ESSAYS ON OFF-FARM LABOR MARKET PARTICIPATION, FARM PRODUCTION DECISIONS AND HOUSEHOLD ECONOMIC WELLBEING: EMPIRICAL EVIDENCE FROM RURAL KENYA

By

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A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the Degree of

DOCTOR OF PHOLOSOPHY

Department of Agricultural Economics

2008

ABSTRACT

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This study uses household level data collected across different regions of rural Kenya to study household welfare dynamics, engagement in the off-farm labor market and its effects on agricultural intensification for these rural households. The dissertation consists of three separate essays.

The first essay estimates a dynamic panel data model of income to determine the pattern of income growth for these rural households. The paper seeks to determine the relationship between educational attainment and the initial economic position of households on their subsequent income growth and mobility. Results show strong evidence of (low) income persistence for the poor and those in the low agricultural potential areas without at least a secondary school education. As expected, higher education seems to reduce income persistence for the very poor and those in the low potential areas, but also enhances convergence for those in the high potential areas. Overall, the results indicates the potential role of education in not only breaking the cycle of poverty for those trapped in it, but also its ability to allow increased recovery from income shocks. Notably, there is no conclusive evidence of the pattern of income growth or the role of education for non-poor households, implying that such are less susceptible to long-term effects of income shocks in either direction.

The second essay explores the relationship between off-farm work and farm production decisions. In particular, the study examines the effects of a household's involvement in off-farm work on farm-input use and intesification namely, fertilizer and improved seed on maize production. The empirical question of research in this paper relate to whether off-farm earnings contribute to the financing of productivity enhancing investments in agriculture especially in credit constrained situations. The results from the study suggest differences in the impacts of off-farm work on input use and intensification across different inputs and off-farm activity types. While the results suggests possible use of off-farm earnings for input purchase especially for those without other forms of credit, the '*combined*' input package seems to represent a substantially greater commitment and one not possibly attractive to those with higher off-farm earnings.

Finally, the third essay seeks to analyze the influence of agricultural and agro-ecological factors in facilitating access to and earnings from the off-farm labor market for these rural households. The study explores how these farm households respond ex-ante to risky production environments and ex-post to unexpected rainfall shocks. Results indicate that these rural households engage in off-farm work as a long-term strategy to deal with anticipated weather risks to their farming operations. Although the results do not show significant short-term engagements as a result of unexpected rainfall shocks, there is evidence of greater reliance on remittance income and petty agricultural wage labor in response to such unexpected rainfall shocks.

This Dissertation is dedicated to My Son Eric, who remained a Source of Joy and Motivation throughout!

ACKNOWLEDGEMENTS

The completion of this dissertation and the entire graduate program would not have been possible without the support and encouragement from several people. I would like to express my deepest appreciation to my Major Advisor and Dissertation Supervisor, Dr. David Tschirley for his total dedication, guidance and support throughout the PhD program. Many thanks for the detailed comments and suggestions that were instrumental in completing this final product. I am also indebted to my guidance committee members; Dr. Eric Crawford, Dr. Scott Swinton, Dr. Valerie Kelly and Dr. John Giles for their diligence in reading my work and offering positive feedback. Thank you all for your individual contribution in bringing this work to completion.

My appreciation to other members of staff in the department; Debbie Conway, Ann Robinson and Nancy Creed, many thanks for all your kindness and help whenever I came to room 202. Thanks Linda Beck, for your patience and help with my laptop. I am also grateful to the department of Agricultural Economics and particularly the Food Security Team for their financial assistance throughout the program.

The support of my fellow students at the department of Agricultural Economics was a treasure; Laura Donnet, Lilian Kirimi, the late Lesiba Bopape, Sarma Aralas, Denys Nzalov, Catherine Ragasa, Elan Satriawan, Kirimi Sindi, Antony chapoto, Ricardo Labata and all others who made my stay in the department enjoyable. Special mention to the late Lesiba Bopape whose positive energy and wisdom helped ease any moments of despair. Thanks to Joshua Ariga for your help in those Stata do files and more so for your positive outlook towards life. Vandana Yadav and Lourdes Martinez, you always made my day!

To my friends Nancy Kariuki and Grace Muna, many thanks for your prayers and emotional support and for those long weekend calls. My appreciation to Muthoni Imungi, and many others whose friendship and fellowship made my stay in East Lansing a memorable time. To May Cho Nai, many thanks for your positive contribution during my last leg of the program.

My special gratitude goes to my family, without whose love, support and encouragement, this journey would not have been completed. Many thanks to my parents, on whose counsel my very foundation is build today. May the good Lord keep both of you ever strong! My appreciation to my sister and brothers for ever standing with me. To Sammy, thanks for constantly checking on me; your calls and text messages kept me uplifted. To my nieces, Anne, Leah and Maryann, you are the best!

My special appreciation to James for your encouragement and support to join the PhD program and especially during those tough moments at the beginning. I owe it to you for ever. And to Eric, you are my hero, thanks for graciously bearing with the stresses of having a student mom and for your great sense of humor even in difficult times. Remember our deal; I will be there for you too when you do yours!

Above all, I thank God for granting me special grace beyond any human understanding, to overcome every obstacle and challenge during the entire period. And unto Him who is able to do exceedingly, abundantly, above what I could ever ask or imagine, to Him alone be the glory now and forever more.

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LIST OF ACRONYMS

TAMPA	- Tegemeo Agricultural Monitoring and Policy Analysis Project
SSA	-Sub-Saharan Africa
PIH	-Permanent Income Hypothesis
OLS	-Ordinary Least Squares
GLS	-Generalized Least Squares
FD-2SLS	-First Difference Two Stage Least Squares
LDV	-Lagged Dependent Variable
LID	-Lagged Income Difference
FD	- First Difference
FE	-Fixed Effects
MVP	-Marginal Value Product
MPT	-Modern Portfolio Theory
CPI	-Consumer Price Index
KG	-Kilogram
OPV	-Open Pollinated seed Varieties
LR	-Log Likelihood
MLE	-Maximum Likelihood Estimation
SD	-Standard Deviation
CV	-Coefficient of Variation

INTRODUCTION

Although global poverty has generally fallen in the last 40 years, progress in Sub-Saharan Africa (SSA) has been slow and uneven. The number of people reported as living on less than a dollar a day (the internationally agreed definition of absolute poverty) has doubled over the past 20 years (World Bank, 2005). This has left many questions as to the best strategies that should be used to deal with the problem, spurring numerous research interests and massive donor funds to be used. The fight against poverty however remains an elusive goal.

Poverty is often viewed as a predominantly rural phenomenon. About 75 percent of the worlds poor are believed to work and live in rural areas (Rahman and Westley, 2001), and it is estimated that, by the year 2020, 60 percent of the poor will still be rural. In Kenya, nearly half of the rural population live below the poverty line (Republic of Kenya, 2007) with meager incomes incapable of sustaining any meaningful livelihood. Even worse, poverty rates in some regions have been on the increase since the second half of the 1990s. Why? What are the alternative pathways out of poverty, and where should the limited resources be allocated? The answer to this question lies in understanding the causes of poverty and whether/how policy can be used to break the cycle. More importantly is the need to identify and target those who are economically disadvantaged so as to set them up on a positive growth process.

Over the years, there have been different approaches to deal with rising poverty. There is however widespread agreement that agricultural growth, especially in the early phases of development, is fundamental to broader economic growth and to successful poverty reduction. This is because of high concentration of the poor in this sector; its strong growth linkages with the non-agricultural sector and its potential to offer low food prices to the urban poor. Infact, according to Byerlee et al. (2005), agriculture remains important for pro-poor growth even in some middle income countries. In general, however, the relative importance of agriculture declines – and that of the off-farm sector rises with increased population density and rapid economic growth.

In the vast majority of countries in SSA, most agree that agriculture retains its fundamental importance to pro-poor growth[1]. Yet poverty in rural SSA continues to be high and agricultural productivity stagnating, thus limiting potential impacts on poverty outcomes. Also, it is broadly recognized that smallholder households in SSA are quite diversified in their income sources, and that higher income households tend to earn greater shares of their income from off-farm sources. These findings point to the important role that the rural off-farm sector can play in poverty reduction as discussed in World Bank (2008). Under these circumstances, policy makers need a much greater understanding of the actual role of the rural off-farm economy than they typically have. More specifically, there is need to understand the importance of the off-farm sector to household welfare directly through its impacts on incomes and employment, and indirectly through investment of earnings to the farm sector. In addition, as urbanization progresses and the share of off-farm income increases, the rural off-farm sector could be expected to take on its own dynamics, not fully dependent on agricultural growth[2].

Compared to other SSA countries, the rural off-farm sector in Kenya is particularly important for several reasons. First, historically Kenya has had higher fully

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[1]See Byerlee et al. (2005) for a detailed discussion of the different arguments on the future role of agriculture in pro-poor growth and poverty reduction.
[2] According to Byerlee et al. (2005), there is evidence of increasing linkages of the rural off-farm sector to urban industrialization in China and Latin America.

incomes and better rural infrastructure than any of its neighbors, and continues to have substantially higher educational levels. Second, Kenya's agricultural areas have high population densities, which facilitate movement into off-farm activities. At the same time, like the rest of SSA, Kenya's smallholder agriculture and agricultural productivity have been relatively stagnant over at least the past decade.

It is against this background that this study uses a 3-period panel of household level data collected across different regions of rural Kenya with the following three broad objectives, each of which constitute an essay topic. First, to study welfare dynamics of smallholder households in agricultural areas of Kenya with a view to understanding the pattern of income growth, any existence of poverty traps, and the role of education in potentially breaking those traps. Second, to investigate the effects of off-farm work on agricultural intensification, and third, to explore the effect of a region's agro-ecological factors on household diversification into off-farm work, and the ability of households to use off-farm work to buffer the effects of climatic shocks to their farm operations.

Data for this study were drawn from the Tegemeo Agricultural Monitoring and Policy Analysis (TAMPA) Project collected across different regions of rural Kenya[3]. The data consists of a three-period panel covering the 1996/97, 1999/00 and 2003/4 cropping seasons and 1324 households. Although the dissertation uses the broad data set, individual essays are based on slightly different samples. Essay 1 is based on the entire 3-period panel, while essay two uses a smaller sample of maize producers. Although essay 3 uses the entire sample, we exclude 1997 due to some limitations with the off-farm work data. See separate descriptions of the data used within each individual essay.

[3] A brief description of the Tegemeo/MSU data set and sample can be found in Argwings-Kodhek et al. (1999, 2001).

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ESSAY 1: INCOME GROWTH AND MOBILITY OF RURAL HOUSEHOLDS IN KENYA: ROLE OF EDUCATION AND HISTORICAL PATTERNS IN POVERTY REDUCTION

Abstract

This paper explores the key factors that cause changes in the economic wellbeing of rural households in Kenya. We specifically determine the relationship between educational attainment and the initial economic position of households on their income growth and mobility. We use a three-period panel dataset to estimate a dynamic panel data model of income. Results show strong evidence of (low) income persistence for the poor without at least a secondary school education. Similarly, there is evidence of income persistence for those in the low potential areas and a (weak) convergence towards the average for those in the high potential areas. The low income persistence for the poor and uneducated may be evidence of cumulative dis-advantage and possible existence of poverty traps. As expected, higher education seems to reduce income persistence for the very poor and those in the low potential areas but also enhances convergence for those in the high potential areas. This indicates the potential role of education in not only breaking the cycle of poverty for those trapped in it, but also its ability to allow increased recovery from income shocks. Notably, there is no conclusive evidence of the pattern of income growth or the role of education for non-poor households, implying that such may be less susceptible to long-term effects of income shocks in either direction.

Keywords: Income growth; income persistence; convergence; education; Kenya

1. Introduction and Problem Overview

The first Millennium Development Goal (MDG) calls for reducing by half the proportion of people living in extreme poverty and hunger by 2015. Studies of household level poverty dynamics in developing countries offer the prospect of contributing to the attainment of this goal by identifying *how many* people are mired in poverty, *who* these people are, and *what might be done* to pull them out of poverty and set them on a growth path. Yet, reliably answering any of these questions poses substantial analytical challenges. The main one among these has been lack of relevant panel data especially in rural Africa[4], where poverty is immense.

Poverty dynamics studies in Africa have used both expenditure and income as their measure of economic well-being. Studies based on expenditure include Grootaert and Kanbur (1995), Grootaert et al. (1997), Dercon and Krishnan (2000) and Dercon 2004. Baulch and Hoddinott (2000) provide a detailed review of these and other studies in developing countries. Recent studies in Africa that have used income include Gunning et al. (2000), Carter and May (2001), Fields et al. (2003a, 2003b) and Woolard and Klasen (2005). All of these studies are based on short panels (two periods at most), thus limiting the extent to which relevant factors can be controlled for in the quantitative analysis. In this paper, we take advantage of a unique, broadly representative three-period panel data set from rural Kenya to study the pattern of income growth and explore any existence of long term poverty.

In Kenya, studies on poverty dynamics have mainly focused on analyzing poverty transitions and/or determinants of poverty status using discrete income-based measures of

[4] Most poverty dynamics studies in Africa use the Cote d'Ivoire Living Standards Survey (CILSS) for Ivory Coast and the Kwazulu-Natal Income Dynamics Survey (KIDS) data set for South Africa.

poverty (Gamba and Mghenyi, 2004; Kirimi and Sindi, 2006; Muyanga et al., 2006). While knowledge of factors associated with movements into and out of poverty have 'great value in the design of safety net policies', an understanding of how and why households increase their well-being relative to others is important for the design of policies that promote equitable growth (Baulch and Hoddinott, 2000). Also, use of transitions may provide only relative rankings and potentially ignore the life-cycle phenomenon (Baulch and Hoddinott, 2000). A more recent study by Burke et al. (2007) explores movement into and out of poverty using an asset based measure. In some ways, the current study parallels Barrett et al. (2006) who uses non-parametric approaches to draw inferences regarding poverty traps. This study was however carried out in a much localized context both in scale and geographical scope, potentially limiting widespread application and generalization.

This paper explores the key factors that cause changes in the economic wellbeing of rural households in Kenya. We specifically determine the effect of a household's initial economic position and educational attainment on income growth and mobility. Further, the study explores the extent to which education and educational policies could be used to break income persistence and/or enhance recovery from negative shocks, especially for the poor. Given the wide variation in poverty across and within regions, differences in the above impacts across income groups and regions of the country are also explored.

Use of expenditure measures in poverty studies has been widely advocated due to the highly variable nature of income. Expenditure has been considered more stable based on its relationship with consumption. The use of consumption, and hence the importance of linking measures of wellbeing to it, has been mainly based on the concept of consumption smoothing. The justification for using household income as a measure of economic wellbeing has been the perceived inability of poor households to smooth their consumption over time, especially within households facing liquidity constraints (Morduch, 1995; Townsend, 1995) or with a limited asset base.

Using evidence from Ivory Coast and Thailand, Deaton (1997) finds consumption profile to be closely linked to the income profile and argues that the 'life-cycle model overstates the degree to which consumption is in fact detached from income over the life cycle'. In addition, Fields et al. (2003b) indicate that data from India and China does not find consumption to be clearly superior to income as an indicator of long term economic wellbeing. This evidence implies failure of consumption smoothing in some cases, thus confirming the relevance of income dynamics studies within the broader context of poverty reduction research. According to Fields et al. (2003b), the rise and fall of income and consumption experienced by households are the most direct indicators of who benefits from economic development. The choice of income as opposed to a discrete poverty measure is based on the advantages that come with analyzing income as a continuous variable as opposed to categorizing using an arbitrary poverty line, thus losing useful information (Jenkins, 2000; Ravallion, 1996).

Various theories offer alternative predictions regarding the evolution of the economic wellbeing of households over time. The theory of cumulative advantage posits that the economic wellbeing of the initially better-off households becomes better while that of the initially disadvantaged worsens (Fields et al., 2003a). This is based on the premise that wealthier households are endowed with both physical and human capital assets, whose further investment (presumably in high return activities) results in higher incomes. Access to skilled jobs, credit facilities and markets also helps in the accumulation process. At the lower end of the income distribution, cumulative disadvantage may be at work, whereby households without a 'minimum level of human, physical and social assets are confined to a life in poverty' (Fields et al., 2003a). Evidence of *income persistence* for the poor would be consistent with the notion of cumulative (dis)advantage and possible existence of poverty traps.

An alternative theory is based on the notion of convergence of incomes towards the average, thus enabling initially disadvantaged households to become better off and vice versa. The convergence argument is based on the assumption that income shocks do not persist and are not correlated over time. This argument parallels that of the Permanent Income Hypothesis of Friedman which assumes that transitory shocks (both positive and negative) are serially uncorrelated, thus leading household incomes to regress to their expected level in the subsequent period. A more plausible hypothesis would allow for partial correlation between successive transitory shocks, resulting in gradual convergence of household incomes towards their mean level (Fields et al., 2003a).

While the theory of cumulative advantage implies targeting those who are economically disadvantaged, to set them on a positive growth path, it may also be true that some important income shocks are independent, especially for rural households who mainly rely on agriculture, thus permitting quick recovery. Information about the extent to which each process is taking place would especially be insightful when disaggregated at regional level in explaining why households in some regions remain disadvantaged over time. Suffice it to say that both these dynamic processes do potentially take place:

cumulative advantage as a result of using access to various endowments and market- and financial institutions to increase future incomes (while disadvantaged households are unable to do so) and convergence towards the mean given large and uncorrelated transitory shocks.

This study contributes to the existing body of literature in the following ways: First, it adds to the limited empirical studies on income dynamics in sub-Saharan Africa, where poverty is immense. Second, the use of a three period panel enables us to control for the household's initial economic position and still benefit from panel data methods, unlike similar studies that have relied on two period panels. The ability to account for both historical patterns and unobserved factors may provide more reliable estimates of individual effects. Third, unlike any of the studies mentioned earlier, we disaggregate the results by household poverty status and by the region's agricultural potential, thus allowing us to identify differential patterns of income growth. This is potentially important for policy design and targeting. Fourth, we look at how policies in education can be used to break income persistence, especially for those trapped in a cycle of poverty. Finally, we deal with the potential endogeneity of lagged income difference in a dynamic panel data setting, a problem either commonly assumed away or not dealt with exhaustively in earlier studies.

