	9
Number of oxen in hh	150	2.7	1.459751	0	6
Hh memers able to work in					
Farm activity	150	2.846667	.8726775	2	6
Hh employing labor mkt	150	1.066667	.2502795	1*	2**
Hh using only own land	150	1.38 .	4870125	1*	2**

*, ** are representing yes and No response respectively for the two upper variables; and accessible and not accessible response for the question provided to respondent whether the project is equally accessible to all farmers or not respectively.

Source: Own survey (2009)

Finally, these are some of the sample household characteristics and any one can draw some points from the tabulation and summery statistics in Table 3 and 4

4.1.2 Vegetable Production Trend in the Wereda

Many types of vegetables could easily be grown in the valley because of the conducive climate and easy access to water. Among these vegetable the culture of growing pepper has a longer history in the area. As a result, farmers have developed own systems (IPMS, 2005) Table 5 is the data from the documentations from the Wereda Bureau of agriculture and rural Development.

The limited expansion of vegetables in the pilot learning Woreda, according to the IPMS project diagnosis 2005, has a lot to do with problems related to the development of water harvesting technologies (ponds and wells) and small scale irrigation schemes (river diversion, streams from the swampy area).

Currently the marketing of vegetables is done on individual basis. Since farmers harvest vegetables at about the same time, prices fall significantly at harvest (IPMS, 2005).

Table 5: Annual income from Vegetables production and Users trend in the Wereda

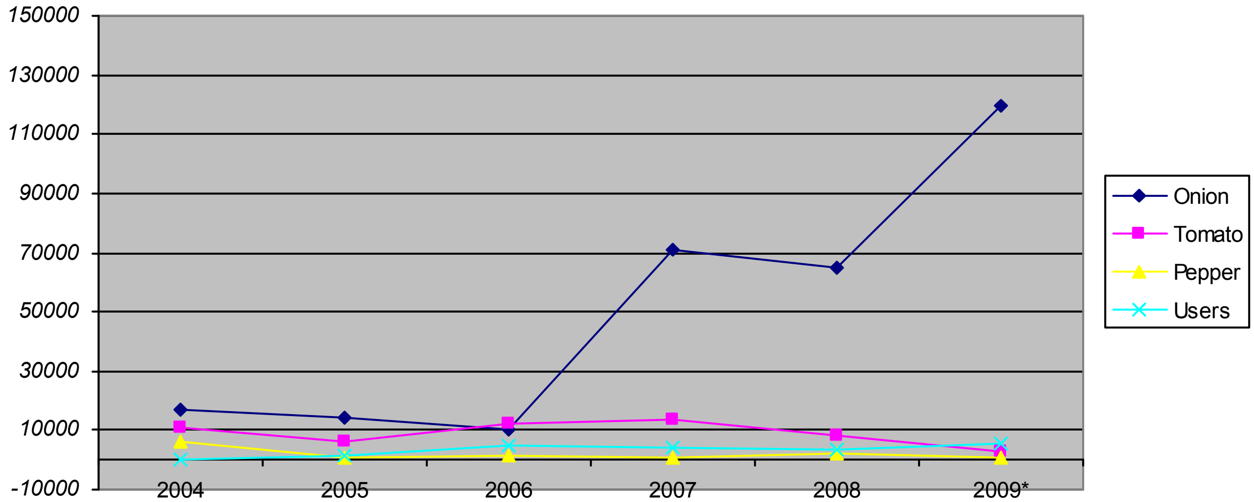
	2004	2005	2006	2007	2008	2009*
Onion	17217.7	14446.98	10458	70780	65217.96	119871
Tomato	10856	6466.76	12070	13304	8030.5	2504.2
Pepper	6094	1084.32	1529.2	1073.6	2233.57	924.2
Users	426	1205	4912	3892	3343	5800

Source: Documentation: Alamata Wereda Bureau of Agriculture and Rural Development

* Data collected in the 1st half of year 2001

The Figure (Line chart) 1 indicates that starting from the 2004, total production decrease continuously to the 1st survey of 2009. The perishable nature of the product and the discouraging price at the harvest season may be some of the reasons for the decrease. Because farmers may bring their output at the same time due the problem of cash liquidity for different purpose including repaying their loan they have taken from different source of loan.

Figure 1: Vegetable production trend in the Wereda



Source: Own line-chart result from Table 5

Pepper product (see chart 1) indicates some fluctuations in out put. It declines at the beginning and continues declining till to the production period of 2007, then rise up to some extent in the year 2008, and finally the 1st survey in the 2009 indicates a decline in the output. Unlike the two vegetable outputs, onion indicates encouraging output. Though there was some output decline in the years 2004 to 2006, starting from the harvest season of 2006 registered a promising result. There is rapid output growth in the years between 2006 and 2007. When we see the production of 2007 to 2008, there was also output decline may be due to the then unbalance rainfall in the area. In the 2008/09 harvest season, the line-chart shows again a rapid output rise may be due to the product price rise and to some extent a balanced rain fall in the area.