The rest of the paper is organized as follows. Section two discusses the conceptual approach, empirical model and estimation methods. The data used in the study and other specification issues are presented in section three. Section four presents the empirical results and discussion, and section 5 provides a summary of the findings and main conclusions.

2. Methods

2.1. Conceptual Approach

The analytical framework used in this study is adopted from an agricultural household model where we assume that households are maximizing utility from consumption of goods and leisure subject to a cash income constraint[5] given by:

$$Y=\pi_f + w_o L_o + N \qquad (1)$$

where Y is cash income, π_f is net farm profits, $w_o L_o$ is net off-farm earnings and N represents other non-labor income[6]. The maximized profits from the farm are a function of farm wages (w_f), input prices (P_Z), output prices (P_Q), human capital variables (H) and locational and other socio-economic characteristics of the household (G):

$$\pi^*_f = f(w_f, P_Z, P_Q, H, G) \qquad (2)$$

Off-farm wages w_o depend on the human capital assets of the household (mainly education and experience) and nature of the rural economy (E) such that:

$$w_o = f(H, E) \text{ and } H = f(\text{education, experience}) \qquad (3)$$

Combining (1), (2) and (3) above, and accounting for the value of total household time and farm production, we write the full income production function of the household as:

$$Y^* = f(w_f, P_Q, P_Z, H, E, G, N) \qquad (4)$$

[5] Among other constraints e.g. the production technology and time constraints.
[6] Refer to Singh et al. (1986) and Huffman (1991) for a detailed exposition of this model.

which indicates that the full income of a household is dependent on performance at the farm level, endowments and characteristics of the household, and the state of the local economy.

2.2. Empirical Model

An income production function based on equation (4) is estimated to determine the key factors that cause changes in the economic well being of rural households in Kenya. In this study, we use the reduced form version of equation (4) consisting of the exogenous variables in the system and other relevant variables.

In linking equation (4) and the estimated model, we proxy the prices of farm inputs and outputs with distance and market access variables and other exogenous factors that affect the earnings from the farm. We specifically include distance to the major input suppliers (e.g., fertilizer) as an indication of access to farm-productivity enhancing technology. Access to extension service is also accounted for.

In considering the role of participation in the off-farm labor market in income growth, we take account of both the supply and demand factors that enable participation in that market. The ability of a household to engage in the off-farm labor market can be facilitated through enabling access, which further depends on the availability of a vibrant economy within the region and good transportation. This is based on the incentives facing the household in the form of public assets, e.g. good infrastructural development, provision of electricity and telecommunication services, public transport or the proximity of a shopping centre.

The measures of access to the off-farm labor market used in this study include access to electricity and telephone services, the proportion of adults working off the farm and the number of months (in a given year) the head of household was home, among others. The proportion of adults working off the farm can be an indication of the availability of employment opportunities in the area, while the number of months the head was *not* at home could give an indication of the role of migratory labor in rural income growth. Village level distance variables could proxy for the level of urbanization and development in the area. We specifically pick electricity and public telephone as these facilities are only likely to be present in growing rural economies. In addition, the two are likely to have substantial impacts on off-farm employment and growth, such as in small manufacturing and service activities. Other variables such as the presence and condition of the tarmac road, and distance to the market or shopping centre are good measures of connection to the rest of the country/region and a vibrant economy, and also facilitate input delivery and output sale for agricultural activities.

The ability of a household to engage in profitable income earning activities is determined by its endowments of human and physical capital assets. Of major importance here are the human capital assets as proxied by education, experience and household composition. The education variables proxy for individual household's ability to gain access to the off-farm labor market. The education of head of household is important as he is the most likely to seek off-farm employment.

Some distance variables in the model may be endogenous. Probable in this category, are distance to electricity and phone service, since wealthier households may be in a position to bring these services closer to them. While possession of these facilities at the household level may be a function of ones' income, the specific distance variable in this case may be less endogenous as only about five percent of the sampled households had electricity at their homestead while less than one percent had telephone service, implying that such amenities are beyond the means of most of these rural households. Other variables such as distance to tarmac road and shopping center are less likely to be endogenous, since households would have to move to those services, and such movement is relatively limited in rural Kenya[7].

Simple regression models of these distance variables on income support these views; income is not only insignificantly associated with distance to tarmac road and shopping centre, but also with distance to electricity and telephone services (see Table A1.1 in the appendices). As expected though, income did have a significant effect on whether a household had electricity or telephone at home. Nevertheless, to reduce any potential bias in using these distance variables, we use their respective village level means which can be considered relatively exogenous to the household. Note that distance to farm input suppliers may reflect response by input suppliers to the forces of demand which in turn could depend on general incomes in the area and is thus treated likewise.

The empirical specification of the income model, accounting for the initial income level is given by:

$$\mathbf{INC_{it} = \alpha_0 + INC_{it-1}\alpha_1 + X_{it}\delta + G_{it}\lambda + E_{it}\zeta + \epsilon_{it} \qquad i = 1,\ldots,n \quad t=1,\ldots,T \quad (5)}$$

where INC is the real value of income. Included in X are variables related to the household's endowments of physical, social and human capital, G represents locational

[7]The low attrition rate per survey (discussed later in the paper) may attest to this fact. In addition, land purchases/sales are minimal in these rural setups and most land is passed on through generations as inheritance. See Low (1986) for a review of the traditional attitudes and non-market benefits of land in much of rural Africa.

and other socio-economic characteristics of the household, while E include variables that proxy for the state of the local economy.

The inclusion of a lagged dependent variable helps to account for historical patterns and may also serve as control for some omitted variables (Wooldridge, 2003 pp 300). The coefficient on this variable indicates the extent to which income changes in one year persist in future years. While an indication of the pattern of income growth is undeniably relevant, it would be of additional policy importance to assess how education affects income persistence, especially for low income households. For the model to capture such an effect, the coefficient of lagged income must be allowed to vary across households with different educational levels. The education of the head of household is used given that in most cases, the heads are responsible for making decisions for the entire household regarding use of the available physical and human assets.

In addition, the inclusion of the lagged dependent variable enables us to allow for any potential feedback process in some of the included variables. Such a feedback process is plausible, given that income received during the previous period could be invested in starting or expanding some income earning activity off the farm or could be used to improve access to public assets such as telephone service. Thus the inclusion of a lagged dependent variable as an explanatory variable in (5) not only serves to account for historical patterns but also allows flexibility in the assumptions made on the regressors.

Accounting for initial income, delineating the education variable and including the respective interaction term, model (5) above becomes:

$$INC_{it} = \alpha_0 + INC_{it-1}\alpha_1 + Ed_{it}\,\beta_1 + INC_{it-1}{*}Ed_{it}\,\alpha_2 + X_{it}\delta + G_{it}\lambda + E_{it}\zeta + \eta_i + \mu_{it} \quad (6)$$

where: Ed is the education variable and X, G and E are as earlier defined. To control for any omitted time invariant unobserved factors that may potentially correlate with the above variables or other included explanatory variables, we have explicitly accounted for them in the above model as η_i . μ_{it} is a purely random component.

2.3. Estimation

The *dynamic panel data model* (6) has implications on the estimation methods often used. First, the unobserved effects are most likely correlated with the lagged dependent variable (LDV), thus rendering OLS inconsistent. Second, though we could get rid of the unobserved effects through differencing or fixed effects, it is logical that future values of the LDV are potentially correlated with the idiosyncratic error term (Cov $(INC_{is}, \mu_{it}) \neq 0$, for s>t) implying that the within estimation is also inconsistent. This problem also bedevils Generalized Least Squares (GLS), since this method requires strict exogeneity of the regressors. The most viable solution to this problem has been to take first differences to eliminate the unobserved effects and then instrument for the lagged difference variable (Ahn and Schmidt, 1995; Wooldridge, 2002).

$$\Delta INC_{it}=\Delta INC_{it-1}\alpha_1 +\Delta Ed_{it}\beta_1 +\Delta(INC_{it-1}*Ed_{it})\alpha_2 +\Delta X_{it}\delta +\Delta G_{it}\lambda +\Delta E_{it}\zeta +\Delta\mu_{it} \quad (7)$$

Taking first differences of the data eliminates the time-invariant unobservable factors, but this comes at a cost of reducing variation in the regressors (Wooldridge, 2002) resulting in high standard errors. This problem may however be minimized in this case since our panel has three- to four years between each round and thus expected to show much more variability than would be across consecutive years. The first difference approach also helps to explain changes in the economic wellbeing of households.

In this study, and to ensure consistency of the estimated parameters, equation (7) is thus estimated using First Difference Two-stage Least Squares (FD-2SLS) so as to account for the endogeneity of the lagged income difference (LID) in the model. Following Anderson and Hsiao (1982) and Wooldridge (2002), we take advantage of the three period panel and use previous lags of income level (INC_{it-2}) as instruments for the LID variable. Since we can only use one such instrument from our data, we also use lagged mean rainfall deviation as another potential instrument. The rainfall variable provides over-identifying restrictions to allow testing the validity of the instrument set. To account for the potential lack of strict exogeneity of the interaction term with education, we use the lagged interaction term ($INC_{it-2}*Ed_{it-2}$) as an instrument. It is however important to note that the use of previous income levels as potential instruments is only legitimate when there is no serial correlation in the errors (Arellano and Bond, 1991; Wooldridge, 2002), a discussion we present later in this paper.

3. Data and Other Specification Issues

3.1. Data and Sample Area

The data used in this study come from the Tegemeo Agricultural Monitoring and Policy Analysis Project (TAMPA) data set which consists of a three-period panel collected over a period of seven years. The household surveys cover the 1996/97, 1999/00 and 2003/04 cropping seasons. The specific sample used in this study consists of a total of 3972 households (1324 for each year). The panel contains data on economic, demographic and other social characteristics of the households. Table 1.1 presents the description of the variables used in this study including their means and standard deviations.

Table 1.1. Summary Statistics of Variables Used in the Models

Variable Description	Unit	Mean	Std Deviation
Household Income	Ksh ('000)	165	193
Household Demographics			
Education of head	years	6.3	4.9
Age of head	years	55	13.6
Gender of head (male headedness)	1/0	0.84	0.37
% adults working off farm	years	0.36	0.27
Number of adult males	count	2.5	1.6
Number of adult females	count	2.4	1.4
Head completed primary school	1/0	0.53	0.50
Head completed high school	1/0	0.21	0.41
Head with some college education	1/0	0.17	0.38
Public Infrastructure			
Distance to tarmac road	Km	7.72	7.90
Mean distance to input seller	Km	5.93	6.22
Distance to shopping centre	Ksh	9.09	13.3
Distance to extension service	Km	5.39	4.79
Mean dist to electricity & phone	Km	4.53	4.86
Other Variables			
Land cultivated	acres	13.7	16.4
Number of livestock owned	count	18.2	42.5
Months head at home	months	10.4	3.53
Group Membership	1/0	0.78	0.42

No. of Observations=2648

3.2. Specification Issues

Sample Attrition/ Selection Bias

Biases can occur in estimation with incomplete panels. Our survey retained 86% of all households over the three survey periods. Some of the reasons given for exclusion were household dissolution, relocation, refusal to interview, and lack of contact, among others. There would be no selection bias if we could assume that the attrition was a purely random occurrence, but in practice, it is possible that households that were not surveyed could be significantly different from those that remained in the panel. However, previous studies using the same data set did not find significant evidence of any selection bias (Burke et al., 2007). This evidence, and the fairly low attrition rate (about 7% for each survey) allows us to consider attrition in this case as a fairly random occurrence and the nature of those who left the sample unlikely to cause any substantial bias in the results.

Measurement Error

A major source of bias with panel data comes from measurement error, due to the relationship between the explanatory variables and the composite error that includes measurement error. Measurement error could arise when computing final measures of wellbeing. Other sources include a downward reporting bias for income, inaccurate interviewing by enumerator, misreporting by respondents, or data entry mistakes. Many of these types of measurement error could be purely random and so become part of $\mu_{it;}$ others could be constant over time and hence eliminated during differencing.

The most serious estimation biases emanate from systematic measurement errors. For instance, households with high incomes may tend to underreport them (to avoid exclusion from any future income generating interventions) while those with very low incomes may overestimate (to portray an average household and avoid dishonor). However, consistent with the other income dynamics literature in Africa, these data show little mobility at the two extremes of the income distribution compared to middle income households[8]. This evidence suggests that errors among high and low income households could mostly be eliminated through differencing. It is also plausible to expect minimal misreporting among middle income groups (no incentive since they fall within the average household). Further, we believe that thorough training of enumerators and close supervision of data collection and data entry has minimized errors from such sources.

4. Empirical Findings and Discussions

4.1. Characteristics and Mobility of Households across Income Groups[9]

The economic wellbeing of a household is defined not only by the income earning ability but more so the physical and human capital assets that each is endowed with. This trend is evidenced in Table 1.2, which shows the endowments of the households by income quintile. It is clear that each of the physical and human capital assets increases with income, implying that the wealthy are not only able to earn higher incomes, but are also endowed with higher levels of other assets including education. We consider the education of the household head to be minimally influenced by current income since rarely are any of these heads in the school-going age, and participation in adult education in Kenya remains low (Republic of Kenya, 2007). Such causality may however be established through income persistence over generations and inheritance.

[8] See Table 1.3 whose contents are presented and discussed later in the paper.
[9] For a detailed descriptive analysis of the characteristics of these households, see Burke at al. (2007).

Table 1.2. Household Endowments by Income Quintiles

Year	Income Quintile	Mean Incomes (Ksh)	Total land cultivated (acres)	Education of head of household (years)	Value of livestock owned (Ksh)	Value of household and farm assets (Ksh)
2000	Lowest	25246	9.1	4.3	19017	43761
	2	64936	14.2	5.1	26314	72538
	3	108562	12.2	6.1	31984	87056
	4	176770	14.1	6.9	47210	189702
	Highest	421816	21.6	8.2	84143	316794
2004	Lowest	25739	7.3	4.2	17691	66861
	2	68064	9.9	4.9	30980	83463
	3	115561	13.6	6.4	44585	114666
	4	189119	15.3	8.1	63833	207529
	Highest	455967	19.5	9.2	128628	386362
Total	Lowest	25493	8.2	4.3	18354	55311
	2	66500	12.1	5.0	28647	78000
	3	112062	12.9	6.3	38285	100861
	4	182945	14.7	7.5	55522	198616
	Highest	438891	20.5	8.7	106385	351578

Source: Author's study

Interestingly, except for the education of the head, there is a sharp jump in the incomes and other assets of the household between the 4th and 5th income quintiles. This reveals the existence of some very wealthy households in these predominantly poor rural communities. Noteworthy also, is the fact that the very poor as defined by the lowest income category are limited in all their endowments[10] and have least education. This is consistent with observations by Baulch and Hoddinott (2000) that 'poverty reflects a conjunction of low endowments, low returns to those endowments and vulnerability to shocks'.

Further evidence can be seen in Table 1.3 which gives the income quintile mobility matrix for these households between 2000 and 2004. The table shows that 48 percent of households in the lowest quintile in 2000 remained in the same quintile in 2004, while another 25 percent moved up only one quintile. On the other hand, about half of the households that were in the highest income quintile in 2000 remained there in 2004 while another 26 percent moved just one quintile lower. In between though, there is evidence of substantial mobility as earlier mentioned, a fact that could be explained by the ability of these households to move in both directions, unlike the highest and lowest income households. Overall, about 75 percent of all households remained relatively immobile between 2000 and 2004 (38% maintained their status quo while 37% moved only one quintile) with less than 10 percent moving across 3 or 4 quintiles (see Table A1.2 in the appendices).

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[10] Possibly due to negative shocks whose impacts tend to persist or lack of a minimum economic empowerment adequate to push them into a positive growth process.

Table 1.3. Mobility of Households across Income Quintiles

		2004 Income Quintiles				
		1	2	3	4	5
2000 Income Quintiles	1	48	25	15	8	4
	2	23	30	21	17	9
	3	11	25	32	20	12
	4	12	12	21	29	25
	5	4	9	12	26	49

Source: Author's study
N/B: Figures represent the distribution of households (%) from each income quintile in 2000 across the five 2004 income quintiles.

4.2. Econometric Results

General Results

Table 1.4 presents the parameter estimates of the first difference model given by equation (7). For comparison purposes, five different models are estimated, representing different treatments of the lagged dependent variable. Only model 5 involves IV estimation. Model 1 is a first difference (FD) model that represents the most basic type of estimation possible, especially with a two-period panel. This model ignores the role of historical patterns in income determination.

Model 2 shows the results when we include lagged income as a level variable in a differenced model. Three things are noteworthy here. One is that the lagged income variable is not differenced. Second, there is a significant increase in the coefficient of determination from the first model, thus indicating the importance of accounting for the household's initial economic position in an income model. Third, the results show evidence of convergence of income towards the mean, a result that is consistent with earlier studies in Africa that followed a similar econometric approach, namely Grootaert et al. (1997) and Fields et al. (2003a). The reliability of these results may however be in question, as the estimation fails to account for the potential endogeneity of the lagged income variable. Fields et al. (2003b) and Woolard and Klasen (2005) use a similar procedure but also instrument for the endogenous lagged income variable. Fields et al. (2003b) find mixed results with the IV method and alludes to the sensitivity of results to the treatment of the lagged income variable. On the other hand, Woolard and Klasen (2005) find that reversion to the mean is maintained with the IV estimation (i.e., the coefficient on LDV is negative) but the coefficient is greatly reduced for rural areas. While this may be an accurate reflection of the KIDS data, it is also possible that the inability to difference the lagged income variable and/or the validity of the instrument set may be introducing additional bias to the results. Of concern here is the use of assets and number of household earners as valid instruments for the lagged dependent variable in an income model.

Model 3 also accounts for historical patterns by including the lagged income variable, but this time in the initial formulation of the model such that it is differenced with the other variables. This is only possible with at least a three year panel. As in Model 2, the coefficient of the lagged income difference is negative and significant. Models 4 and 5 both interact the LID with education; in the latter, we instrument for the LID and its interaction with education as discussed in the methods section.

Table 1.4. Determinants of Income Growth

Model	1 FD-No LDV	2 FD-with LDV	3 FD-with LID	4 Full-No IV	5 Full - 2SLS
Lagged Income Variable (LDV)		-0.68***			
		(14.31)			
Lagged Income Difference (LID)			-0.58***	-0.48***	0.49*
			(7.11)	(3.99)	(1.80)
LID* Education				-0.02	-0.15*
				(1.62)	(1.95)
Δ Distance to tarmac road	0.66	0.61	-0.00	-0.17	-1.16
	(0.34)	(0.38)	(0.00)	(0.10)	(0.48)
Δ Mean distance to input seller	-1.08	1.00	1.07	0.76	-2.32
	(0.97)	(1.05)	(0.58)	(0.46)	(1.29)
Δ Distance to shopping centre	-0.13	-0.73**	0.48	0.41	-0.34
	(0.30)	(2.19)	(0.96)	(0.88)	(0.66)
Δ Distance to extension service	0.81	1.01	3.67	3.32	-0.34
	(0.34)	(0.57)	(1.46)	(1.40)	(0.12)
Δ Mean dist to electricity & phone	7.30**	4.69**	5.40*	5.48*	6.79**
	(2.21)	(2.28)	(1.78)	(1.87)	(2.05)
Δ Age of head	2.83	3.51*	4.26*	3.78*	-0.36
	(1.05)	(1.87)	(1.89)	(1.86)	(0.08)
Δ Age of head squared	-0.02	-0.02*	-0.03	-0.03*	-0.01
	(0.90)	(1.67)	(1.64)	(1.66)	(0.26)
Δ Education of head	2.41	4.78***	1.54	6.09*	40.50**
	(1.22)	(3.24)	(1.03)	(1.83)	(2.23)
Δ Gender of head (male headedness)	-4.57	29.28**	10.14	16.57	59.47
	(0.25)	(2.50)	(0.50)	(0.94)	(1.31)
Δ % adults working off farm	102.60***	89.17***	74.96***	76.49***	97.93***
	(5.82)	(6.69)	(4.82)	(4.97)	(4.14)
Δ Land cultivated	1.37	-0.14	1.45	1.19	-0.82
	(0.71)	(0.13)	(1.06)	(0.95)	(0.54)
Δ Number of livestock owned	1.27***	0.73***	1.15***	1.12***	0.91***
	(3.93)	(2.95)	(5.41)	(5.65)	(3.73)
Δ Number of adult males	8.89	11.10**	9.74*	10.87**	19.02*
	(1.34)	(2.46)	(1.88)	(2.22)	(1.94)
Δ Number of adult females	12.38**	10.96***	13.11***	12.71***	9.45
	(2.44)	(3.18)	(3.03)	(2.95)	(1.54)
Δ Months head at home	-2.92	-2.08	-2.19	-2.34	-3.73
	(1.53)	(1.23)	(1.51)	(1.62)	(1.51)
Δ Group Membership	11.83	3.66	11.49	10.67	4.69
	(0.98)	(0.45)	(1.16)	(1.12)	(0.34)
year dummy	-32.08***	98.60***	-9.15	-5.73	11.66
	(3.47)	(8.55)	(1.06)	(0.68)	(0.32)
Observations	1324	1324	1324	1324	1324
R-squared	0.09	0.51	0.43	0.44	

Dependent Variable = Δ Income
Robust t statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Source: Author's study

As shown from the results, the parameters from models 4 and 5 show broadly similar patterns, but with important exceptions for the LID. Without accounting for the endogeneity of the LID (model 4), its coefficient is negative and significant and does not vary significantly with education of the head. This implies that households are recovering from income shocks, such that worse off households become better in future periods and vice versa. This result is consistent with earlier studies which find overwhelming support for the convergence of household incomes towards the mean, and suggests that serially uncorrelated gains/losses are a substantial proportion of the full income of households.

The above results however change when we account for the weak exogeneity of the LID (model 5). The coefficient of the LID turns positive and significant and varies significantly with education of the household head. The combined effect however remains positive but insignificantly different from zero at mean education changes (0.43 increase in years of education between 2000 and 2004; see Table 1.5). The positive and significant coefficient of the LID provides evidence of income persistence for those with less education. It is noteworthy that a 3.3 increase in years of education fully eliminates income persistence, after which the coefficient of the LID turns negative. This indicates possible recovery of income shocks for those with higher education.

Table 1.5. Combined Effects of LID and Education at Mean Levels

Table	Model	Variable	Combined effects	F- statistics	p-value
	4	LID	-0.48	19.67	.0000
1.4		Education	5.47	3.37	.0668
	5	LID	0.42	1.59	.2073
		Education	39.88	4.98	.0258

Source: Author's study

The difference in the results given by Models 4 and 5 may not be very surprising and could be explained by looking at the estimation methods applied to both models. The method of 2SLS applied to Model 5 uses only the predicted portion of the suspect endogenous variable; this prediction can be viewed as the permanent income component of full income. On the other hand, the LID variable in model 4 consists of both the permanent and transitory components, the latter part possibly generating the 'reversion towards the mean' phenomenon. The differences in these results justify the use of appropriate estimation methods to enable the drawing of relevant conclusions. In this paper, we take Model 5 as representing the most reliable parameter estimates based on the appropriateness of the estimation procedure that not only accounts for the endogeneity of the LID, but its interaction with education as well. An additional benefit of the approach is that, by eliminating the transitory component of income, model 5 allows us to focus on whether long-term income persistence is present. This argument is fairly consistent with that in Barrett et al. (2006).

The results of the over identification test for the validity of the instrument set used in model 5 and the first stage regressions are given in Table A1.3 in the appendices. The instruments are both individually and jointly significant in the first stage regressions of the two endogenous variables. There is also strong evidence of failure to reject exogeneity of the instrument set.

Specification Issues with Dynamic Panel Data Models

As discussed earlier in section 2.3, the estimation of a dynamic panel data model as given in this study has implications for estimation. The presence of the potentially endogenous lagged dependent variable as an explanatory variable results in inconsistent estimates for many estimation procedures. As discussed by Bond (2002), standard results for omitted variable bias are likely to result in a pooled OLS estimator that is biased upwards while the fixed effects (FE) estimator (and by extension the simple first difference (FD) estimator) is biased downwards, at least in panels with large samples (N) but small/short time periods (T)[11]. Consistent estimates could however be obtained by taking first differences[12] to eliminate the unobserved effects and then estimate using instrumental variables method with lagged values (2 or more periods) of the dependent variable as potential instruments. Thus, in a well specified model, it is expected that the consistent estimator as obtained by the 2SLS method, should lie between the OLS and the FE/FD estimators. Our results (excluding the interaction term) as indicated in the table below seem to follow this pattern. The coefficient of the LDV/LID is clearly biased upwards of the 2SLS estimator for the OLS estimate and downward for the within and simple FD estimate. As expected, the FE and the simple FD estimates are comparable.

Table 1.6. Comparison of the LDV Estimate across Different Estimation Methods (No interaction term)

	(1) OLS	(2) FE	(3) FD-No IV	(4) FD-2SLS
LDV/LID	0.26***	-0.58***	-0.58***	0.08
	(5.85)	(7.11)	(7.11)	(0.32)
Controls	Yes	Yes	Yes	Yes
Observations	2648	2648	1324	1324
R-squared	0.59	0.43	0.43	

Robust t statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Source: Author's study

[11] The inconsistency in the FE estimator vanishes in panels with large T. However, the correlation between LDV and individual effects (part of the error term) in an OLS estimation persists even with large T. See detailed discussions on the sources of these biases in Nickell (1981) and Bond (2002).

[12] First differencing allows for more general violations of strict exogeneity than the within transformation (Wooldridge 2002). Unlike in the latter case, its inconsistency does not depend on time period T.

The consistency of the 2SLS estimator is dependent upon the validity of the instruments which in this case imply that the Inc_{it-2} must be correlated with LID but orthogonal to $\Delta\mu_{it}$. The validity of lagged values as instruments is also dependent upon the time series properties of the data. As mentioned earlier, original errors (without the fixed effects) are assumed to be serially uncorrelated. Arellano and Bond (1991) suggest using a second order test for serial correlation or the Sagan test of over-identifying restrictions. Given that we have only 3 time periods, it was not possible to perform a second order test for serial correlation. However, the general failure to reject the exogeneity of the instrument set and the fact that the 2SLS estimator lies within the expected bounds (between OLS and within estimates) does provide support to the specification and validity of our model.

Another concern usually stems from the level of persistence in the data series. If α_1 is high, use of lagged levels of the dependent variable provide weak instruments. For a pure random walk (α_1=1), the LID is uncorrelated with previous income levels dated t-2 and earlier and such instruments cannot be used to identify the pattern of income growth. Our results show an α_1 between -0.58 and 0.47 for all estimation methods including the autoregressive model without other regressors. The 2SLS estimate of 0.47 reflects some level of persistence in the series but not sufficient enough as to weaken identification. The results of the first stage regressions and the validity of the instruments set does attests to the relevance of the lagged income level in identifying the coefficient of interest in this case.

Disaggregated Results

Though the result of how education can break the cycle of low income persistence for the poor is interesting by itself, deriving policy recommendations requires further analysis as to the level of education that can achieve the required results. Table A1.4 in the appendices presents regression results of model 5 with four different specifications for the education variable: continuous (as in the original model) and three binary variables indicating completion of primary school, completion of secondary school, and at least some college education. Results show that attainment of a primary school education made no significant contribution to household income and also failed to significantly reduce income persistence or enhance convergence. Among households whose head had attained either a secondary or some college education, the respective education variable was positive and highly significant on its own, and also caused large reductions in the positive coefficient for the LID. This is an indication of the role of post-primary education in feeding income growth and also in breaking (low) income persistence for the poor.

Results by Poverty Status: Based on the above findings, Table 1.7 presents the regression results of the models with the binary variable for secondary education, disaggregated by poverty status.[13] For poor households, the coefficient on LID is positive and significant, while the coefficient on its interaction with education is negative and significant. These results show that poor households whose heads have less than a secondary education are locked in a cycle of low income persistence, which is evidence

[13] We use the Kenya Central Bureau of Statistics (CBS) definition of poverty line to define households above and below this line.

of cumulative disadvantage and possible existence of poverty traps. This is in contrast to their counterparts with secondary education that manage to break this cycle and recover from negative shocks and hopefully into a positive growth process. However, for households above the poverty line, there is neither evidence of income persistence, nor the role of education in breaking that persistence; these households may be less susceptible to long-term effects of income shocks in either direction[14]. On its own, attainment of secondary education does not have a significant influence on income growth for those who are non-poor, but has a very large and significant positive effect for the poor.

As for the other determinants of income growth, it seems that having a male head of household positively influences income growth for poor households, but has no significant effect for the non-poor. This could possibly be explained by the reduction of discriminatory practices based on gender for non-poor female heads as compared to their poor counterparts. The proportion of adults working off the farm, which could be an indication of the availability of employment opportunities in the area, shows the same pattern: a clear positive effect for the poor but not as clearly for the non-poor. This is not surprising given that the poor are endowed with less land and other assets hence likely to benefit from other income earning activities and is further an indication of the role of access to the off-farm labor market in rural income growth. These findings are consistent with those of Giles (2006) in studying China's rural labor market.

A similar pattern is observed for the number of months the head stayed home. The higher the number of months the head was at home, the lower the impact on income growth for the poor, which again implies that working away from the farm for the head,

[14] It is possible that incomes for such non-poor households is driven by their (higher) asset holdings.

Table 1.7. Models Disaggregated by Poverty Status

	1 General	2 Below Poverty	3 Above Poverty
LID	0.13	0.32***	-0.01
	(0.53)	(3.02)	(0.01)
LID*Secondary education	-1.43*	-3.07***	-1.15
	(1.93)	(4.36)	(0.84)
Δ Distance to tarmac road	0.44	5.23*	-3.32
	(0.21)	(1.82)	(0.86)
Δ Mean distance to input seller	-0.47	-1.15	2.85
	(0.34)	(0.83)	(0.69)
Δ Distance to shopping centre	-0.17	-0.73	0.35
	(0.39)	(1.42)	(0.23)
Δ Distance to extension service	1.81	-1.23	13.35
	(0.66)	(0.51)	(1.55)
Δ Mean dist to electricity & phone	5.71*	2.78	10.46
	(1.75)	(0.87)	(0.95)
Δ Age of head	2.03	-0.95	13.66*
	(0.77)	(0.18)	(1.70)
Δ Age of head squared	-0.02	-0.01	-0.12
	(1.09)	(0.22)	(1.62)
Δ Secondary education	354.60**	539.79***	475.07
	(2.19)	(4.32)	(1.18)
Δ Gender of head (male headedness)	42.11	87.62**	49.15
	(1.36)	(2.31)	(0.55)
Δ % adults working off farm	108.10***	92.60***	137.76
	(5.05)	(3.71)	(1.34)
Δ Land cultivated	-0.13	-2.01	-2.21
	(0.16)	(1.47)	(1.40)
Δ Number of livestock owned	1.21***	0.73**	2.42**
	(5.39)	(2.14)	(2.42)
Δ Number of adult males	14.54**	1.56	49.77***
	(2.05)	(0.23)	(2.59)
Δ Number of adult females	10.46*	12.12*	19.65
	(1.91)	(1.85)	(0.93)
Δ Months head at home	-2.62	-3.75*	1.42
	(1.31)	(1.75)	(0.34)
Δ Group Membership	5.61	2.48	15.42
	(0.48)	(0.13)	(0.46)
year dummy	-8.60	-27.78**	52.02
	(0.45)	(2.16)	(0.62)
Observations	1324	935	389

Robust t statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Source: Author's study

resulted in positive income gains for the poor. This may indicate the role of migratory labor in rural income growth. The number of livestock owned had positive income effects for both the poor and non-poor, but the amount of land cultivated had no significant influence on either. This latter result is surprising given that we observe a general increase in land cultivated with income, but is consistent with findings from Burke et al. (2007). It is however possible (as may be the case with a few other variables) that the low variability of these variables across the years may cause an insignificant result in an otherwise significant variable.

Results by Agricultural Potential: Considering the pattern of income growth by agricultural potential[15] (Table 1.8), we observe strong evidence of income persistence for those households in the lower agricultural potential areas whose heads had no college training[16]. This persistence is however broken for households with post secondary training (as indicated by the negative coefficient of -0.89 on the interaction term), thus showing evidence of convergence towards the average for such households. This observation is plausible given the low returns to agriculture in the low potential areas and the fact that reduction of income persistence in such areas may only be realized through access to the off-farm labor market, whose entry may require more education and training beyond what a secondary school education may offer. As expected, households in the high potential areas seem to recover from shocks with or without college training. However, those with college training tend to recover faster (coefficient of -1.14) from such income shocks than do their counterparts without this training.

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[15] See the classification of the sample by agricultural potential in Table A1 in the appendices.
[16] Attainment of secondary education was found to result in insignificant results

Table 1.8. Models Disaggregated by Agricultural Potential

	1 General	2 Low Potential	3 High Potential
LID	0.04	0.16***	-0.03
	(0.20)	(2.65)	(0.12)
LID*college education	-1.19*	-0.89**	-1.11*
	(1.94)	(2.41)	(1.84)
Δ Distance to tarmac road	0.19	-0.54	0.63
	(0.10)	(0.22)	(0.24)
Δ Mean distance to input seller	-0.68	0.86	-1.61
	(0.52)	(0.80)	(0.50)
Δ Distance to shopping centre	-0.16	-0.00	0.15
	(0.37)	(0.01)	(0.22)
Δ Distance to extension service	1.44	0.91	5.89
	(0.57)	(0.44)	(0.99)
Δ Mean dist to electricity & phone	6.52**	2.55	11.45***
	(2.24)	(0.70)	(2.59)
Δ Age of head	1.32	0.80	3.67
	(0.54)	(0.26)	(1.07)
Δ Age of head squared	-0.01	-0.01	-0.03
	(0.75)	(0.21)	(1.30)
Δ College Education	321.63**	200.32**	329.15**
	(2.33)	(2.42)	(2.28)
Δ Gender of head (male headedness)	30.55	19.41	47.60
	(1.18)	(0.81)	(1.49)
Δ % adults working off farm	105.78***	122.79***	88.78***
	(5.32)	(4.62)	(3.18)
Δ Land cultivated	0.38	-0.36	0.99
	(0.42)	(0.63)	(0.50)
Δ Number of livestock owned	0.78*	1.01*	0.78
	(1.77)	(1.84)	(1.62)
Δ Number of adult males	12.21*	10.16	10.94
	(1.90)	(1.21)	(1.32)
Δ Number of adult females	9.37*	16.20**	3.28
	(1.77)	(2.30)	(0.48)
Δ Months head at home	-3.01*	-1.52	-4.17*
	(1.69)	(0.68)	(1.85)
Δ Group Membership	1.71	8.79	-5.29
	(0.17)	(0.53)	(0.37)
year dummy	-9.38	17.91	-11.85
	(0.51)	(1.41)	(0.40)
Observations	1324	430	894

Robust t statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Source: Author's study

5. Summary and Conclusions

The results from the study suggest differences in the role of initial economic position of households on rural income growth and mobility, across agricultural potential areas and across poverty status. Overall, rural households in Kenya show evidence (at 10% level) of income persistence, which is broken at higher levels of education. As discussed earlier, this result deviates somewhat from earlier findings from Africa where overwhelming support for convergence of incomes has been indicated, possibly due to the differences in the econometric procedures employed. These differences underscore the importance of using appropriate estimation methods. Disaggregation of these results by poverty status and agricultural potential does however provide some answers and also reveal differences that could be important for policy.

Households below the poverty line and whose head does not have a secondary education show strong evidence of income persistence, which is clearly broken for households whose head had a secondary education. No clear pattern emerges for non-poor households with or without secondary education; the direction of effects does however show faster recovery for those with higher education. The existence of income persistence for the poor and uneducated is consistent with the theory of cumulative advantage and possible existence of poverty traps. This does imply the need for targeting those who are economically disadvantaged so as to set them on a positive growth process. Overall, results indicate the potential role of education in not only breaking the cycle of poverty for those trapped in it, but also its ability to allow increased recovery from income shocks.

A similar pattern emerges for households in the low potential areas where evidence of income persistence is observed. As expected, a much higher education in the form of college training is required to break this cycle of low income persistence; the need for such a high level of education is likely related to high entry barriers into viable income earning activities in the off-farm sector as a substitute to the low returns from agriculture. Higher education in this case enables quick recovery from income shocks for those in the high agricultural potential areas.