Finally, number of producers using the packages of the IPMS increases from 2004 to 2006; but, we see that the participation trend declined in the years 2007 and 2008 production seasons where the trend increased in the year 2009. Here, the participation of the farmers on producing these vegetables may follow the pattern of rain fall and market condition.

Because these vegetable products consume large amount of water where the farmers' water source for irrigation is partly the rain fall and river diversion, the balanced rain fall may be become the significant factor for the participation of farmers in this package.

4.2 Empirical Results

4.2.1 A Decision on Agricultural Technology Adoption

As explained in part 3.2.1 above, decision on new agricultural technology adoption with the given technology preferences with particular emphasis on profits from the products of vegetable and other crops or cereals (in this case 'compprofit') is dependent on different determining factors. In here, to see the factors that contribute for the decision to adopt or not, as it is explained in equation 1, 2 in part 3.2.1 above, robust logit model estimation result which estimates the log likelihood maximum estimation result is in Table 6.

Logically, the smallholder is going to adopt if the profit difference is greater than zero, not adopt other wise; that is, Y_i is 1 if 'compprofit' >= $0, Y_i = 0$ if 'compprofit'<=0 (See part 3.2.1 in this thesis)

To see the elasticity or the responsiveness of the smallholder farmer to the explanatory variables that can have either effect on the farmer's decision to adopt or not, elasticity after logit is estimated (see Table 6 or Annex 2). This elasticity estimation is nothing but it measures the responsiveness (elasticity) of the smallholder farmer in relation to the determining factors (explanatory variable) which are estimated in the logit regression because it is impossible to interpret the rate of responses of a farmer taking the coefficient results only.

Labor employment: Labor can be measured either as the size of the family or the number of males in the family or number of individuals employed in, where the labor employment exposure of the smallholder farmer is center of analysis for this study.

The effect of the labor variable often depends on whether the new technology is labor saving or labor using. Most studies agree that labor scarcity is often an operative constraint in farming systems. Labor-intensive technologies are more readily adopted by households with a higher labor supply (Jones, 2005). Jones found that shortages of family labor explained the non- adoption of technologies on the adoption of improved soybeans; the analysis by Jones also found that labor constraints had a significant impact on the adoption decision, as soybeans are a relatively labor using technology.

Table 6: Results of logistic and elasticity estimation after logit estimation

Variable Description	Logit Coef.	Logit Std. Err.	Elasticities after logit ey/ex	Std.Err	X
Vegetable -cereal profit difference					
Age of the respondent	-0.322722*	0.0891715	-.0115233	.01774	43.0673
Land source rented in	-0.9855314***	0.5531729	-.001165	.00148	1.42579
Market info by agents	0.5006184***	0.9550094	.0001122	.00026	.270442
Labor employed in	9.54715*	2.489083	.000525	.00069	.066323
Technology comparison	0.2360221***	1.445243	1.18304	.0002315	.00153
Respondents education level	3.818758*	0.968907	.0133015	.01722	4.20124
Water source	6.214443*	1.38911	.0027321	.00365	.530263
Price expectation	1.343384**	1.08612	.0004853	.00071	.435765
Distance from Alamata	-0.1815789*	0.0494109	-.0020047	.00313	13.3161
Household land size	2.711823*	0.5438193	.0072659	.01035	.23169
Credit taken by household	6.647488**	2.692927	.0049923	.00629	.905826
Constant	-010.94104***	6.529505			

Summary statistics	***Logit***	
Log pseudolikelihood	= -1.8158682	Elasticities after logit ,
Number of obs	= 123	y= Pr(compprofit) (predict) = 0.99917091
Wald chi2(11)	= 57.10	
Prob > chi2	= 0.0000	
Pseudo R2	= 0.9777	

Source: Own Survey (2009), *, **, *** represents significant values at 1%, 5% and 10% level of significance respectively,

As can be seen from Table 6, the dummy response for the question whether the household has an experience to employ labor factor from the local market or not, reveals that the family hold which did not have the experience, meaning, the ones with the large family members which can work or participate in the farm activity are more likely to adopt the new agricultural technology interventions by the project. The explanatory variable 'employedin2' from Table 6, is the response of the farmer that s/he has no experience to employ man labor from the market. The coefficient of this variable which indicates 1% level of significance shows a robust positive effect for new technology adoption.

The coefficient of the elasticity estimated after logit amounting at 0.000525 (approximately 0.05%) is an evidence that as the farmer reduces one percent of employed labor from the market for the purpose of farming taking other variables effect constant (ceteris paribus); in other words, if the farmer has an access of one percent additional household member to be member of the working force in the farm activity, the probability of adopting the new agricultural technology increases by the 0.05%. Taking the strength of elasticity concept, we can say the response by a smallholder to the new agricultural technology adoption in relation to this explanatory variable is very much weak or inelastic meaning significant but weak effect on the decision.

Water Source: Most of the people in the area drink water from ponds, together with their livestock which is collected from rain water or river diversion during flood (REST, 1996)

In general, access to water is not mere to drinking and sanitary but this water resource accessed from different sources as explained above and like from hand dug well, 'Horeye' is becoming of the fundamental factors of producing agricultural produces. Water is a main factor to be more productive in agricultural farming, particularly vegetable; that is why farmers put water resource as the main factor for decision.

Similarly, the logit estimation in Table 6 indicates that the water resource (vwsourced) explanatory variable is significant at 1% level of significant. When it is interpreted, the more the farmer is getting an additional water source the more the farmer is likely to adopt the new vegetable production system (intervention). The elasticity after logit is approximately amounting at 0.0027321(or 0.27%). This elasticity indicates that water source increases by one percent the probability of (decision to adopt) adopting increase by 0.27% though the elasticity can be considered as weak one.

Education: Literatures provided several theoretical or conceptual models on farmers' decisions to adopt new technology (Feder and Slade, 1984; Abadi Ghadim and Pannell, 1999; Negatu and Parikh, 1999 as sited by Chirwa 2003). Those literatures develop a model of technology diffusion and adoption based on human capital and land constraints.

The education variable is typically measured as the average education level of the entire household or just the respondent household head where the later one is the main measurement in which it is chosen because it is easy to measure and is thus popular among adoption studies.

Several studies have looked at the role of education in adoption and have concluded that higher education levels lead to earlier and more effective adoption (Jones, 2005). Education is thought to improve the farmer's ability to better process the information provided about new technologies and to increase their allocation and technical efficiency

Similar to these ideas and the theoretical construction in this study, human capital plays great role to understand and adopt of that technology. The null hypothesis is rejected at 1% level of significant with positive coefficient assuring the existence positive effect of farmer's education on adopting the new agricultural technology. Here, elasticity which is estimated after the robust logit result is approximately 0.0133015(1.3%) which reveal that one more educational level of the respondent may increase the probability of adopting the new agricultural technology by 1.3%. This implies that providing educational facilities like increasing schools in the locality, undertaking short term agricultural trainings particularly focusing on the technology which is assumed to be adopted by the farmers plays the lion's share on farmers' interest to adopt or not that technology.

Land Size: Plot size is a common variable across adoption studies. It is correlated with adoption in 67% of the studies in Pattanayak *(*2003). However, the sign of the correlation for this variable is inconsistent across studies.

Farm size can have different effects on adoption depending on the nature of the technology. Literatures suggest that plot size is correlated with a number of other important factors such as access to credit, capacity to bear risks, access to scarce inputs, wealth, access to information, and so forth. Since the effect of each of these factors on adoption varies over time and place, so does the relationship of farm size and adoption.

This is thought to correspond with the assumption that larger farms have lower risk exposure and improved access to resources.

Consistent with literatures above and the theoretical formulation in this study, the result shows that those farmers with large farm land size are more likely to adopt a new agricultural technology. Here as an evidence, the null hypothesis (Ho) that express, taken other things constant, land size have zero contribution to the technology adoption is rejected at 1% level of significance. Accordingly, the farmer who has larger farm plots can have multi-options of allocating her/his land to different crop varieties. This crop variety production can secured the farmer from different hazards and risks. Having minimizing the risks of drought, natural hazards, pesticides, market failure etc., farmers can diversify their technology use. For instance, if the smallholder producer wants to minimize the dangers from market failure of vegetable outputs, certainly, s/he is going to supplement the vegetable production by cereal production and then arises the question of land size for the purpose of apportioning the farm plot size s/he own among these different crop variety production activities. The explanatory variable land size (vlsize) estimation on adoption decision shows the coefficient has positive effect on decision and it can be interpreted as the farmer owns one more additional unit of land plot, her/his probability of adopting the new technology is positively influenced. Elasticity estimation after the robust logit estimation is 0.00726559(0.73%) which can measure the response of smallholder farmers. Precisely speaking, as the smallholder's farm plot increases by 1% the probability of adopting the new agricultural technology increases approximately by 0.73%.

In other direction, when the study tries to see the extent of farmer's interest of new agricultural technology innovations adoption provided that s/he is producing an agricultural produce by having the land through different mechanisms (in this case 'landsource') like rent land in from others, being a tenant etc, the logit estimation result indicates significant at 10% level of significance with negative coefficient. This may be implicitly due to the fear of the risks or uncertainties of land ownership or due to the lack of formal system of being tenant or sharecropping in the country.

Age: This variable can be typically measured as the average age level of the entire household or just the household head or the respondent's age; here we measure it as the age of the respondent. Statistically, this variable performs poorly in explaining adoption behavior in the Pattanayak (2003) study; it was significant in only 24% of studies.

There is often inconsistency of evidence about the effect of age on innovativeness. In a study by Cotlear (1986) as sited by Jones (2005), age was shown to have a negative influence on adoption of biological and chemical inputs, seemingly because older farmers are more conservative. Contrary, other studies come up with their evidence that age has positive effect; while others also indicates that age has neither effect(insignificant effect) on new agricultural technology adoption.