The above results indicate the need for policy intervention for the poor and those residing in the low agricultural potential areas. Of importance is the need to enact policies that help break the low income persistence for these households. While the Kenya government pronouncement of free primary education for all children four years ago was a policy step of major importance, our analysis suggests that it is not sufficient to improve income growth, nor is it adequate to break the cycle of persistent low incomes for those trapped in poverty. Investments and programs in education to encourage enrollment and completion of secondary school education are therefore going to be key for future poverty reduction strategies.

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ESSAY 2: OFF-FARM WORK AND FARM PRODUCTION DECISIONS: EVIDENCE FROM MAIZE-PRODUCING HOUSEHOLDS IN RURAL KENYA

Abstract

This paper explores the extent to which off-farm work affects farm production decisions through reinvestment in farm input use and intensification. We estimate farm input demand functions for fertilizer and impoved seed for Kenyan maize producers. The results indicate differences in off-farm work effects across different inputs and off-farm activity types. While the results suggest possible use of off-farm earnings for input purchase especially for those without other forms of credit, the 'combined' input package seems to represent a substantially greater commitment and orientation, one possibly not attractive to those with higher off-farm earnings. Thus, while engagement in off-farm work may allow some partial intensification, it may also compete with farming at higher levels with households shifting their resources to other uses perhaps with higher returns than agriculture. We find the presence of a regular source of earnings to be the driving force behind any reinvestment behavior.

Key words: Off-farm work; Input intensification; Credit; Kenya

1. Introduction and Problem Overview

It has been widely argued that, during early stages of development and in societies where most of the population is composed of rural smallholder farmers as in much of Sub-Saharan Africa (SSA), increased agricultural productivity is necessary to increase incomes of most of the poor directly, and to stimulate the development of the rural non-farm economy (Timmer, 1984; Block, 1994; Reardon et al., 1994; Reinert, 1998; Byerlee et al., 2005). Without such impetus, broader growth in the rural economy will be constrained and poverty reduction much more difficult to achieve.

Three observations are noteworthy in this regard. First, agricultural productivity has stagnated in SSA and, in many instances, poverty is rising (World Bank, 2005). Productivity growth in the smallholder sector has been especially difficult to achieve. Second, research has shown that most households in rural Africa tend to earn larger shares of their income and even higher absolute incomes from off-farm employment (Reardon and Taylor, 1996; Reardon et al., 2000; Tschirley and Benfica, 2001). These findings point to the important role that off-farm employment can play in poverty reduction as enumerated in vast literature (Reardon, 1997; Lanjouw and Lanjouw, 2001; Barrett et al., 2001; Barrett et al., 2005). Finally, agricultural credit for smallholder farmers is severely lacking in most countries of SSA, making it difficult for poor farmers to finance the inputs typically needed for increased productivity (Carter, et al., 2004). This difficulty is especially great for food crops, which lack the institutional arrangements that sometimes relieve credit constraints for cash crops such as coffee, tea and cotton.

While the above studies and many more have made numerous contributions on the role of both farm and off-farm employment to poverty reduction, little is known about the exact nature of the interaction between these two sectors at the household level. Specifically, there exists minimal empirical literature on the relationship between off-farm work and agricultural productivity. At an aggregate level, the relationship between farm and off-farm sectors can be explained through growth of linkages whereby an increase in agricultural productivity increases agricultural output and incomes which spur growth in the non-farm sector (Reinert, 1998). While this is indeed very important for rural development, the design of specific pro-poor policies could benefit from more specific information on the nature of the interaction between farm and off-farm sectors at the household level.

The above observations raise the question of research in this paper: do off-farm earnings contribute to the financing of productivity enhancing investments in agriculture? If so, such income could help drive a "*virtuous circle*" of self-reinforcing growth and serve as an engine of rural transformation. If, on the other hand, off-farm income is primarily used for consumption, investment in household assets, and expansion of other off-farm activities, its contribution to agricultural transformation and thus to broad-based growth and poverty reduction in rural areas will be more limited.

With limited availability of credit for smallholder agricultural activities, productivity growth in the smallholder sector remains a major challenge. Under such circumstances, agricultural intensification may be reliant on cash generated within the household. According to Lamb (2003), households use off-farm work to mitigate the effects of production shocks, leading to greater use of fertilizer. He argues that, to the extent that farmers choose traditional over modern inputs to lower their risk, any mechanism that allows farmers to smooth consumption can be expected to raise the use of modern inputs and increase farm productivity. Consistent with Lamb (2003), we argue apriori that earnings from off the farm may be used to compensate for missing and imperfect credit markets by providing ready cash for input purchases as well as other household needs. These arguments are also consistent with those of Collier and Lal (1984), Reardon et al. (1994) and Barrett et al. (2001). According to Clay et al. (1998), greater off-farm income means more cash available to the household to invest on-farm.

A few earlier studies examining the interaction between farm and off-farm sectors in Africa have been empirical in nature (Collier and Lal, 1984; Haggblade et al., 1989; Savadogo et al., 1994; Clay et al., 1998). These studies look at different aspects of farm investment, and thus have found mixed evidence for the direction of off-farm work effects on farm investment. Savadogo et al. (1994) conclude that non-farm earnings do positively influence animal traction adoption. Clay et al. (1998) find a positive effect of non-cropping income on land conservation investments and an insignificant effect on use of chemical inputs. Reardon et al. (1994), using a capital market perspective, argue that the evidence on the interaction between farm and off-farm sectors is mixed and point to the lack of studies in Africa that explore the 'direction and nature of reinvestment' into the farm. A similar finding was later echoed by Clay et al. (1998).

More recently, analysts have begun to explore more rigorously these relationships, perhaps as a response to the growing need for increased farm productivity and income growth in rural areas. Some of the studies have looked at the effects of off-farm work on farm investment (Ahituv and Kimhi, 2002; Chikwama, 2004; Morera and

Gladwin, 2006) while others have analyzed the impacts of off-farm work on various aspects of farm production decisions (Lamb, 2003; Dusen and Taylor, 2005; Phimister and Roberts, 2006). Though using different approaches and analytical tools, most of these studies, with the exception of Lamb (2003), indicate a negative relationship between off-farm work and agricultural investment/production.

Among those finding a positive relationship, Lamb (2003) indicates that fertilizer demand in the semi-arid tropics of India increases with the depth of the off-farm labor market, thus suggesting some complementarities between the off-farm labor market and own-farm production. In addition, while studying poverty-environment patterns in Chile, Bahamondes (2003), concludes that 'non-farm employment permitted agricultural intensification' that in turn reduced pressure on the natural resource base. A similar finding was echoed by Gasson (1988) who suggested that off-farm work was frequently undertaken to finance debts on the farm, purchase machinery and other farm equipments in addition to other family needs (p.27). See Phimister and Roberts (2006) for a review of other arguments for the two alternative predictions.

In this study, we look at how off-farm earnings affect farm input use and intensification. As with Clay et al. (1998)[17], Lamb (2003) and Phimister and Roberts (2006), the paper analyzes the relationship between off-farm work and fertilizer use in addition to the use of improved seed for maize-producing rural households in Kenya. We however deviate from the above studies by looking at input intensification in a particular crop, maize, thus facilitating more concrete interpretation of results.

[17] Clay et al (1998) analyzes the effects of non-farm income on an aggregate of chemical inputs which include fertilizer, pesticides and lime.

The study uses maize to explore this relationship for the following reasons. First, it is the most widely grown and locally traded crop in Kenya, with 98 percent of households outside of semi-arid areas growing it. Second, the crop uses substantial inputs in form of fertilizer and hybrid seeds and accounts for about 28 percent of gross farm output from the small-scale farming sector. Third, maize is far and away the main staple food in the country. Finally, there is hardly any organized credit system for maize (and most other annual crops), thus creating potential for use of other off-farm sources of cash to finance input purchases. This collection of facts suggests that increased maize productivity is likely to be an important goal for most households, and that maize will be among the first choices for many of them in deciding whether and how to intensify their agricultural production.

This paper adds to the literature in a number of ways. First, it is a contribution to the sparse body of literature that empirically examines the effects of off-farm work on agriculture. Among the studies reviewed in this paper, only Clay et al. (1998) and Chikwama (2004) were carried out in Africa where increased agricultural productivity is much needed and credit limited. The current paper adds to this course. Second, the paper distinguishes the effects of different types of off-farm work on agricultural intensification. Finally, by using a particularly rich data set, the analysis controls for a number of other relevant household and locational characteristics frequently omitted in other studies. In addition, we deal with the possible endogeneity of off-farm work, thus allowing identification of off-farm work effects.

The paper is organized as follows. In section 2, we develop a conceptual model to motivate the rest of the paper and also outline the empirical strategy adopted in the study.

Section 3 decribes the data used in the analysis. The econometric models to be estimated plus the specification and estimation issues are discussed in section 4. In Section 5, the results are discussed and summary and conclusions given in section 6.

2. Theory and Empirical Strategy

2.1 Conceptual Model

We consider a risk averse, single member household engaged in a portfolio of on-farm and off-farm activities. Returns from each activity are uncertain and imperfectly correlated. In a two period decision model[18], the household decides at period t=0 how to allocate its time and previously earned income. Earned cash can be spent on input purchases, on hired farm labor, or can be invested in an off-farm enterprise, among others. The household may also attempt in this initial period to obtain credit. In the second period (t=1), the household earns income and repays credit.

We define an on-farm production function $Q=Q(L^f, L^h, Z; A, H, G)$, where L^f is on-farm family labor, L^h is hired labor, Z represents a vector of purchased inputs, and A, H, and G are vectors relating to agro-ecological conditions, human capital, and other household and locational characteristics, respectively. H embodies both the skills and the orientation of the household. The household is endowed with a fixed quantity of labor time, $L=L^O + L^f$, where L^O represents off-farm labor. In a credit constrained world, credit (CR_0), cash allocated to off-farm activities (C^O), and the quantity of purchased inputs and

[18] We consider two periods, rather than n periods, to simplify the derivations that follow. This simplification should not affect the key implications from the model.

hired labor are determined simultaneously. Purchased inputs and on-farm labor (both family and hired) are assumed to be complements in production[19].

The household's objective is to maximize the risk-adjusted discounted total net earnings (Y) from its portfolio; only revenues and costs from the second period are discounted:

$$Y = \left[\frac{R_1}{1+r+\alpha} - C_0\right] + \left[CR_0 - \frac{CR'_1}{1+r+\alpha}\right] \quad (1)$$

Where all subscripts indicate time period, R_1 is total revenue (on- and off-farm), C_0 is total costs (on- and off-farm)[20], r is the household's risk-free discount rate, α is its risk premium, CR'_1 is the nominal value of repaid credit, and all other terms are as previously defined.

Incorporating the production function and time constraint, we have:

$$\text{Max } (Y) = \left[\frac{P_1^Q Q(\cdot) + W_1^O L_1^O(\cdot)}{(1+r+\alpha)} - P_0^Z Z_0 - W_0^h L_0^h(\cdot) - C_0^O(\cdot)\right] + \left[CR_0(\cdot) - \frac{CR_0(\cdot)(1+r')}{(1+r+\alpha)}\right] \quad (2)$$

Where P_1^Q is output price, W_1^O is the off-farm wage rate[21], P_0^Z is the price of inputs, W_0^h is the wage paid to hired labor, $C_0^O(\cdot)$ is cash allocated to off-farm work at period t=0, and r' is the rate of interest paid on any credit the household obtains. The first term in

[19] While this is considered true for the kind of inputs referred to in this study, it is however not necessarily so for all other inputs. Herbicides are clearly an exception.
[20] For ease of exposition, we do not distinguish between capital costs and variable costs for off-farm work.
[21] We conceive this as a general term reflecting both wages and returns to labor in businesses operated by the household.

brackets is the risk adjusted discounted net earnings on- and off-farm, while the second bracketed term is the risk adjusted discounted cost of credit.

Taking first order conditions with respect to Z, we get:

$$Z: \frac{P^Q\left(\frac{\partial Q}{\partial Z}+\frac{\partial Q}{\partial L^f}\frac{\partial L^f}{\partial Z}+\frac{\partial Q}{\partial L^h}\frac{\partial L^h}{\partial Z}\right)+W^O\frac{\partial L^O}{\partial Z}}{(1+r+\alpha)}-P^Z-W^h\frac{\partial L^h}{\partial Z}-\frac{\partial C^O}{\partial Z}$$

$$+\frac{\partial CR}{\partial Z}\left(1-\frac{1+r'}{1+r+\alpha}\right)-\lambda\left(\frac{\partial L^O}{\partial Z}+\frac{\partial L^f}{\partial Z}\right)=0 \qquad (3)$$

Where λ is the shadow wage rate. Re-arranging, we find the optimality conditions:

$$P^Z=\frac{P^Q\frac{\partial Q}{\partial Z}}{1+r+\alpha}+\left(\frac{P^Q\frac{\partial Q}{\partial L^f}}{1+r+\alpha}-\lambda\right)\frac{\partial L^f}{\partial Z}+\left(\frac{P^Q\frac{\partial Q}{\partial L^h}}{1+r+\alpha}-W^h\right)\frac{\partial L^h}{\partial Z}+\left(\frac{W^O}{1+r+\alpha}-\lambda\right)\frac{\partial L^O}{\partial Z}$$

$$+\frac{\partial CR}{\partial Z}\left(1-\frac{1+r'}{1+r+\alpha}\right)-\frac{\partial C^O}{\partial Z} \qquad (4)$$

Equation (4) indicates that at the optimal solution, inputs should be used up to the point where the risk adjusted discounted marginal value product (MVP) of inputs equals its price. The first term on the right is the risk adjusted discounted marginal value product of inputs without taking into account imperfections in labor and credit markets. We denote this MVP'_Z. We find that accounting for the risk associated with earnings reduces MVP'_Z, thus resulting in decreased input use. More specifically, MVP'_Z is decreasing in the variance of returns to input use and in the correlation of those returns with returns from the existing portfolio. Using the familiar Beta approach (Boardman et al., 2001 pp 251), we can represent the risk premium as:

$$\alpha = [E(r_m) - r_f]\beta_j \tag{5}$$

where:

$$\beta_j = \frac{Cov(r_m r_j)}{Var_m} = \rho_{jm}\frac{\sigma_j}{\sigma_m} \tag{6}$$

Where *r* denotes a rate of return, subscripts m, j, and f refer to the portfolio, the investment/activity of interest, and a risk-free asset, respectively, E is the expectations operator, ρ denotes a correlation coefficient, and σ denotes standard deviation. β_j (and hence α) increases – and MVP'_Z declines -- with the variance of returns of the investment of interest (as indicated by σ_j) and with its correlation with the existing portfolio (ρ_{jm}).

Terms two through four in equation (4) capture the effects of labor market imperfections. Examining the second term, the bracket is the risk adjusted discounted marginal value product of family labor on the farm minus the shadow wage rate. This value is multiplied by the marginal effect of inputs on family labor use on the farm (assumed positive, as the two are complements). Assuming household input choices do not affect input prices, the bracketed term is non-negative, and will equal zero if the household is able to optimize its time allocation. If non-zero, this term is decreasing in risk. The same logic applies to the third term: an optimizing household will not pay hired labor more than its risk adjusted discounted marginal value product, and the term is thus either equal to zero or, if non-zero, is decreasing in risk.

By the same logic, the fourth term will be either zero or *negative*, since $\partial L^O / \partial Z$ is expected to be negative. However, because few households in sub-Saharan Africa hire in farm labor, $\partial L^O / \partial Z$ for most households will (by the labor constraint) be comparable in absolute value to $\partial L^f / \partial Z$. As a group, therefore, we expect terms two through four to be positive or zero and, if positive, to be decreasing in risk. These terms thus reinforce the effect of risk seen in the first term, implying that demand for inputs will decrease with the variance of returns to their use and with their covariance with the existing portfolio.

The fifth and sixth terms capture imperfections in credit markets. The partial derivative in the fifth term is positive, and the bracketed term is positive or zero: a household will not pay more than $r + \alpha$ in interest, and perfectly competitive credit markets dictate $r' = (r + \alpha)$. Demand for inputs will rise for households able to obtain credit at rates below $(r + \alpha)$. An example here would be for households that belong to farmer groups/cooperatives which generally provide inputs at lower cost through bulk buying and lower borrowing rates. Finally, perfectly competitive credit markets will allow decisions on purchase of inputs and investment in an off-farm enterprise to be made independently, driving both these terms to zero.

Note that including off-farm considerations, as captured in terms four (negative) and six (positive), has an ambiguous effect on input use.

In general, anything that increases (decreases) the right hand side of equation (4) will increase (decrease) demand for inputs. Thus, in addition to the above, we can also generate the following expectations regarding MVP'_Z. First, it is increasing in A by the definition of A. Second, MVP'_Z is ambiguous in education (a key component of H): while education should increase skills that would increase the efficiency of input use, it may also reflect a greater orientation away from agriculture towards off–farm activities, which would tend to decrease input use efficiency.

To evaluate the implications of the above theoretical model on farm input use, we solve the resulting first order conditions with respect to all the choice variables to derive input and labor demand functions. In particular, the input demand function defined by the vector of inputs Z is given by:

$$Z^* = f(W^h, W^O, P^Z, P^Q, CR, A, H, G) \quad (7)$$

2.2. Motivation and Empirical Strategy

From Modern Portfolio Theory (MPT), diversification involves the reduction of market risk through investment in several instruments with imperfectly correlated returns. Thus, in making decisions on whether to invest earnings from off-farm into farming activities, our conceptual model shows that farm households consider how the anticipated returns may be correlated with their current portfolio. Risk-averse households are likely to prefer portfolios with activities whose individual returns are uncorrelated or negatively correlated. Since diversification does not eliminate all variance (Markowitz, 1952), the optimal portfolio is a trade-off between expected returns and associated risk. On the margin, a household's propensity to invest off-farm earnings into farm intensification will depend on 1) the expected returns from intensification (and their variance) as dictated by agro-climatic conditions and the household's aptitude for farming and 2) the correlation of those returns with the existing portfolio; of special interest here is the type of off-farm activity already in the portfolio, and its relationship to farm activities.