In this regard, the logit estimation (see Table 6) shows that the null hypothesis that age has no contribution to the agricultural technology adoption is rejected at 1% level of significance. The explanatory variable age (coded as vage) indicates an approximate coefficient of -0.32. This negative coefficient result coincides with the idea that older farmers are more conservative to accept new things quickly though such conclusions might hide the truth that young aged farmers are more close to market information about their farm inputs, their output markets and more interactive with their surroundings than the old aged ones. Hence, according to this result, as the farmer is becoming younger by one more year old, s/he is very much quick to understand new things and take action; that is as the age of the smallholder is less and less than the others; s/he is the more active to adopt the new agricultural technology. The elasticity after a robust logit estimation is -0.0115233(or -1.15%) which reveals that the opposite action of the older farmers. It is, as the farmer's age increases by one more year the probability of not adopting the new agricultural technology is decreased by 1.15%.

Credit access: This variable is not included in many studies, but is always significant when included in the studies reviewed by Pattanayak *et al.* (2003).

When fixed costs for a new technology are large, access to capital is often considered to be a factor in the adoption decision. Large fixed investments prevent many small farms from adopting innovations quickly. Likewise, the need to access credit can prevent adoption though a number of studies have also found that lack of credit limits adoption of technologies even when fixed costs are not large. Shortage of funds was cited as a major constraint on adoption of divisible technologies. However, others have argued that lack of credit alone does not inhibit the adoption of innovations when profitability from the innovation is perceived as large. In this case, small farmers are believed to mobilize all available resources in order to acquire the necessary inputs. Similarly, credit (explanatory variable coded as 'credit1') is estimated and the null hypothesis is rejected at 5% level of significance. The estimated coefficient in this logit likelihood estimation is approximately 6.65 which magnify the contribution of credit access to the agricultural technology adoption. To be frank, since the Dedebit Credit and Saving institution is the major formal credit provider for the rural farmers, the more the all rounded facility efficiency of this institution the more its contribution is significant to agricultural technology adoption by these farmers. Similarly, the elasticity measurement amounting at 0.0049923(or 0.5%) indicates that as the accessibility of credit by the smallholder increases by 1%, the probability of adopting the new agricultural technology increases by 0.5%.

Distance to Local Market-Alamata: this explanatory variable was estimated in many regressions and it was highly significant with the expected negative correlation; as distance increased, adoption decreased (Jones, 2005). Distance from a main market or local administration has multi-dimensional effect on farm productivity. According to Jones, the negative correlation in between agricultural technology adoption and distance is probably, among others, due to farm inputs transportation facility problem, facilities for the extension agents who can train and help those rural farmers.

Of different circumstances, time and transportation cost limits farmers not to go to the nearby town and thereby get access on input and output market information so that motivated to produce more by using the new technology packages. Like wise, the estimation result in Table 6 shows that negative correlation between distance (dalamata) and the dummy dependent variable 'compprofit'. The -0.18 estimated coefficient significant at 1% level of significance reveals that as the location of the farm area is getting far by one more kilometer, it is more likely that farmers decide not to adopt the new agricultural technology preference. Here again the elasticity measures the responsiveness of smallholder farmers to distance in relation to new agricultural technology adoption. As the farm area is becoming one more kilometer far from the local market (Alamata) the probability of adopting the new agricultural technology by a smallholder decreases by 0.2%.

Finally, though information provided by the project extension agents remains insignificant, in other words the null hypothesis is accepted, the sign of this variable (mktinfo2) is similar with the theoretical formulation that as it was formulated to have positive effect on the adoption decision. This may be true because ones the farmers are connected with traders by the project extension agents, they may use or follow that link and depend on the information provided by the local traders. Besides, the comparison between the new agricultural technology set and the traditional farming system made by the smallholder accepts the null hypothesis; that is comparison in between these two sets do nothing with the technology adoption.

Market price expectation of farmers in this case 'expectation1'explanatory variable shows a positive value though it is insignificant.

4.3 Impact on Project Participants

To examine whether smallholder farmers are benefiting from project participation where the project participation comprises of new agricultural farming technology sets, smallholder's utility maximization function is used to examine the impact of the program. As it is explained in part 3.3.1 in this thesis above, the new agricultural farming technology sets which are provide by the progeramme (ILRI and WBOARD) are use of improved seeds, farm technology like planting (spacing), supporting the vegetable (for Tomato), provision of pesticide, training on post harvest output management and provision of output market information from the project extension agents. For this study, project participant are defined as those farmers who adopt at least one of the technology sets which are indicated above. Using these new agricultural technologies, the smallholders in the study area are expected to maximize their utility as where utility is assumed an increasing function of agricultural output profits. The agricultural output profits can be realized through producing varieties of farm outputs. To come up with the study's main concern here, sources of agricultural output profits are classified in to two categories; namely profits from vegetable (where vegetable in this case is Onion, Tomato, and Pepper) produce using at least one of the technology sets and the second is profits from other agricultural produce mainly cereals and to some extent vegetables produces with out using the new agricultural technology sets. Net profit gain from the progamme participation is estimated by comparing the differences in profits of vegetable using the new agricultural technologies and profits from cereals and vegetables with out using the technology. The net difference is a continuous value which is the explaining factor to the utility of the smallholder. Now, the researcher's principal aim here is to see whether project participation, adopting at least one of the technologies, has a positive effect on the net profit and in return may maximize the smallholder utility.

Heckman treatment effect is estimated to see the effect of the progamme. In the second stage of the two step treatment effect estimation, the control function, hazard lambda is included. That means the outcome equation estimation estimates the ordinary least square estimation(the second step estimation) where Stata software package results consistent and asymptotically normal estimators for the parameters in the out come equation and consistent variance estimator or corrected standard errors automatically (Heckman 1979).

As shown in Table 7, the hazard lambda which is similar to inverse Mills ratio estimated as selection bias equation is significant at 10% level of significance showing the existence of selection bias. For comparison, see Appendix 4 estimated results from the ordinary least square regression; which indicates different results from the treatment effect estimation. The selection equation taking the participation dummy variable 'particpat~1' estimated the probit regression for participation. Here, pre treatment variables are taken for the participation decision.

Participation (particpat~1): as indicted in Table 7, smallholder farmer adopting at least one of the new agricultural technologies is better profitable than the ones who do not. The estimated coefficient of the participation dummy variable revealed that the null hypothesis which states participation does have zero effect on the profitability of a smallholder is rejected at 10% level of significance. Smallholder farmers taking at least one of the project packages are able to enjoy the intervention by IPMS project. Particularly speaking, the use of modern seeds, farm technology like planting (spacing), supporting the vegetable (for Tomato), protection from damage the vegetable using chemicals, post harvest output management, training are enabling participant farmers better profitable than households who do not use these types of interventions.

Though the main interest of this study is to see the impact of those technology variables, in the treatment effect estimation, the result shows that cooperative membership is significant at 10% level of significance. This could probably be farmers who have the exposure to be member of any association may be familiar to the new innovations made at their surroundings. Besides, their association may help them on how to produce and market their produce because usually associations like cooperative are objectively founded to help the rural farmers and acquaint farmers with new happenings in the farmers' surroundings and the output and input markets.

Market information provided by the extension agents is another factor for profitability of the smallholder farmer. The result shows the alternative hypothesis is accepted at 10% level of significance where the estimated coefficient in Table 7 is indicating the variable for market information (mktinfo3) is positively and significantly affecting the profitability of a smallholder in the project area.

In reality, farmers expect their future earnings where these future earnings are dependent on different circumstances. Market price expectation of their output is among the various conditions that may have an influence on the farmer's productivity and thereby profitability. The finding of this study indicates that market price expectation has significant effect on net profit gain of the participants (at P-value <0.1; which indicates that the farmers who expect higher future price of their output are motivated to produce more marketable vegetable better than the ones who do not. This price expectation may help the smallholder farmers to be more productive and produce quality output in return help them to enjoy the market as well as the just price in their locality.

Current Marital status and household head gender are other factors that can affect the profitability of a smallholder vegetable producer. Here again, the null hypothesizes for these variables are rejected at 1% and 5% level of significances respectively. The acceptance of the alternative hypothesis for the farmer being couple is more profitable than the single ones may be due to the resource sharing of the household that the husband can be devoted and exert all the time he has for caring and treating the vegetable production than the single ones because the remaining household tasks in the former case can be covered by his wife (since a woman is responsible in activating tasks inside a home the nation). Besides male headed household is profitable than the women headed household may be because biologically male are more energetic in the farm activities and may also male have more exposure to market and all farm activities than women.

Table 7: Treatment-effects model -- two-step estimates

Variables	Coef.	Std. Err.
Out come equation Continuous dependent variable(Net profit)		
Respondent's age	-20.39113	211.5391
Respondent's Education level	607.6945	811.0818
Farming Experience of the farmer	256.6872	814.2511
Household Land holdings size	1800.927	1642.924
Market information by extension agents	5739.669***	3399.467
Cooperative membership of farmer	7135.042***	4096.946
Experience of employing man labor	3797.118	5944.355
Farmer's output market price expectation	6341.895***	3367.31
Household Oxen ownership for farm	417.9894	1570.86
Current Marital status (couple=yes, single=no)	44209.61*	9913.212
Household head gender	22563.88**	8795.217
Farmer's project participation	18860.16***	9634.253
Constant	-41259.58**	15547.9
Dummy dependent variable for participation selection bias equation		
Respondent's age	0.0078915	0.0167159
Respondents Education level	0.0153433	0.0653304
Current Marital status (couple=yes, single=no)	-0.8678923	0.688941
Household Oxen ownership for farm	0.1133201	0.1223032
Comparison of technology sets	0.4076394	0.2838772
Equal access of the project to all farmers	0.3212764	0.2874741
Household Land holdings size	0.3638681*	0.1013288
Different sources water for irrigation	1.286454*	0.3627506
Constant term	-3.905218*	1.089756
hazard		
lambda	-10276.58***	5921.017
rho	-0.55279	
sigma	18590.532	
lambda	-10276.584	5921.017

Number of obs = 150, Wald chi2(17) = 129.24, Prob > chi2 = 0.0000, *, ** and *** represents significant values at 1%, 5% and 10% level of significance respectively

Source: Own survey result (2010)

Chapter V. Conclusions and Recommendations

5.1 Limitations

Here, the major constraints are of time and resources for gathering all rounded data. Since this study was conducted and finalized in short period of time, it faced challenges of enough time to have all information that might fill every gab in the study though the study have tried to collect the important data (information). Finance is another constraint to address all the issues in this research.