The fact that off-farm activities may differ in their relative returns and riskness, and more importantly in how they relate to farm activities, is an indication that the probability that earnings from these activities will be invested in agriculture may also differ by type of off-farm activity. This is implied in equation (4) by the fact that for a given risk preference, different portfolio composition may lead to different levels of risk premium and thus different implications for input use. In this study, and guided by both data and the perceived levels of ρ_{jm}[22] hence β_j and α for different off-farm work types, we explore the impacts of three different types of off-farm earning activities, based on their stability and likely correlation between their returns and returns to agriculture: salaried labor/pension, remittances, and other business and service activities.

Salaried labor/pension: Salaried wage labor and pensions have relatively high returns, low risk and low correlation with earnings from agriculture: these activities are unlikely to suffer from shocks such as weather that impact farming, and will on average depend less on local demand (which is driven to a great extent by agricultural outcomes) than other types of off-farm activities. Thus, we expect households with salaried wage (part of

[22] Data shows correlations of 0.1344, 0.0490 and 0.0298 of crop income with informal business, salaried wage and remittance income, respectively. Only the correlation with informal business is significant at 1% level.

portfolio m) to have a lower β_j and hence lower α as compared to households with informal business activities. For a given risk preference, expected return and activity mix, households with salaried income may be more willing to take on the risk of modern inputs[23] than those with informal business and remittance income[24].

Remittances: Remittances are likely to be a heterogeneous category, because the level, timing and volatility of income from this source for the receiving households depends on the characteristics of the remitter, including their relationship with the household, and on the characteristics and geographical location of activities they engage in. Overall, we expect this source of income to be more uncertain than income from salaries/pensions. However, specific impacts will depend on the above three issues and the expected returns from agriculture. For example, a salaried head of household living away from the family may remit higher amounts on a regular basis, hence facilitating investment into agriculture. Similarly, since remittances could come from an explicit strategy of migratory labor to spread risk over space, the low correlation of such earnings with local agriculture could imply potential reinvestment behavior into agriculture. Because we do not have information on the remitter and the activities they are involved in, the expected effects of this category remain an empirical question. We can however draw a priori expectations from Collier and Lal (1984) who found that in Kenya, remittance income

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[23] Though the use of fertilizer and improved seed is likely to increase both the expected returns and the variance of those returns, there are other important non-monetary gains from investing in farming such as food security which can affect the above expectations.

[24] The broader point is that salaried income will most likely allow investment in two types of activities: those with higher return and higher risk, and those with a longer time horizon, such as education or mortgage payments. Investment in hybrid seed and fertilizer is one example of the first type, but of course is not the only type of investment that will be more likely due to the presence of salaried income.

from urban wage employment was being used to finance farming activities resulting in increased agricultural incomes.

Other business and service activities: This classification includes several types of activities such as agricultural wages (typically seasonal, low wage work on neighboring farms), trade, manufacturing, and services. The expected returns, relative riskiness and correlation with agriculture may differ with specific activity types, but generally, the returns from these activities will be less stable than salaried wages. They are also more likely to depend on local demand, meaning that returns are expected to be correlated with returns to the dominant income source in the area. Reinvestment of income from these activities into farming may thus be expected to increase with: 1) the share of off-farm earnings in total cash income in the geographical region, and 2) the expected returns from farming as determined by the agricultural potential of the region. However, given that low potential regions (with low expected returns from farming) tend to have high shares of off-farm income[25], the net effect of these counteracting forces becomes an empirical question.

3. Data

Data for this study were drawn from the Tegemeo Agricultural Monitoring and Policy Analysis Project (TAMPA) data set. It consists of a household level panel collected during the 1999/00 and 2003/04 cropping seasons by Tegemeo Institute, Kenya. The specific sample used in this study consists of 1832 observations i.e. 916 maize-

[25] Mean off-farm shares for the low and high potential regions are 46% and 35% respectively. Much wider differences exist with more disaggregated data (see Table A2.1).

producing rural households for each year. The households included in this analysis live in regions that have bimodal rainfall patterns, which enables the assessment of the impact of income earned in the previous season on current use of inputs within a given year (see later discussion on endogeneity). Because the "high potential maize zone" of the Rift Valley has a single cropping season (higher altitude means that maize takes much longer to mature), we were unable to use this part of the sample. The sample that we did use accounted for 66 percent of all farms, 45 percent of the total value of fertilizer use during 2003/04, and includes high potential areas such as the Central and Western Highlands, low potential areas such as the coastal, eastern, and western lowlands, and other medium potential areas. The data contains information on economic, demographic and other locational characteristics of the households.

Table 2.1 presents the description of variables used in this study including their means and standard deviations. The dependent variables include the binary input adoption variables and the intensity of use as given by the amount used per acre for both fertilizer and hybrid seed. Given the nature of the problem, we use off-farm earnings in place of wages (w_o) as indicated in equation (7). Prices of inputs and all cash values are adjusted for inflation (to 2004) using the respective consumer price indices (CPI). The binary variable for agricultural potential was constructed based on agro-regional zones[26] as defined in the TAMPA data set. Based on maize productivity in low- and medium-high altitude areas, the lowlands were assigned to the low agricultural potential areas while the highlands were put in the high agricultural potential areas. See Table A1 on the TAMPA sample and its distribution across Kenya in the appendices.

[26] These agro-regional zones were created by Tegemeo during sample design and are based on agro-ecological zones and population densities.

Table 2.1. Summary Statistics of Variables used in the Models

Variable Description	Type	Unit	Mean	Std Deviation
Adoption and Intensity Measures				
Fertilizer Amount	continuous	kg	14.5	32.19
Hybrid seed Amount	continuous	kg	2.4	5.16
Fertilizer adoption	binary	1/0	0.36	0.48
Hybrid Seed adoption	binary	1/0	0.31	0.46
Fertilizer and Seed adoption	binary	1/0	0.25	0.43
Monetary Incentives				
Price of fertilizer	continuous	Ksh/kg	30.02	6.71
Price of hybrid seed	continuous	Ksh/kg	120.10	19.65
Price of other seed	continuous	Ksh/kg	28.30	31.43
Farm wage rate	continuous	Ksh.day	71.85	30.94
Price of maize	continuous	Ksh/kg	13.08	1.87
Presence of major cash crop	binary	1/0	0.29	0.45
Income sources(previous season)				
Agricultural Cash Income	continuous	Ksh('000)	33.07	58.48
Off-farm Earnings	continuous	Ksh('000)	22.96	42.07
Informal Income	continuous	Ksh('000)	9.60	24.13
Salary/pension Income	continuous	Ksh('000)	12.02	30.75
Remittances	continuous	Ksh('000)	1.33	5.23
Public Infrastructure				
Distance (fertilizer seller)	continuous	km	3.96	5.62
Distance (seed seller)	continuous	km	3.68	4.86
Agro-ecological conditions				
Main (planting) season	binary	1/0	.26	.44
Agricultural Potential	binary	1/0	.48	.49
Long-term rainfall mean	continuous	mm	946.19	256.85
Demographics				
Age of head	continuous	years	55.27	13.51
Male head of household	binary	1/0	.81	.39
Number of adults	continuous	count	4.72	2.30
Primary Education	binary	1/0	.37	.48
Access to credit				
Group Membership	binary	1/0	.82	.38

No. of Observations=1832

Group membership is a binary variable representing whether a household belonged to a farmer cooperative/group or not. We use this variable to proxy for access to credit given that nearly all agricultural credit was received through cooperative societies: in the 2003/04 survey, 96 percent of those who received agricultural credit were members of a cooperative society.

The table shows that about 36 percent of households in our sub-sample used fertilizer and 31 percent used hybrid seed, while about 25 percent used both inputs during the period under consideration. Table 2.2 shows that adoption rates for hybrid seed and the combined package are clearly lower for those households with off-farm work (any type) than for those without. A similar pattern is observed for fertilizer though the difference in means is not significant. When disaggregated by type of off-farm work, informal business and remittances follow a pattern similar to overall off-farm work. This is in contrast to the pattern that emerges with salaried wage and pension. We observe a higher proportion of households using both fertilizer and hybrid seed for those households with salaried wage and pension than for those without.

Table 2.2. Fertilizer and Hybrid Seed Use by Type of Off-farm Work

Type of off-farm work	Fertilizer		Hybrid Seed		Fertilizer and Hybrid Seed	
	Adoption (% of hhs)	Intensity (kg/acre)	Adoption (% of hhs)	Intensity (kg/acre)	Adoption (% of hhs)	Intensity (Ksh/acre)
Any off-farm work						
No	0.39	43.65	0.36	7.84	0.28	2466
Yes	0.36	38.40	0.30	7.63	0.24	2387
t-value	1.17	1.34	2.18**	0.32	2.03**	0.29
Salary/pension						
No	0.34	40.86	0.30	8.02	0.23	2515
Yes	0.43	37.67	0.34	7.03	0.29	2218
t-value	-3.60***	0.96	-1.85*	1.91*	-2.82***	1.28
Informal/business						
No	0.41	40.94	0.35	7.58	0.29	2344
Yes	0.32	38.27	0.27	7.82	0.21	2492
t-value	3.59***	0.80	3.61***	0.43	3.77***	-0.56
Remittances						
No	0.37	40.79	0.32	7.77	0.26	2436
Yes	0.36	35.53	0.27	7.32	0.20	2272
t-value	0.33	1.29	2.02**	0.62	2.29**	0.54

N/B: Quantity figures represent amount of inputs used among those using. The t-value represents the tabulated t for the difference in the means for each respective category while *** significance at 1%, ** significance at 5% and * significance at 10%

In the past, Kenya has been categorized as a high cost maize producer relative to neighboring countries such as Uganda (Nyoro et al., 2004). Among the reasons for this lack of competitiveness are high cost of farm inputs, low seed quality and a weak extension system. Nyoro et al. (2004) show that fertilizer and seed expenses account for about a third of the total cost of production for most production systems. Yet previous studies (mostly using this data set) have clearly shown that fertilizer use remains profitable in most agricultural areas of Kenya (See Wanzala et al., 2001 for a brief review of these studies). In addition, data presented in Muyanga et al. (2005), show relatively high maize fertilizer productivity (maize output/kg of fertilizer) even for the lowland areas. Although maize is the most fertilized crop, intensity of use tends to be less than on high-value and export crops (Nyoro et al, 2006), a factor that has been identified as limiting maize productivity. This has called for an effective extension system to educate farmers on the appropriate fertilizer types and recommended levels of use.

One of the factors hampering the adoption of hybrid seed and its relative profitability has been a decline in seed quality (Nyoro et al., 2004; Ayieko and Tschirley, 2006). This is indicative from the TAMPA data set, which shows declining use rates and intensity for hybrid seed between 2000 and 2004[27]. According to Ayieko and Tschirley (2006), a large share of seed used in Kenya is from the informal sector with no clear certification procedures. This scenario has potential for opening up room for production of low quality seeds, an issue that not only raises the relative cost of production as yields decline, but also acts as disincentive to use of improved seed.

It is also possible that hybrid seed is being used in areas less suited to its use. It has been shown that a higher maize output per unit of seed can be achieved in some regions like the lowlands and some of the highlands when open pollinated seed varieties (OPV) are used as compared to hybrid seed (Muyanga et al., 2005). Also, in comparing Ugandan and Kenyan maize production systems, Nyoro et al. (2004) concludes that Ugandan households achieve higher profitability using OPV and lower levels of fertilizer than their Kenyan counterparts who mainly used hybrid seed and higher levels of fertilizer. Though it would have been insightful to estimate input demand functions for OPV, the limited number of cases available thwarted any such efforts. Only about 10% of reported seed type was OPV. Local varieties formed about 37% of the total reported cases.

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[27] Adoption of hybrid seed for our sample households declined from 35% to 28% (8.4 kgs to 6.7 kgs for intensity among those using) between 2000 and 2004.

4. Model Specification and Estimation

4.1. Econometric Model

Input demand functions based on equation (7) were modeled to determine the factors that drive farmer's decision to use inputs and to assess how engagement in off-farm work affects this decision. Separate regression models for fertilizer and hybrid seed are estimated, each with aggregated and disaggregated off-farm work types. The timing of cash flow from the off-farm sector and farm input requirements are harmonized by considering the impact of past earnings on current use of farm inputs. To ensure identification of the coefficients of interest, we control for the economic incentives facing the households, household resource endowments, investment in public infrastructure, credit availability, other income sources and agro-ecological and locational characteristics of households.

Input prices were included to control for variations in input use as a result of changes in economic incentives facing households. We included the previous season's price of maize based on a naive expectations model of farmer decision making. Previous cash income from agriculture is included as a control for other potential sources of income to finance input purchases, and also to capture the household's capacity and orientation towards agriculture. Presence of a major cash crop[28] in the household was included to capture how this affects input intensification of food crops like maize. Distance to the respective input seller was included to proxy for the cost of transport from the input supplier to the farm.

[28] Major cash crops include tea, coffee and sugarcane, all of which involve long term investments that households cannot easily move in and out of.

The data used in this study run across areas of differing agricultural potential and planting seasons; we include dummies to allow for the regression intercept to vary across each. We expect input use to be higher during the 'main' season and in the high potential areas as discussed in section 2.1. The inclusion of the long term (village) rainfall variable helps control for heterogeneity within zones of broadly comparable agricultural potential.

To control for the availability of inputs through credit, we use membership in a cooperative society or any such group as discussed earlier. It is noteworthy that these groups tend to provide inputs on credit to cash crop growers, but experience has shown that there is a spillover effect to cereal and other food crops. It is therefore expected that households that are members of a group will have a higher likelihood of using these modern inputs and may use them more intensely when they do. The period dummy is equal to one for 2004 and captures any trend in input use as a result of external factors common to all households.

We control for household resource endowments and characteristics using the education, gender, and age of the head of household. Education is captured in a dummy variable for whether the household head had acquired a primary school education or not. We control for experience using age and include gender (male headedness) to assess whether and how the regression intercept changes between male and female head of household who is assumed to make decisions on input use. Consistent with other studies (Lamb, 2003), our conceptual model assumes that input use and farm labor are complements[29] in production, thus we include number of adult household members to control for labor availability.

The model allows the coefficient of off-farm work to differ across agricultural potential, group membership and households with and without primary education. With the exception of the interaction with group membership, we cannot form clear apriori expectations on the other two variables, for several reasons, First, while education may imply more specialization in off-farm work, the ability to get earnings from these activities may also allow households to take on more risk from agricultural production. However, based on extensive literature showing higher returns to education in the off-farm sector (Huffman, 1980; Yang, 1997), it is plausible to expect that, holding all other factors constant, more educated households may prefer to invest their off-farm earnings outside their farms. Second, although households in high potential areas may generally invest more in input use (given the higher expected returns), it may be difficult to isolate the specific off-farm work effects from these general effects. Further, given the argument presented earlier, we expect households with some group membership and hence access to some credit, to rely less on their off-farm earnings to finance farm intensification.

Following the above discussion, the basic model for estimation is given by:

$$Z_{its} = \beta_0 + \beta_1 OFE_{its-1} + N_{its-1}\beta_2 + M_{its}\beta_3 + \gamma I_{its} * OFE_{its-1} + \delta_0 d04_t + \epsilon_{its} \quad i=1,..,N \; t=1,2 \; S=1,2 \qquad (8)$$

[29] Though not much additional labor would be needed during planting, demand for harvest and topdressing (if any) labor would clearly go up. Also, timely weed control is a critical factor affecting fertilizer profitability.

Where Z_{its} represents different aspects of input intensification namely fertilizer and hybrid seed use per acre for household i in period t and season s. OFE_{its-1} represent previous season's off-farm earnings, N_{its-1} include variables that control for other sources of income in the previous season, M_{its} is a vector of all other exogenous variables affecting Z which includes input prices, characteristics of the head of household, distance variables, group membership and other locational and agro-ecological characteristics of the household, I_{its} include variables in M that are interacted with off-farm earnings; $d04_t$ is a time period dummy and ϵ_{its} is the composite error term.

4.2. Specification Issues

Zero-expenditure (non-adoption)

If every household in the sample were observed to have used the respective inputs, estimation of model (8) would have been achieved through the standard panel data methods (fixed or random effects). However, Table 1 showed that only 36% and 31% of households used fertilizer and hybrid seed, respectively. Equation (8) can thus be visualized as a latent variable[30] model given by:

$$\mathbf{Z^*_{its} = \beta_0 + \beta_1 OFE_{its-1} + N_{its-1}\beta_2 + M_{its}\beta_3 + \gamma I_{its}{*}OFE_{its-1} + \delta_0 d04_t + \epsilon_{its}}$$

Such that $Z_{its} = Z^*_{its}$ if $Z^*_{its} > 0$ and

[30] Unlike in sample selection problems, we place less emphasis on the latent variable in such a corner solution outcome given that our interest is in the conditional expectation of Z (Wooldridge, 2002 pp.520)

$Z_{its} = 0$, otherwise

Thus our model becomes:

$$\mathbf{Z_{its} = max\ (0,\ \beta_0 + \beta_1 OFE_{its-1} + N_{its-1}\beta_2 + M_{its}\,\beta_3\ + \gamma I_{its} * OFE_{its-1} + \delta_0 d04_t + \epsilon_{its})\ \ (9)}$$

Model (9) defines the usual Tobit model. This model however suffers from the following major limitation. It postulates that the decision to use an input and the amount used are defined by a single mechanism (Wooldridge, 2002). This implies that not only does the same set of parameters and variables determine both the discrete probability of adoption and the intensity of use, but that the magnitude of effects are identical.

The "*double hurdle*" model helps to relax the above assumption. The specification enables the modeling of two separate decisions in this case: the decision to use an input and the intensity of use. To observe a positive level of input use, the model postulates that two separate hurdles must be passed. First, the household must decide to use the input or not, and second, conditional on the first hurdle, the household allocates some cash to purchase a specified amount of the input. Model (9) can thus be defined using two latent variables, Z^*_{its1} and Z^*_{its2}:

$$\mathbf{Z^*_{its1} = X_{its}\pi + \mu_{its}} \qquad \mathbf{(10)}$$

$$\mathbf{Z^*_{its2} = Y_{its}\,\lambda + \eta_{its}} \qquad \mathbf{(11)}$$

Where $\mathbf{Z^*_{its1}}$ denotes the unobservable individual household propensity to use the respective input as defined by a Probit model and $\mathbf{Z^*_{its2}}$ is a latent variable that describes the intensity of input use. X and Y represent the vectors of explanatory variables that affect the two decisions as given in model (8). μ_{its} is assumed to be distributed as N(0,1) and η_{its} as $N(0, \sigma^2)$.