5.2 Conclusions

This paper examined the underlying determinants of agricultural technology adoption decision by rural households in Tigray, Alamata Wereda and impacts on the project participant smallholder vegetable producers. The major findings can be briefly summarized as findings on determinants of the adoption and impact of participation which are estimated using robust logit estimation and Heckman two step treatment effect econometric models respectively. Higher levels of education, access to water source, comparatively owning larger farm plot, access to credit services have positives effect on new agricultural technology adoption. Farmers who produce their farm outputs only using their household members for farming are close and quick to adopt the new agricultural technology than the ones who farm using an employed labor from the market. The findings on age of the household head, location of the farm area from the local market- Alamata, producing the agricultural produce using farm plots from others like renting in, being tenant, sharecropping etc. have negative effect on decisions on adoption.

The finding with respect to respondent's level of education is particularly strong positive and robust (see the strength of the elasticity in Table 6). Difficulty in education service provision appears to be one of the major implicit constraints to agricultural technology adoption. This finding is an implicit indication that there exists positive relationship between public investment on educating farmers and farmers' decision on new agricultural innovations adoption. The result shows that older farmers strongly resist for the new coming agricultural technology which is robust for the idea that older farmers are more conservative to adopt the new technology. In other words, younger farmers are not as conservative as the older one to the new farm innovations may be due to their active participation in the community.

Distance from the local market has also negative effect on adoption decisions. This negative effect on adoption reveals that farmers residing at a distance area from the center of hot economic interaction are preferring the existing traditional farming system where such farmers behavior entails that there is a need of infrastructural setup or the outreach of the project extension agents training regarding the project is limited to the side way of the main roads and nearby the town (Alamata town) only.

Credit is another variable which has positive effect on farmers' adoption decision. This positive estimated coefficient result revealed that farmers can be confident that they can have liquid cash access that can be used for purchasing the farm inputs from the market. The efficient existence of the credit providers is explicit constraint for farmers' decision on adoption and productivity because if they lack such financial provision, the resource they have may not allow them to adopt the new farm innovations.

One finding worth mentioning here is that the case of farmers who produce their agricultural output by using rented in land, being tenant, or sharecropping system fear to adopt the new agricultural innovations because the system of tenancy, sharecropping or farm land renting are not supported with legal guide lines or rules. In most circumstances, farmers own the farm plot for short period of time, usually for one harvest season while some of the vegetable for instance pepper need long period of time and can be harvested more than one time using the same root. The short period contract agreement between the land owner and the farmer who rented the land hinder the farmer to enjoy the benefits from long harvest and thereby affects negatively to the new agricultural technology adoption decision.

Last but not least points for the concept of determinants for adoption decision are the findings of water sources accessibility and farmers' household land holding size. The result indicates that water source is one of the main factors that can positively affect the adoption decision because it is one of the main and mandatory inputs in agricultural production especially in vegetable production. Household land size estimated on the adoption decision revealed that farmers with larger farm plot more are likely to adopt the new innovated farm technology when compared to the farmers with small farm plot size.

The Heckman treatment effect estimation result indicates that the participation dummy variable taken as dependent in the selection estimation and simultaneously as explanatory variable in the outcome equation is significant at 10% level of significance both in the selection equation and outcome equations. This result reveals that the new agricultural technology set have an impact on the profitability of the smallholder vegetable producer. Such agricultural project intervention helps the smallholder's profitability. Producing vegetable is the main agricultural practice in the study area. There is fertile land, huge underground water potential and culturally vegetable production is accustomed as the local consumption for food. Unlike these realities in the area, before the program intervention, farmers producing vegetable in the study area were not as such profitable from vegetable production and thereby were not motivated to produce vegetable surplus than their direct consumption. Thanks to the IMPS project, the technical and other all rounded supports provided by the project experts brigs the farmers familiar with markets and benefits of vegetable production and of course their participation in the project makes the farmers more profitable than the ones who do not participate in the project.

Apart from its main interest here, the study found that, though not significant, age affects to the profitability of the smallholder negatively. For this regard, it can be concluded that younger farmers are more profitable than the older ones because besides the conservative behavior of the older farmers, the younger ones are more active in the market interactions and farming activities than the older ones and as a result they are more profitable. Market information provided to the farmers, cooperative or any association membership, farmers' output market price expectation variables are both significant at 10% level of significance indicating positive effect on profitability of the smallholder vegetable produce. The dummy variable asked if the family head is coupled or not is significant 1% level of significance showing that married farmers are more productive than the single ones, may be due to household resource sharing and allocation efficiency. Gender has also another contribution to be profitable or not. Male sex variable is significant at 5% level of significance which can in broad be concluded as men are more energetic and productive than female. The frequency male visit to the farm and treat the vegetable may also be another factor of their profitability than women.

5.3 Policy Recommendations

According to the results revealed in the discussion part above, the following policy implications are forwarded.

Education is one way of acquainting individuals with circumstances that enable them to use it as mechanism to solve the problems they may face. Farmers are assuring that education is one factor on adopting and improving their farm productivities. Hence, public and private investment on the provision of education and short period farm trainings are important to change the all round farmers' behavior so that it can enable them to compare things quickly and take advantages of the new innovations. Age has negative effect on decisions to adopt the new technologies. Awareness creating programs are desired to all age level of the farmers but it is rational if the project intervention focuses on the age level that can be more fruitful and thereby the project can achieve the pre designed targets or objectives. This may support the educational policies of the country with the motto of 'Education for all' for which it leads to create farmers with medium level of education in the countryside.

The high under ground water and surface water potential in the study area should be exploited to change the livelihood of the local farmers, while this potential may possibly leads to commercialized farming in the Wereda. Any one who passes through the roads of Raya Valley could not accept citizen's food insecurity easily because situations of food insecurity may happen most of the time due to the area's potential resources over exploitation which is the reverse in Alamata (Raya Valley). Some efforts are there but these efforts must be strengthened to exploit the economic resource potentials there in the Wereda in return farmers can enhance their productivity which may help them to solve or break the vicious circle poverty in the area.

Credit services and distance from the market are significant variables inviting policy makers and concerned bodies to improve them. Infrastructural improvements such as road, telecom services, local market facilities, temporary stores, constructing residence houses for the extension agents is very important in order to help and follow farmers' productivity closely etc. can minimize the negative effect of distance on new agricultural technology adoption decisions. Thus, the government and non government institution have to give due emphasis to improve these infrastructural set ups.

The sense of productivity can lie to the issues of increasing the amount of an agricultural output per unit hectare, per unit labor or in general per unit of any resource employed and quality of the agricultural output. The finding regarding the farmer's profitability being using the new technology sets provided by the project intervention is an evidence to strengthen such project interventions. That is to say the result promises that there is a need of some additional efforts to help and address the technology needs of the local farmers.

Because any farmers or cooperative membership has positive effect on the profitability of the smallholder farmer that may be due to the all round support provided by the associations or cooperatives, the associations has to wide and strengthen their outreach to all farmers.

According to the estimation result, male headed family farmers are more profitable than the female headed ones. In order to improve and help the discouraged female headed families, equal, if not better to female headed family, attention is needed to all families in the locality. It is meant, such projects have to design special women supportive system or programs.

Finally, farmer's market price expectation explanatory variable is indicating that farmers with some market price expectation are motivated to be better in quantity and quality of their produce thereby becomes more profitable than the ones who do not expect future output price. To this regard, the project, the Wereda office of agriculture and other concerned bodies are needed to work in collaboration on providing the market information to smallholder farmers in the manner that can address the demand of smallholders. .

Further Research Questions

The results of the stated objectives are indicating the existence of some variables that can affect adoption decision and the project intervention has positive impact on project participants. But there are issues which need detail analysis. These can be set as the following:

1. What is the impact of the project on farmers who are not actually participating in the project but imitating the program interventions from their neighbors?
2. What is the effect of local market price variations on decision of improved agricultural technologies adoption?
3. Does the existing market structure favoring the smallholder farmers to produce more?

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Annexes

Annex 1: Robust logit estimation result for adoption decision

Logistic regression	Number of obs = 123
	Wald chi2(11) = 57.10
	Prob > chi2 = 0.0000
Log pseudolikelihood = -1.8158682	Pseudo R2 = 0.9777

Compprofit	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf. Interval]	
vage	-.322722	.0891715	-3.62	0.000	-.497495	-.1479491
landsource	-.9855314	.5531729	-1.78	0.075	-2.06973	.0986675
mktinfo2	.5006184	.9550094	0.52	0.600	-1.371166	2.372403
employedin2	9.54715	2.489083	3.84	0.000	4.668637	14.42566
tcompare	.2360221	1.445243	0.16	0.870	-2.596602	3.068646
vedu	3.818758	.968907	3.94	0.000	1.919735	5.717781
vwsourced	6.214443	1.38911	4.47	0.000	3.491838	8.937049
expectation1	1.343384	1.08612	1.24	0.216	-.7853725	3.47214
dalamata	-.1815789	.0494109	-3.67	0.000	-.2784225	-.0847354
vlsize	2.711823	.5438193	4.99	0.000	1.645956	3.777689
credit1	6.647488	2.692927	2.47	0.014	1.369449	11.92553
_cons	-10.94104	6.529505	-1.68	0.094	-23.73863	1.856558