Endogeneity:

We can potentially envision simultaneity of off-farm work and farm production and investment decisions: while input use could depend on earnings from off-farm work, involvement in off-farm work could be triggered by financial need for farm inputs or unemployment of family labor. In addition, involvement in off-farm work could compete for labor and capital with farming activities especially where input markets are missing. To eliminate these potential endogeneity problems, we consider the impact of off-farm earnings during the previous season on current farm input use and intensification.

Given the difficulties in controlling for unobserved heterogeneity in non-linear models like the ones in this study, we can expect potential biases in some of the estimated parameters especially for those variables that may correlate with the farmer's innate ability and unmeasurable land characteristics e.g. inherent soil quality that may impact on input use. One such variable would be education, whose coefficient may have an upward bias, but given that this coefficient remains insignificant (see results in Table 2.3 and 2.4), the impact of this bias may be limited. The coefficient of agricultural cash income may be positively correlated with soil quality which may negatively affect input use. This implies that this coefficient as observed may be biased downwards. However, that this coefficient remains positive and significant is an indication that any bias would only reinforce the basic result.

4.3. Estimation

There are two formulations of the double hurdle model depending on the assumed distribution of the second stage. Using the value of the log-likelihood, we rejected the log-normal formulation in favor of the truncated normal regression. The advantage of the truncated normal distribution version or the so called hurdle model of Cragg (1971) is that it nests the usual Tobit, thus allowing us to test the Tobit formulation hypothesis. Given the results of the likelihood ratio (LR) test in Table A2.2, the Tobit model specification is rejected in both fertilizer models but not in the hybrid seed models. Failure to reject the Tobit model implies that the Tobit results are not significantly different from when the assumed restrictions do not hold and is thus equally well specified for the hybrid seed models.

Under alternative assumptions, the two stages of the double hurdle model can be estimated separately or jointly. Estimation of the two stages separately is based on the assumption that there is no correlation between the errors in the two stages implying that the two decisions are made independently of each other. The LR test for this hypothesis strongly rejects the composite model in favor of joint estimation which allows for correlation between the two stages (see Table A2.3).

Following the discussion above, each of the two stages of input demand functions for fertilizer and hybrid seed were estimated jointly using maximum likelihood estimation (MLE) procedures. Although theory does not clearly point to the necessity of imposing exclusion restrictions in the double hurdle model (as with the Heckman model), we exclude distance to the respective input supplier in the second stage of the estimation. This is plausible given that distance traveled may be largely a fixed cost for the second hurdle, and is thus unlikely to affect the quantity decision[31]. These findings are consistent with those of Ariga et al. (2006).

5. Empirical Findings and Discussion

Tables 2.3 and 2.4 present the joint MLE parameter estimates of both stages of fertilizer and hybrid seed demand, respectively using aggregated off-farm earnings. Given the failure to reject the Tobit hypothesis in the hybrid seed models, we report the results from the Tobit model side by side and compare them. The results support the hypothesis that fertilizer adoption decisions are driven by different mechanisms from the intensity decision. This is especially so for variables like cash crop, previous agricultural cash income, planting season, primary education, and gender of head, all of which show clear differences in their impacts between the double hurdle and Tobit model. For example, having a male head seems to positively influence the decision to use fertilizer but has no impact on the level used. On its own, the Tobit model predicts an overall positive but insignificant impact of male headedness on fertilizer use. This coefficient is however uniformly predicted for the hybrid seed model as seen in Table 2.4. A similar pattern is observed with the education variable.

It is noteworthy that both the Tobit and double hurdle models deliver comparable estimates for off-farm work effects in both fertilizer and hybrid seed models. Overall, the Tobit model uniformly predicts (compared to the double hurdle) the impacts of more of its variables in the hybrid seed model than it does with the fertilizer model. This evidence

[31] The mean land cultivated for this sample is about an acre, implying relatively low amounts of fertilizer and hybrid seed purchases (recommended DAP fertilizer and hybrid seed per acre are 50-75kg and 10kg respectively). In addition, the distance variable turns out insignificant in the intensity models.

Table 2.3. Double Hurdle and Tobit Estimates for Fertilizer Demand (Aggregated Off-farm)

	Double Hurdle		Tobit
	Adoption	Intensity	
Price of Fertilizer	-0.1007**	-0.0599***	-1.3511**
	(2.22)	(5.04)	(2.46)
Price of hybrid seed	-0.0032	0.0048	-0.1231
	(0.15)	(1.33)	(0.68)
Price of other seed	0.0113**	-0.0001	0.1180**
	(2.02)	(0.07)	(2.27)
Daily Wage rate for farm labor	-0.0127**	0.0003	-0.2586***
	(2.19)	(0.19)	(3.69)
Price of maize (s-1)	-0.1461*	-0.0247	1.5516*
	(1.91)	(1.51)	(1.95)
Presence of major cash crop	0.8479	0.3619***	16.4725***
	(1.45)	(3.96)	(3.26)
Agricultural cash income(s-1)	0.0142***	0.0026***	0.0071
	(3.24)	(3.55)	(0.26)
Off-farm earnings(s-1)	0.0673***	0.0134***	0.4852***
	(2.65)	(2.92)	(2.76)
distance to fertilizer seller	-0.1268***		-3.4813***
	(3.80)		(4.91)
Main planting season	2.7515***	-0.1296	33.3545***
	(3.19)	(1.62)	(7.01)
Agricultural potential	3.8146***	1.1250***	62.4628***
	(6.62)	(10.84)	(11.80)
Long term yearly average rainfall	0.0003	0.0002	-0.0195*
	(0.20)	(1.21)	(1.82)
Age of head	-0.0292**	-0.0177***	-0.4974***
	(2.29)	(7.61)	(3.64)
Male head of household	1.0920**	0.0501	4.6362
	(2.57)	(0.58)	(0.98)
Number of adult members	0.0015	0.0383***	0.9943
	(0.02)	(2.73)	(1.31)
Primary education	-0.0614	-0.1308*	2.0041
	(0.14)	(1.75)	(0.48)
Group Membership	2.0549***	0.4979***	25.4065***
	(4.29)	(4.11)	(3.99)
2004 period dummy	0.2349	-0.4486***	10.5849*
	(0.45)	(3.06)	(1.67)
off-farm*primary	-0.0031	-0.0009	0.0200
	(0.34)	(0.73)	(0.29)
off-farm*agric potential	-0.0036	-0.0022	0.0365
	(0.51)	(1.57)	(0.51)
off-farm*group membership	-0.0662***	-0.0109**	-0.5677***
	(2.61)	(2.42)	(3.25)
Constant	4.2869	4.7740***	0.7628
	(1.03)	(5.76)	(0.02)
Observations	1832		1832

Absolute z statistics in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%

Source: Author's study

Table 2.4. Double Hurdle and Tobit Estimates for Demand for Hybrid Seed (Aggregated Off-farm)

	Double Hurdle		Tobit
	Adoption	Intensity	
Price of Fertilizer	-0.1390***	-0.0443***	-0.1783
	(4.50)	(3.84)	(1.64)
Price of hybrid seed	0.0032	0.0011	0.0138
	(0.44)	(0.35)	(0.39)
Price of other seed	0.0088**	0.0024	0.0046
	(2.45)	(1.55)	(0.40)
Daily Wage rate for farm labor	-0.0011	-0.0009	-0.0342**
	(0.33)	(0.55)	(2.52)
Price of maize (s-1)	0.1196***	0.0104	0.4809***
	(3.11)	(0.61)	(3.21)
Presence of major cash crop	0.4934	0.0904	4.0627***
	(1.50)	(0.82)	(4.08)
Agricultural cash income (s-1)	0.0045**	0.0000	0.0029
	(2.26)	(0.06)	(0.60)
Off-farm earnings (s-1)	-0.0015	-0.0028	-0.0029
	(0.18)	(0.68)	(0.07)
distance to hybrid seed seller	-0.0783***		-0.2663***
	(3.26)		(2.58)
Main planting season	1.3895***	-0.2487***	7.5674***
	(3.86)	(3.04)	(8.36)
Agricultural potential	1.9443***	0.4922***	9.7837***
	(7.48)	(4.44)	(9.77)
Long-term yearly average rainfall	0.0008	-0.0003	0.0004
	(1.19)	(1.27)	(0.20)
Age of head	-0.0082	-0.0042	-0.0678***
	(1.16)	(1.40)	(2.59)
Male head of household	0.5595**	0.2459***	1.9199**
	(2.50)	(2.59)	(2.08)
Number of adult members	0.0254	0.0307**	0.1660
	(0.66)	(2.02)	(1.13)
Primary education	-0.3034	-0.0209	-0.9143
	(1.37)	(0.25)	(1.15)
Group Membership	0.8108***	0.2285*	3.7035***
	(2.89)	(1.80)	(3.07)
2004 period dummy	-1.8059***	-0.8286***	-2.0115
	(5.20)	(5.95)	(1.63)
off-farm*primary	0.0032	-0.0007	0.0118
	(0.90)	(0.60)	(0.86)
off-farm*agric potential	0.0062*	0.0024	0.0220
	(1.82)	(1.40)	(1.41)
off-farm*group membership	-0.0071	-0.0007	-0.0343
	(0.91)	(0.19)	(0.86)
Constant	1.0163	3.3467***	2.3001***
	(0.50)	(4.35)	(70.33)
Observations	1832		1832

Absolute z statistics in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%

Source: Author's study

plus the general failure to reject the Tobit specification in the hybrid seed models, is not unexpected, given the fact that we expect much lower variability of hybrid seed use per acre, compared to fertilizer. This indicates a possible domination of the adoption decision over the intensity one and thus no significant difference in the two decisions. Table A2.4 offers statistical support for this argument: the coefficient of variation for the value of fertilizer use per acre (among those using) is 1.59, while that for hybrid seed is 0.88[32].

Given the above, we now focus on the double hurdle results, paying special attention to the off-farm work effect and its interactions with primary education, agricultural potential and group membership. We first discuss the results using the aggregated off-farm earnings (Model set I) and then briefly with the disaggregated off-farm work types (Model set II). By and large, the results of the two sets of models are plausible with quite stable coefficient estimates between the aggregated and the disaggregated models. A few key points are however worth noting:

First, the results of the test for the Tobit hypothesis have implications for the estimation methods used, especially for fertilizer. The strong evidence of rejection for the restrictions implied by the Tobit model may cast doubts on estimation results that assume a single mechanism for both the adoption decision and the intensity of use. This underscores the importance of using appropriate estimation methods.

Second, because of the interaction terms, the coefficients on off-farm earnings reflect the effect of that income among households whose heads did not complete primary education, who live in lower potential agricultural areas, and who are not members of any cooperative or group. The coefficients on the interaction terms show

[32] For input quantities, the coefficient of variation is greater than one in nearly all cases of fertilizer and less than one for hybrid seed.

how the above off-farm work effects differ for households with primary education, those in the high potential areas, and those with group membership. Results for the combined effects of primary education, agricultural potential and group membership and their significance are also presented.

Third, the variables for cash earnings from agriculture and from off the farm each embody two factors which can influence household decisions on agricultural intensification. First, they directly capture cash availability with which to purchase the inputs. Second, each variable reflects past decisions of households regarding how to allocate their resources and captures the learning that resulted from these decisions. Households with high incomes from off-farm activities are likely to have a stronger orientation towards them and a greater level of knowledge useful in such activities. Likewise, those with high cash income from agriculture are likely to have a stronger orientation towards agriculture and to have developed greater capacity for it as a result. Indeed, a household's agricultural cash income may reflect the overall strategy and orientation towards cash crops and production for the market in general.

Finally, most of the households using hybrid seed tend to also use fertilizer (see Table A2.4). Thus, while the two inputs are likely complements, the use of hybrid seed more often implies the use of a broader input *package* and thus may be a stronger indicator of intensification than is the simple use of fertilizer. The effects of this difference between the two inputs are clear in the data and are discussed in the results. In addition, and as discussed in the beginning of this section, fertilizer use per acre is more variable than is hybrid seed use. This difference again presents itself in the various results to which we now turn.

From Table 2.3, previous off-farm earnings have a positive effect on both the adoption of fertilizer and the intensity of its use. This implies that, in general and holding other factors constant, households with higher previous off-farm earnings have a higher probability of using fertilizer and use more when they do. In this case, off-farm earnings could be viewed as acting to relax the cash constraint on fertilizer use.

The presence of a household head with primary education does not affect the probability of using fertilizer. It does however affect negatively (at 10% significance), the intensity of use. As expected, households in the high potential areas tend to have a higher probability and intensity of using fertilizer. This is because of the expected higher returns to input use in these regions compared to the lower potential areas. The results in Table 2.3 and 2.5 (below) clearly show that fertilizer adoption and use is greater and highly significant in high potential areas (3.8146 for adoption and 1.1250 for intensity), but that the (still positive and significant) effects (3.7319 and 1.0745 respectively) are slightly less at mean levels of off-farm earnings. Membership in a group seems to increase significantly the probability of using fertilizer and the intensity of use, an observation consistent with expectations.

Table 2.5. Wald Test for the Combined Effects in the Fertilizer Models (Aggregated Model)

	Adoption Model			Level Model		
Variable	Combined Effect	Wald Stat	p-value	Combined Effect	Wald Stat	p-value
Primary education	-0.1326	0.02	0.8792	-0.1515	3.18	0.0744
Agric potential	3.7319	44.04	.0000	1.0745	117.15	.0000
Group Member	0.5349	18.15	.0000	0.2476	12.81	.0003

Source: Author's study

It is important to note that the positive effect of off-farm work on the probability and intensity of using fertilizer does not vary significantly with education of head. In addition, the hypothesis that the impact of off-farm work varies across agricultural potential is rejected for both fertilizer adoption and intensity models. The coefficient of this interaction term is insignificant in both models.

The impact of off-farm earnings varies significantly between households with membership in a farmer group and those without such membership. The results in Table 2.3 show that households belonging to a group are much less likely to allocate their off-farm earnings to fertilizer adoption and allocate less when they do. In fact, the coefficient of off-farm income in fertilizer adoption nearly vanishes for households with group membership (.0673-.0662) implying that the positive off-farm effects on fertilizer adoption are minimal for such households. This is plausible given that group membership, especially in producer cooperatives, is a major source of credit or direct receipt of inputs for agricultural production. In this case, off-farm earnings may not be needed to relieve cash constraints for input purchase.

The high and significant off-farm work effects on fertilizer adoption for households without group membership imply that off-farm income relieves credit constraints to agricultural intensification within such households. This result is consistent with findings from Chile that 'targeted credit' (and off-farm employment) help to overcome the capacity barrier allowing increased agricultural intensification and reduced overgrazing (Swinton et al., 2003). Note that the coefficient on the intensity model is also positive, implying that once the decision to adopt has been made, the off-farm work effects on fertilizer intensity remain positive for both group and non-group members though clearly reduced for group members.

For hybrid seed models, the impact of previous off-farm earnings is insignificant in both the adoption and intensity models (See Table 2.4). This implies that increased off-farm earnings have no impact on hybrid seed use in maize. While this result is clearly surprising given the fertilizer result, our data does however shed some light. First, Table A2.4 in the appendices shows that, while only 68% of households that used fertilizer also used hybrid seed, about 80% of hybrid seed users also used fertilizer. These differences are more pronounced in 2004, where only about 59% of households using fertilizer also used hybrid seed compared to 85% of hybrid seed users who also used fertilizer. These results may indicate that, for most households, the use of hybrid seed implies using fertilizer as well, a combination which may imply *deeper* crop intensification and orientation in maize, and one possibly not attractive to those with higher earnings from off-farm work.

The argument above is partly supported by the regression results of the Probit model on the combined use of both inputs presented in Table A2.5. These results show that previous off-farm earnings have no significant impact on current use of the combined fertilizer and hybrid seed package. The implication could be that while households may be willing to invest their off-farm earnings into partially intensifying their maize through use of some fertilizer, using fertilizer plus hybrid seed may represent a substantially greater commitment and orientation in maize. This argument is indicative given that the coefficient of agricultural cash income is positive and significant in the hybrid seed adoption model.[33] This coefficient is also significant in the combined fertilizer and hybrid seed adoption model (Table A2.5). It is thus possible that only those households with a strong orientation towards agriculture and more specifically toward market oriented crops are willing to invest in hybrid seed.

It is also noteworthy that hybrid seed use and intensity declined over the study period, implying that the hybrid seed models could be missing out on some important factors that could have contributed to the decline. An example here could be the limited supply of certified hybrid seed and the growth of informal seed marketing that have resulted in declining quality of seed as earlier discussed.

The education variable remains insignificant in the two hybrid seed models which is consistent with earlier findings. As expected, and holding other factors constant, households in the high potential areas have a higher probability of using hybrid seed, and use more intensely (plant at higher density) when they do. As shown in Table 2.6, these effects change minimally at mean levels of off-farm earnings.

Table 2.6. Wald Test for the Combined Effects in the Hybrid Seed Models (Aggregated Models)

	Adoption Model			Level Model		
Variable	Combined Effect	Wald Stat	p-value	Combined Effect	Wald Stat	p-value
Primary education	-0.2299	1.87	0.1713	-0.0369	0.04	0.8333
Agric potential	2.0866	56.74	.0000	0.5473	20.34	.0000
Group Member	0.6478	8.46	.0036	0.2124	3.09	.0788

Source: Author's study

[33] That this coefficient remains insignificant in the hybrid seed intensity model is not surprising as earlier discussed.

As with fertilizer models, the coefficient of off-farm work in hybrid seed models does not vary significantly with education. This is not surprising given that off-farm work and education variables are both insignificant in the adoption and the intensity models. The off-farm work effect does however vary across agricultural potential for the adoption of hybrid seed (at 10% significance level). Households in the high potential areas have a higher probability of allocating their off-farm earnings to using hybrid seed compared to their counterparts in the lower potential areas.

The impact of off-farm earnings on hybrid seed use and intensification does not significantly differ with group membership as in the fertilizer models. This result is not surprising given that most cooperatives deal with cash crops where fertilizer is the key input and opportunities do exist for diverting this fertilizer to maize and other food crops. Since hardly any such groups are specific for maize nor provide hybrid maize seed, belonging to a group is less likely to have a bearing on whether off-farm earnings are allocated for hybrid seed purchase. It is however plausible that belonging to a group may ease the financial constraints on the entire input purchase allowing households to more easily purchase those inputs not offered by the cooperatives. This is consistent with our finding that, on its own, group membership significantly increases both the probability of using hybrid seed and the intensity of use.