Annex 2: Elasticity estimation after robust logit estimation

Elasticities after logit

y = Pr(compprofit) (predict) = 0.99917091

variable	ey/ex	Std. Err.	z	P>|z|	[95% C.I.	]	X
vage	-.0115233	.01774	-0.65	0.516	-.046292	.023246	43.0673
landso~e	-.001165	.00148	-0.78	0.433	-.004075	.001745	1.42579
mktinfo2	.0001122	.00026	0.44	0.660	-.000388	.000612	.270442
employ~2	.000525	.00069	0.77	0.444	-.000819	.001868	.066323
tcompare	.0002315	.00153	0.15	0.880	-.002765	.003228	1.18304
vedu	.0133015	.01722	0.77	0.440	-.020441	.047044	4.20124
vwsour~d	.0027321	.00365	0.75	0.454	-.004425	.009889	.530263
expect~1	.0004853	.00071	0.68	0.495	-.000907	.001878	.435765
dalamata	-.0020047	.00313	-0.64	0.522	-.008136	.004127	13.3161
vlsize	.0072659	.01035	0.70	0.483	-.013013	.027545	3.23169
credit1	.0049923	.00629	0.79	0.428	-.007342	.017326	.905826

Annex 3: Heckman Treatment effect model estimation result

treatreg netprofit vage vedu vexperi vlsize mktinfo3 cooprative2 employedin1 expectation1 oxen marriage1 msex, twostep treat(participation1 = vage vedu marriage1 oxen tcompare access1 vlsize vwsourced)

Treatment-effects model -- two-step estimates Number of obs = 150
Wald chi2(17) = 129.24
Prob > chi2 = 0.0000

	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
netprofit						
vage	-20.39113	211.5391	-0.10	0.923	-435.0001	394.2179
vedu	607.6945	811.0818	0.75	0.454	-981.9966	2197.385
vexperi	256.6872	814.2511	0.32	0.753	-1339.216	1852.59
vlsize	1800.927	1642.924	1.10	0.273	-1419.146	5021
mktinfo3	5739.669	3399.467	1.69	0.091	-923.1641	12402.5
coopprativem	7135.042	4096.946	1.74	0.082	-894.8244	15164.91
employedin1	3797.118	5944.355	0.64	0.523	-7853.604	15447.84
expectation1	6341.895	3367.31	1.88	0.060	-257.9106	12941.7
oxen	417.9894	1570.86	0.27	0.790	-2660.84	3496.818
marriage1	44209.61	9913.212	4.46	0.000	24780.07	63639.15
msex	22563.88	8795.217	2.57	0.010	5325.568	39802.18
participat~1	18860.16	9634.253	1.96	0.050	-22.62481	37742.95
_cons	-41259.58	15547.9	-2.65	0.008	-71732.9	-10786.26
participat~1						
vage	.0078915	.0167159	0.47	0.637	-.0248711	.0406541
vedu	.0153433	.0653304	0.23	0.814	-.112702	.1433885
marriage1	-.8678923	.688941	-1.26	0.208	-2.218192	.4824071
oxen	.1133201	.1223032	0.93	0.354	-.1263897	.35303
tcompare	.4076394	.2838772	1.44	0.151	-.1487496	.9640284
access1	.3212764	.2874741	1.12	0.264	-.2421625	.8847152
vlsize	.3638681	.1013288	3.59	0.000	.1652674	.5624688
vwsourced	1.286454	.3627506	3.55	0.000	.5754754	1.997432
_cons	-3.905218	1.089756	-3.58	0.000	-6.0411	-1.769335
hazard						
lambda	-10276.58	5921.017	-1.74	0.083	-21881.56	1328.397
rho	-0.55279					
sigma	18590.532					
lambda	-10276.584	5921.017				

Annex 4: OLS regression estimated for comparion with heckman treatment effect model

reg netprofit vage vedu vexperi vlsize mktinfo3 coopprativem employedin1 expectation1 oxen marriage1 msex participation1

Source	SS	df	MS		
Model	3.5811e+10	12	2.9842e+09	Number of obs =	150
Residual	4.6468e+10	137	339186002	F(12, 137) =	8.80
Total	8.2279e+10	149	552210227	Prob > F =	0.0000
				R-squared =	0.4352
				Adj R-squared =	0.3858
				Root MSE =	18417

netprofit	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
vage	-.5194592	211.6268	-0.00	0.998	-418.9968	417.9579
vedu	877.4927	792.3065	1.11	0.270	-689.2388	2444.224
vexperi	109.8155	851.9834	0.13	0.898	-1574.923	1794.554
vlsize	3661.679	1227.531	2.98	0.003	1234.32	6089.037
mktinfo3	4868.664	3514.542	1.39	0.168	-2081.101	11818.43
coopprativem	7698.605	4316.942	1.78	0.077	-837.8506	16235.06
employedin1	3964.926	6278.493	0.63	0.529	-8450.362	16380.21
expectation1	5879.37	3525.269	1.67	0.098	-1091.607	12850.35
oxen	1160.018	1503.841	0.77	0.442	-1813.725	4133.761
marriage1	38474.81	9492.235	4.05	0.000	19704.57	57245.05
msex	19091.64	9233.949	2.07	0.041	832.1428	37351.14
participat~1	3844.893	3902.795	0.99	0.326	-3872.615	11562.4
_cons	-41638.3	15922.47	-2.62	0.010	-73123.88	-10152.71