To identify the impact of off-farm earnings on input intensification, it is important to control for other sources of cash income that could potentially be used to finance input purchases. The variable for cash earnings from agriculture in the previous season has positive and significant effects in all the models except intensity of hybrid use as previously discussed. This implies that households that earn high incomes from farming tend to continue to earn more through modern input use and intensification. In addition, households with major cash crops tend to intensify more in their maize production. This is evident given the highly significant and positive coefficient of cash crop in the fertilizer intensity models. This coefficient is also nearly significant in both fertilizer and hybrid seed adoption models. This finding is consistent with earlier studies that find a positive relationship between cash and food crop intensification within households (see discussions on this in Kelly et al., 1996; Govereh and Jayne, (1999); Freeman and Omiti, 2003).

As expected, distance to the nearest input seller negatively and significantly influences the probability of using each of the inputs. It is noteworthy, however, that the average distance to the nearest fertilizer seller has declined from 4.7 km in 2000 to 3.2 km in 2004 and from 4.5 to 2.9 for hybrid seed which could be a result of improved input delivery systems after liberalization, a point well advanced by Freeman and Omiti (2003) and Ariga et al. (2006).

Most of the other variables we used as controls generally behaved as expected, with a few exceptions. The price of fertilizer was found to negatively and significantly influence its adoption and intensity of use, and also that of hybrid seed. This is plausible given that most households using hybrid seed also used fertilizer; while the fertilizer adoption decision can be made independently of the hybrid decision, use of hybrid seed typically implies the use of fertilizer. The price of hybrid seed however remains insignificant in both the fertilizer and hybrid seed models. Price of other seed was expected to be positive in hybrid seed and most likely in fertilizer regressions (for both adoption and levels). The results meet these expectations in both adoption models and remain insignificant in the intensity models. The previous season's maize price is positive and significant in the hybrid seed adoption model and has no impact on the intensity of hybrid seed. That this coefficient remains negative and significant in the fertilizer adoption model is both puzzling and an issue of further investigation.

The main season variable is positive and significant in both adoption models as expected, but it turns out negative and significant in the hybrid seed intensity model. While it may be possible that households tend to follow recommended input rates when the weather is unfavorable than when it is, this result may also reflect the fact that the planting season variable only runs across regions given the inability to use data for both seasons from the same households. Long-term mean rainfall is insignificant in both fertilizer and hybrid seed models. While this may seem unexpected, it is possible that its effects are captured through related variables like agricultural incomes, the season variable, and agricultural potential.

As expected, the number of adult household members positively and significantly influences the intensity decisions in both fertilizer and hybrid seed models. Other characteristics of the household, for example, age and gender of the head generally behaved according to expectations.

Tables 2.7 and 2.8 present the regression results with disaggregated off-farm earnings as described in section 2.2 (the results of the combined effects are presented in Table A2.6 in the appendices). This analysis was done to identify which of the different types of off-farm work drives reinvestment decisions. As mentioned earlier, other coefficients remain relatively stable across the aggregated and disaggregated models.

Table 2.7. Double Hurdle and Tobit Estimates for Fertilizer Demand (Disaggregated Off-farm)

	Double hurdle		
	Adoption	Intensity	Tobit
Price of Fertilizer	-0.1008**	-0.0587***	-1.3221**
	(2.21)	(4.88)	(2.40)
Price of hybrid seed	-0.0125	0.0036	-0.1434
	(0.59)	(0.94)	(0.80)
Price of other seed	0.0103*	0.0005	0.1235**
	(1.87)	(0.54)	(2.38)
Daily Wage rate for farm labor	-0.0131**	-0.0000	-0.2560***
	(2.26)	(0.01)	(3.66)
Price of maize (s-1)	-0.1708**	-0.0269	1.6433**
	(2.27)	(1.63)	(2.06)
Presence of major cash crop	1.0338*	0.3361***	17.1392***
	(1.81)	(3.62)	(3.39)
Agricultural cash income (s-1)	0.0166***	0.0030***	0.0061
	(3.82)	(4.13)	(0.22)
Informal/business income(s-1)	-0.0050	-0.0009	-0.0235
	(0.74)	(0.81)	(0.41)
Salaried/pension income (s-1)	0.0638***	0.0128***	0.6999***
	(2.75)	(2.63)	(2.83)
Remittances (s-1)	-0.0030	-0.0100*	-0.5138*
	(0.22)	(1.71)	(1.79)
distance to fertilizer seller	-0.1287***		-3.5203***
	(3.83)		(4.94)
Main planting season	3.0145***	-0.1120	33.5910***
	(3.52)	(1.41)	(7.06)
Agricultural potential	3.8296***	1.1900***	62.8771***
	(6.64)	(12.11)	(12.32)
Long-term yearly average rainfall	0.0004	0.0001	-0.0198*
	(0.30)	(0.58)	(1.85)
Age of head	-0.0308**	-0.0174***	-0.4620***
	(2.41)	(7.29)	(3.33)
Male head of household	1.2094***	0.0698	4.0637
	(2.91)	(0.80)	(0.86)
Number of adult members	-0.0120	0.0323**	0.9351
	(0.19)	(2.31)	(1.23)
Primary education	0.0254	-0.0710	5.1122
	(0.06)	(0.98)	(1.30)
Group Membership	1.2774***	0.3111***	19.7213***
	(3.10)	(2.94)	(3.44)
2004 period dummy	0.1497	-0.4457***	10.5744*
	(0.30)	(2.99)	(1.67)
salary*primary	-0.0143	-0.0049**	-0.1701
	(1.10)	(2.50)	(1.57)
salary*agric potential	-0.0041	-0.0051***	-0.0186
	(0.49)	(2.69)	(0.20)
salary*group membership	-0.0511**	-0.0048	-0.5970**
	(2.42)	(0.97)	(2.53)
Constant	6.4953	5.1394***	3.9669***
	(1.51)	(5.94)	(135.23)
Observations	1832		1832

Absolute z statistics in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%

Source: Author's study

Table 2.8. Double Hurdle and Tobit Estimates for Hybrid Seed (Disaggregated Off-farm)

	Double Hurdle		
	Adoption	Intensity	Tobit
Price of Fertilizer	-0.1408***	-0.0491***	-0.1776
	(4.53)	(4.36)	(1.63)
Price of hybrid seed	0.0034	0.0017	0.0144
	(0.47)	(0.54)	(0.41)
Price of other seed	0.0095***	0.0028*	0.0050
	(2.62)	(1.80)	(0.44)
Daily Wage rate for farm labor	-0.0024	-0.0016	-0.0340**
	(0.73)	(1.06)	(2.51)
Price of maize (s-1)	0.1202***	0.0099	0.4797***
	(3.12)	(0.59)	(3.20)
Presence of major cash crop	0.5035	0.0726	4.1290***
	(1.52)	(0.67)	(4.14)
Agricultural cash income (s-1)	0.0054***	0.0005	0.0028
	(2.65)	(0.70)	(0.58)
Informal/business income(s-1)	-0.0037	-0.0028**	-0.0139
	(1.37)	(2.29)	(1.29)
Salaried/pension income (s-1)	0.0009	-0.0005	-0.0162
	(0.07)	(0.08)	(0.27)
Remittances (s-1)	0.0006	0.0063	-0.0151
	(0.05)	(1.03)	(0.29)
distance to hybrid seed seller	-0.0755***		-0.2676***
	(3.15)		(2.58)
Main planting season	1.4204***	-0.2514***	7.5574***
	(3.96)	(3.06)	(8.32)
Agricultural potential	2.0666***	0.5615***	10.1022***
	(8.30)	(5.71)	(10.47)
Long-term yearly average rainfall	0.0007	-0.0003	0.0005
	(1.06)	(1.50)	(0.26)
Age of head	-0.0082	-0.0048	-0.0678**
	(1.16)	(1.61)	(2.55)
Male head of household	0.5300**	0.2332**	1.9080**
	(2.35)	(2.48)	(2.05)
Number of adult members	0.0168	0.0215	0.1534
	(0.44)	(1.42)	(1.04)
Primary education	-0.2785	-0.0420	-0.6595
	(1.34)	(0.53)	(0.87)
Group Membership	0.7068***	0.1885*	3.2572***
	(2.86)	(1.71)	(2.98)
2004 period dummy	-1.7974***	-0.8529***	-2.0208
	(5.17)	(6.25)	(1.63)
salary*primary	0.0039	-0.0020	0.0091
	(0.66)	(1.11)	(0.40)
salary*agric potential	0.0072	0.0028	0.0187
	(1.52)	(1.29)	(0.89)
salary*group membership	-0.0101	-0.0018	-0.0176
	(0.93)	(0.30)	(0.30)
Constant	1.2008	3.5935***	-14.7538*
	(0.59)	(4.78)	(1.90)
Observations	1832		1832

Absolute z statistics in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%

Source: Author's study

For the fertilizer demand models, we find that salaried work and pensions drive the positive impact of off-farm income on both adoption and intensity of use: informal business income is insignificant with small coefficients. This result is consistent with our conceptual model and mirrors the bivariate result from Table 2.2, which showed that households with salaried wage and pension income were more likely to use both inputs, while those with the other off-farm activity types were less likely to do so. The combined effects show similar patterns as with the aggregated model.

For hybrid seed, all three off-farm work types have insignificant coefficients in the adoption models. The negative and significant impact of informal business on the intensity model is consistent with our expectations: use of both fertilizer and hybrid seed increases the risk of farm earnings, which, coupled with the high correlation with informal earnings, may reduce input use.

The results from this study indicate that previously received remittance income has no bearing on input adoption decisions. Conditional on using fertilizer, households with higher remittance income tend to use less. This result may seem to deviate from that by Collier and Lal (1984) as discussed earlier. However, the kind of remittance in Collier and Lal (1984) came strictly from wage employment and thus could be more regular and stable. In our case, given that we have no information on the remitter and the kind of activities they engage in, it is not possible to draw firm conclusions from this result.

The fact that salary and pension income is positive and significant on fertilizer adoption and intensity but insignificant on both adoption and amount of hybrid seed used suggests that these households are using some of their off-farm earnings to purchase fertilizer, but they are not making the additional investment of money, time, and knowledge to adopt the hybrid seed/fertilizer *package*. As with the aggregated off-farm models, the impact of salaried income on input intensification is greater for households with no group membership and thus limited access to credit. This result is again consistent with arguments by Collier and Lal (1984) that urban wage employment is an important means of breaking both the credit and risk constraints upon agricultural income.

6. Summary and Conclusions

The results from this study suggest differences in the impacts of off-farm earnings on input use and intensification across different inputs and off-farm activity types. The emerging picture is that, holding prices, other incomes, locational and relevant household characteristics constant, previous off-farm earnings have a positive impact on fertilizer use for maize producing households in Kenya. This impact is greatest for households without any group membership thus indicating the importance of off-farm work in relieving cash constraints for those households who have no access to other forms of credit.

The impact on hybrid seed is however insignificant, suggesting that even though households with high off-farm earnings tend to use more fertilizer for their maize, using hybrid seed (plus fertilizer) may imply deeper crop intensification and orientation in maize, and one possibly not attractive to those with higher earnings from off-farm work. Off-farm earnings can thus be used to relax the cash constraint on farming, but only up to some point, beyond which such households appear likely to shift their resources to other uses perhaps with higher returns than agriculture.

Further, the presence of a regular source of earnings in form of a salary or pension seems to be the driving force behind any reinvestment behavior that does occur as originally hypothesized. This is consistent with our conceptual model, given that salaried wages and pension are relatively stable and have low correlation with farming compared to informal business and remittance income. Again, just as with overall off-farm work, households with salaried income may find it optimal to invest some of their earnings to intensify their maize production, but may not be willing to go all the way at which point the two activities act as competitors for the available labor and capital resources.

The above results for off-farm income are in stark contrast to the effects of agricultural cash income which is positive and significant in all regressions except for the level of hybrid seed use, an exception which is not surprising given discussions earlier in the paper. Controlling for all cash income, the growing of a cash crop seems to positively affect maize intensification. This is consistent with substantial other empirical evidence regarding the spillover effects of cash cropping on food crop production. Education of the household head consistently has a negative effect on maize intensification, again consistent with past literature showing that returns to education are higher off-farm than on-farm, and more educated households as a result allocate more of their resources to off-farm activities.

This paper provides empirical evidence of the importance of certain types of off-farm work in relaxing the credit- and risk constraints that typically limit agricultural intensification in Kenya. As regards policy, a multifaceted approach that considers other contraints to intensification, especially in regards to technology generation, returns to input use, input delivery systems and effectiveness of extension, must be considered in drawing policy recommendations.

Given the results of this study, further research on other major crops may help in generating clear patterns, and hence conclusions. Additional important questions for research would be whether off-farm earnings are reinvested in agriculture through purchase of farm capital, commercialization or other non-income generating activities e.g. education, health which too may have an impact on farming and off-farm activities but in the long-run. Further, it would also be important to understand how the household member earning the income affects its reinvestment into agriculture.

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ESSAY 3: OFF-FARM LABOR MARKET DECISIONS, MIGRATORY LABOR AND AGRICULTURAL SHOCKS FOR RURAL HOUSEHOLDS IN KENYA

Abstract

This paper analyzes the determinants of participation and earnings from the off-farm labor market for rural households in Kenya. We specifically explore how these rural households respond to risky agricultural production environments and existence of ex post adjustments in off-farm labor supply in response to unexpected rainfall shocks. While controlling for a wide range of educational, demographic, and other locational factors, we look at how long-term weather risks and specific rainfall shocks influence a household's decision to engage in the off-farm labor market and on the earnings generated from such labor. Results indicate that these rural households engage in off-farm work as a long-term strategy to deal with anticipated weather risks to their farming operations. When examining off-farm work as a whole, we do not find adjustments in off-farm labor supply as a result of specific, unexpected rainfall shocks. A disaggregated analysis does, however find greater reliance on remittance income and petty agricultural wage labor in response to such unexpected short-term rainfall shocks. Holding other factors constant, and conditional on participation, households in areas with a more productive local agriculture tend to earn more from off-farm work especially in self-employment than those living in regions with a less productive agriculture. As expected, a vibrant local economy in form of public investment does increase the probability of participation.

Key words: Off-farm labor market; agricultural shocks; rural economy; Kenya

1. Introduction and Problem Overview

The increasing importance of off-farm employment for rural households in developing countries has been widely documented (Barrett et al., 2001a; Barrett et al., 2005; Janvry and Sadoulet, 2001; Lanjouw and Lanjouw, 2001; Lanjouw et al, 2001; Reardon, 1997). In the past, rural development strategies and policies have emphasized increasing farm productivity through use of modern technologies as a way out of poverty. The effectiveness of this strategy has become a question of debate in the literature as poverty rates in Sub-Saharan Africa continue to be high among rural communities and agricultural productivity stagnates over time. Poverty rates are also found to be high in low agricultural potential areas that are difficult to reach directly with interventions targeted towards the farm sector. The off-farm sector could thus be a potential entry point in such areas. Further, research has shown that most households in rural Africa tend to earn larger shares of their income from off-farm employment. These findings point to the important role that off-farm employment can play in poverty reduction as enumerated in vast literature.

As in many other rural economies of developing countries, most rural households in Kenya combine farming with off-farm work for their livelihoods. The nature of rural off-farm work varies from high end salaried wage labor (such as teachers and doctors) and profitable business enterprises to low wage labor and marginal businesses best viewed as part of household survival strategies. A small proportion of households appear not to engage in off-farm work at all. The fact that the type and level of involvement in off-farm work is unequally distributed across households indicates the importance of understanding the main drivers of the different types of off-farm activities. Of major importance is an understanding of the reasons why rural farm households diversify into off-farm work. This is important if gainful advances are going to be made to poverty reduction through expansion of off-farm opportunities to the poor.

Although there is mixed evidence as to the reasons rural households diversify their farming activities into some off-farm employment as reviewed in Goetz and Debertin (2001) and Kimhi (2000), most studies agree that in most rural areas of developing countries, off-farm earnings supplement family income and are important to both low and high income households (Davis, 2003; Barrett et al, 2005). Even in developed rural economies, studies have shown that farmers view off-farm work as a stable long-run combination with farming (Kimhi, 2000). According to Fuller (1991), multiple job-holding is a key dynamic of rural systems. It is a flexible mechanism for adjusting to changes in agriculture, family needs and the external environment. Although uncommon outside of agriculture, multiple job-holding among farm households in modern farming history has been the norm (Fuller, 1991) rather than the exception.

Barrett et al. (2001a) analyses different motives that prompt households to diversify into off-farm work and classifies them into a set of *push* and *pull* factors. From the push factor perspective, Barrett et al. (2001a) argues that diversification is driven by limited risk-bearing capacity and climatic uncertainty, among others. This argument is consistent with literature documenting the use of off-farm labor supply to deal with risky production environments (see Lamb, 2003 for a discussion of other mechanisms for dealing with production risks in developing countries). Using mainly data from rural India, Kochar (1995, 1999), Rose (2001) and Lamb (2003) show that farm households respond to farm production shocks through supply of labor to the off-farm labor market.

In this study, we use data from rural households in Kenya to analyze the influence of agricultural and agro-ecological factors in facilitating access to and earnings from the off-farm labor market. As with Rose (2001), we look at how farm households respond ex-ante to risky production environments and ex-post to unexpected rainfall shocks, while controlling for a wide range of educational, demographic, and other locational factors. We also consider the extent to which access to and earnings from off-farm work depend on the dynamism of the local agricultural economy. Given that off-farm work encompasses a great diversity of activities, we disaggregate the results based on different types of off-farm work to understand household response and constraints to each.

A few empirical studies have examined the nature and role of rural off-farm work in poverty reduction in Kenya (Barrett et al., 2001b; Barrett et al., 2005; Collier and Lal, 1986; Hoddinott, 1994). Most of these studies address particular aspects of the off-farm rural labor market. Barrett et al. (2001b) emphasized the importance of food-for-work transfers on household liquidity constraints. In a cross-country study on income diversification strategies, Barrett et al. (2005) includes a case from rural Kenya in which they point out the important role played by inter-household heterogeneity in constraints and incentives. Hoddinott (1994) looks at determinants of migration using data from some villages in Western Kenya. Other studies like House and Rempel (1976) and Manda et al. (2006) have looked at the determinants of earnings in the labor market, but focus on urban areas. Most of such earlier studies also tend to concentrate on wage labor, leaving out self-employment and migratory labor.

This study makes various contributions to the existing literature. First, we use a relatively large, representative sample of rural households across all agricultural zones of

Kenya to explore determinants of participation in off-farm work. Second, we add to the previous literature on off-farm work in rural Kenya by looking at whether and how long-term weather risks and specific, unexpected rainfall shocks influence labor allocation to the off-farm labor market for these rural households. As mentioned above, we disaggregate into wage labor[34] and self-employment[35] so as to consider the main drivers of each. We also analyze agricultural wage labor vis-à-vis other self-employment activities to determine any divergent patterns. Since remittance income from migratory labor is an important source of income for some rural households, we also consider the factors that affect the likelihood that a house will receive some remittances and the amounts received. We also look at the role of sample selection bias in these models and possible implications for estimation.

The rest of the paper is organized as follows: Section two discusses the conceptual approach and the empirical strategy adopted in the paper. The data used in the study is discussed in section three. The econometric model and other estimation issues are presented in section four. Section five presents the empirical results and discussion, and section 6 provides a summary of the findings and main conclusions.

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[34]In this paper, we use salaried employment and wage labor interchangeably to imply any regular paid job. We also use informal business and self employment interchangeably to define household-owned trade and business activities.

[35] Though self employment typically entails sale of goods and services, we use a general term for the off-farm labor market to imply both wage labor and business activities.

2. Theory and Empirical Approach

2.1. Conceptual Approach

We consider a rural farm household that combines production, consumption and labor supply decisions. Following derivations well enumerated in Huffman (1991) and Singh et al. (1986), a general supply of labor function to the off-farm labor market is generated and can be summarized as:

$$L_O = L_O\,(w_O, P, I, H, G) \qquad (1)$$

where L_O represents individual household's supply of labor to the off-farm labor market, w_O is the off-farm wage, P represents the economic incentives in the form of farm input and output prices faced by the household at the farm level, I is a measure of household wealth, H is human and other household characteristics, and G represents the state of the local economy and local labor market characteristics. For a rural economy, we expect wages received off the farm to depend on human capital endowment, the state of the local economy, the demand for labor (D_L, which is derived from the demand for off-farm goods and services, D_G), and labor supply in the local area (S_L). Thus our wage offer equation would become $w_O= f\,(H, G, D_L, S_L)$ where H and G are as earlier defined.

Demand for off-farm goods and services (D_G) depends upon the overall income in the area, which for predominantly agricultural areas would depend heavily on the performance of the farm sector in the short- and long-term. Thus the environment of the farming community as dictated by agro-ecological conditions and weather related risks are key. The local labor supply (S_L) will also depend on the ability of the farming sector to keep labor employed, which is again dependent on the weather and other agro-ecological conditions. We characterize the environment of the farming sector using three variables: 1) the distribution and riskiness of the rainfall regime as given by the long-term rainfall average ($\bar{R}$) and its standard deviation (SD), 2) the rainfall shock as defined by the previous main season's rainfall deviation from the long-term mean (DV)[36] and 3) the productivity of local agriculture as given by the mean district value of per capita agricultural production (V_a^d). Incorporating the above factors in the labor supply function (1) above, we get:

$$L_O = L_O\left(w_O\left\{H, G, D_L\left[D_G\left(\bar{R}, SD, DV, V_a^d, M\right)\right], S_L\left(\bar{R}, SD, DV, V_a^d, N\right)\right\}, P, I, H, G\right) \quad (2)$$

where M and N are other factors that affect D_G and S_L respectively. So, how do the variables that describe the farming environment affect the supply of labor to the off-farm labor market? More specifically, do rural households engage in off-farm work as an adaptation to the risky environment they live in, and how do they adjust ex-post to unexpected weather shocks? Taking first order conditions with respect to these variables of interest, we get:

$$\frac{\partial L_O}{\partial DV} = \frac{\partial L_O}{\partial w_O}\left[\frac{\partial w_O}{\partial D_L}\frac{\partial D_L}{\partial D_G}\frac{\partial D_G}{\partial DV} + \frac{\partial w_O}{\partial S_L}\frac{\partial S_L}{\partial DV}\right] \quad (3)$$

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[36] DV=R_{jt} - $\bar{R}$ where j stands for village and t is period.

$$\frac{\partial L_O}{\partial \bar{R}} = \frac{\partial L_O}{\partial w_O}\left[\frac{\partial w_O}{\partial D_L}\frac{\partial D_L}{\partial D_G}\frac{\partial D_G}{\partial \bar{R}} + \frac{\partial w_O}{\partial S_L}\frac{\partial S_L}{\partial \bar{R}}\right] \tag{4}$$

$$\frac{\partial L_O}{\partial V_a^d} = \frac{\partial L_O}{\partial w_O}\left[\frac{\partial w_O}{\partial D_L}\frac{\partial D_L}{\partial D_G}\frac{\partial D_G}{\partial V_a^d} + \frac{\partial w_O}{\partial S_L}\frac{\partial S_L}{\partial V_a^d}\right] \tag{5}$$

All three equations are mathematical representations of simple demand/supply frameworks. In each case, the first term on the right hand side represents the change in the quantity of labor supplied in response to a change in local wage rates. The terms in parentheses expresses the change in local wage rates as the sum of two changes: the change due to a shift in the demand for labor (driven by a shift in demand for local goods and services), and the change due to a shift in the supply of labor, each in response to the variable of interest: a rainfall shock in (3), long-term mean rainfall in (4), and local agricultural productivity in (5). Focusing on the effect of a rainfall shock, a negative rainfall deviation will typically affect farm outcomes negatively, thus shifting back the effective demand for off-farm goods and services ($\frac{\partial D_G}{\partial DV} > 0$). Decreased demand for off-farm goods and services will reduce demand for off-farm labor, causing off-farm wages to decline (assuming an upward-sloping supply of labor curve, implying $\frac{\partial w_O}{\partial D_L} > 0$).

On the other hand, and as a push factor, a negative rainfall shock will generally increase the supply of labor to the local off-farm labor market as a coping strategy (thus $\frac{\partial S_L}{\partial DV} < 0$). Increased labor supply in the local market will have a negative impact on off-farm wages as long as the demand curve is negatively sloped ($\frac{\partial w_O}{\partial S_L} < 0$). Thus we find that the overall impact of a negative rainfall shock through both the demand for and supply of labor is a reduction in local wage rates.

The impact of this reduction in wage rates on the quantity of labor supplied off the farm ($\partial L_O / \partial w_O$) will depend on 1) the elasticities of demand and supply of labor[37] and 2), the magnitude of the shifts in demand and supply of labor. The first point is illustrated in Figure 3.1. The value of L_0 is identical in each of the four panels, and supply and demand shift by exactly the same horizontal distance in every case. The only thing that changes is the elasticity of supply (on the left) and the elasticity of demand (on the right). More elastic supply increases the likelihood that quantity of labor supplied will decrease as a result of the shock, while more elastic demand increases the likelihood that it will increase.

The magnitude of shifts in the demand and supply of labor are positively related to the share of local incomes generated from agriculture. Thus, although a negative rainfall shock is expected to decrease local off-farm wages, the exact impact on the supply of labor to the off-farm labor market may be indeterminate a priori and may be different for different regions and households. This means that the change in off-farm earnings is also indeterminate and affected by the factors discussed above.

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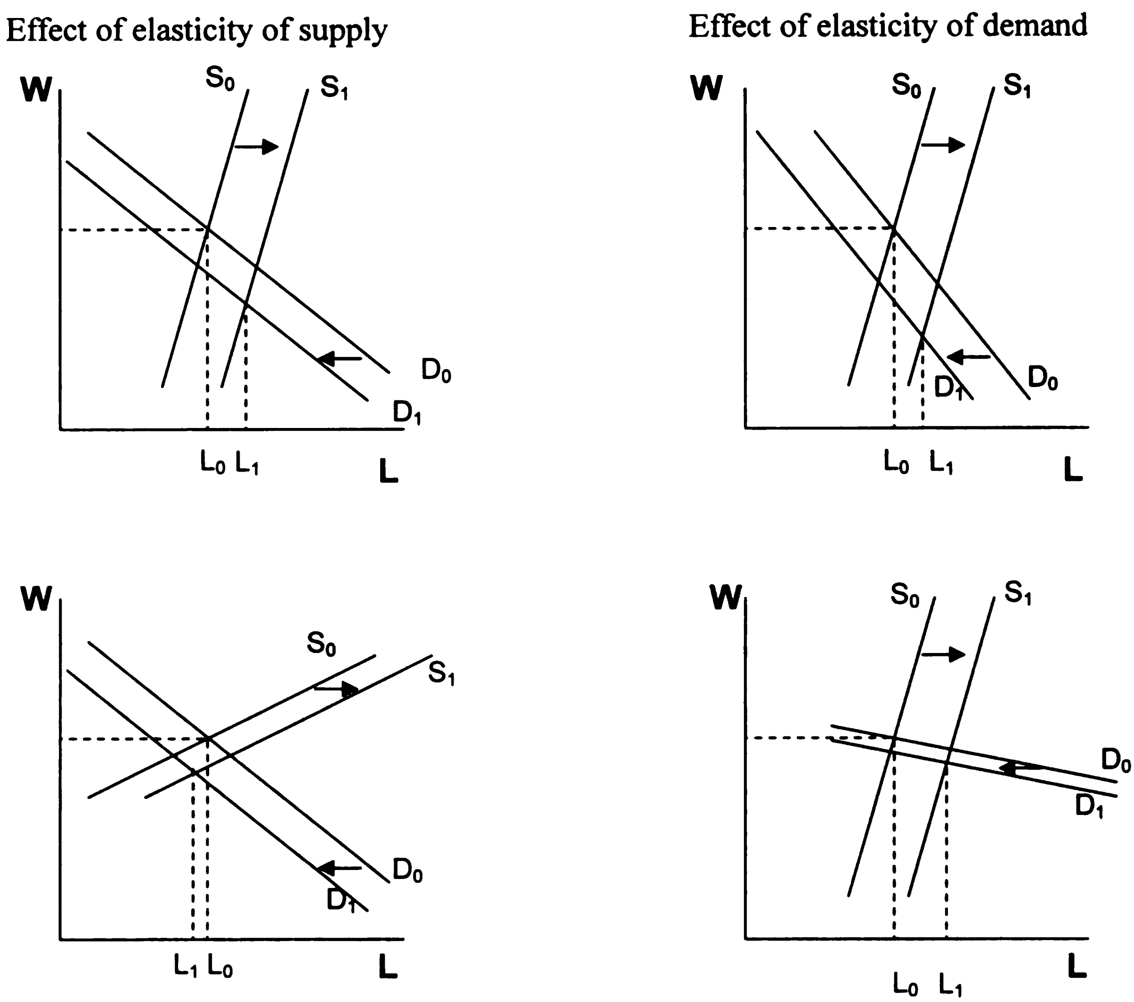
[37] See a graphical illustration of how the elasticities of demand and supply would affect the quantity of labor supplied to the off-farm labor market later in this section.

Figure 3.1: Effect of the Elasticities of the Supply and Demand for Labor on the Quantity Supplied



As for equations (4) and (5), an increase in long term average rainfall will generally result in an increase in off-farm wages through a reduction in off-farm labor supply and an increase in the effective demand for off-farm good and services. A similar argument may be made for regions with a high value of agricultural production. A high value of agricultural production may reduce the need to have off-farm complements for many households, thus contracting off-farm labor supply and a possible increase in off-farm wages. At the same time, high incomes from agriculture would drive demand for the local goods and services that are produced by self-employment activities, thus increasing demand for off-farm labor and another possible increase in wages. The converse must also be true; a region with a low rainfall regime and/or low agricultural productivity will generally have lower off-farm wages. However, as discussed earlier, the impact on labor supply (hence earnings), cannot be determined a priori and remains an empirical question.

2.2. Motivation and Empirical Strategy

Various motives cause farm household to engage in alternative income earning activities off the farm. We can generalize the determinants of supply of labor to the off-farm labor market from both the *push* and *pull* perspectives as discussed earlier. As a push phenomenon, households will engage in off-farm work so as to reduce risks on their current portfolio of activities, cope with market imperfections especially in relation to credit and crop insurance, counter the effects of declining returns from agriculture as a result of poor land quality, high input prices and low farm output prices, and cope with external shocks to agriculture such as crop failure and other weather-related shocks (See Barrett et al., 2001a for a broader discussion of why households diversify into off-farm work). In this study, and following our conceptual approach, we concentrate on weather-related push factors and specifically look at how households adjust their off-farm labor allocations in response to production risks and weather shocks to their farming environment.

As discussed in section 2.1, we characterize the long-term rainfall environment by a nine-year main season rainfall average and its standard deviation at the village level. Long-term mean rainfall can be interpreted as a proxy for a households' perceived probability that precipitation will fall below a critical threshold level that would put household livelihoods at risk. The lower the mean rainfall, the higher this perceived probability[38]. In response to this risk, households may adopt long-term strategies that emphasize more off-farm work than in areas where rainfall is higher. The standard deviation captures the variability of the main season rainfall[39]. Both the long term mean and standard deviation define the riskiness of the environment in which households live and are at least known with some probability.

To capture the effects of unanticipated rainfall shocks, we use the previous cropping seasons' rainfall deviations from the long term mean. Here, the question is whether households are able to respond to a negative rainfall shock (which will decrease agricultural earnings) by increasing their participation in, and earnings from, the off-farm labor market. Whether households are able to do this in practice is again an empirical question as discussed earlier.

Long-term rainfall clearly affects agricultural productivity, but so do many other factors. For a given rainfall regime, productivity will be affected by soil quality, altitude, the quality of infrastructure, institutional support to cash crop production (e.g., tea and coffee), and attitudinal factors such as orientation to agriculture and interest in intensifying. This introduces the possibility of separately testing the effect of the size and

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[38] In fact, mean rainfall in our data set is highly negatively correlated (-0.92) with a direct indicator of stress: the proportion of 20 day periods in which rainfall fell below 40 mm during the growing season.
[39] Other studies use the coefficient of variation (CV) which is not sensitive to scaling (Rose, 2001) but given the high correlation of the mean and CV in our data, use of both would cause identification problems.

productivity of local agriculture on off-farm decisions and thus the inclusion of this variable[40] in the model.

As argued by Rose (2001), the use of regional rainfall data (at village level in this case) is important as an indicator of aggregate risk given the difficulties of insuring such through formal and informal mechanisms[41]. The agricultural productivity variable is at the district level due to having fewer cases in the sample for some regions at lower geographical divisions.

In addition to the push factors, a household must have the capacity to access the available opportunities in form of human and physical asset endowments. The level and quality of assets required depends on the type of activity in question.

On the 'pull' side, engagement in off-farm employment is assumed to depend on 1) the incentives offered by the labor market in form of wages and other benefits, and 2) the availability of employment opportunities as provided by the local labor market characteristics and government investment in public assets such as infrastructure and service provision in the area. The incentives offered by the off-farm labor market act as a *pull* to better paying activities in the off-farm market. These pull factors are strongly influenced by the level of demand for off-farm goods and services. Any factors that increase the demand for off-farm goods and services will, holding other factors constant, increase derived demand for labor.

[40] Note that multicollinearity among these variables does not appear to be a problem, with correlations all below 0.22.
[41] Refer to detailed discussion on risk and insurance in Townsend (1994).

3. Data

Data for this study were drawn from the Tegemeo Agricultural Monitoring and Policy Analysis Project (TAMPA) data set collected during the 1999/00 and 2003/04 cropping seasons. The specific sample used in this study consists of a total of 2648 observations (1324 households for each year). The panel contains data on economic, demographic and other social characteristics of the households. Table 3.1 presents the description of the variables used in this study including their means and standard deviations.

For the purposes of this study, we classify off-farm work into salaried or wage labor employment and informal business (self-employment) activities. Salaried employment includes all types of activities with a regular (usually monthly) wage paid for labor while informal business encompasses a diverse group of self-employment activities. We disaggregate further the informal business activities into agricultural wage labor[42] (farm kibarua) and all other informal activities so as to assess the pattern that emerges.

The table shows that slightly more than 73 percent of households are involved in off-farm work, with the informal business sector taking the highest proportion of this number. It is however noteworthy that this participation and the earnings from it vary greatly across agro-regional zones as shown in Table 3.2. Table A3.1 in the appendices shows the Tegemeo sample districts included in this study by agro-regional zones. Refer to Table A1 for a classification of agro-regions across agro-ecological zones and districts. We also show how the agricultural potential variable as used in this study was generated.

[42] This represents piece meal work on neighboring farms. It doesn't quite fit into salaried employment since it's not regular and it involves frequent decisions on whether to work or not.

Table 3.1.Summary Statistics of Variables Used in the Models

Variable	Unit	Mean	Std Dev.
Participation and earning measures			
Total Off-farm earnings	Kshs ('000)	61.9	124
Salaried wages	Kshs ('000)	31.0	75.3
Informal business income	Kshs ('000)	30.9	97.8
Remittance income	Kshs ('000)	3.60	12.4
Agricultural wages	Kshs ('000)	1.68	8.11
Other Informal business earnings	Kshs ('000)	29.2	94.5
Any off-farm work participation	Binary	0.73	0.44
Salaried employment	Binary	0.33	0.47
Any self employment (Informal/business)	Binary	0.57	0.49
Received remittances	Binary	0.30	0.46
Agricultural wage activities	Binary	0.12	0.32
Other informal activities*	Binary	0.51	0.50
Household Demographics			
Education of head	Years	6.3	4.9
Education of spouse	Years	4.6	4.4
Gender (Male head)	Binary	0.84	0.37
Age of head	Years	55	13
No. of adult males	Count	2.5	1.6
No. of female adults	Count	2.4	1.4
Agricultural risk			
Previous main season rainfall deviation	mm	-9.93	132
Long term main season rainfall average	mm ('00)	5.41	1.72
Main season rainfall standard deviation	mm ('00)	2.24	0.80
Other variables			
Land cultivated	Acres	13.7	16.4
Major cash crop	Binary	0.55	0.50
Distance to electricity & phone	Kilometers	4.53	4.73
Bus fare to shopping center	Kshs	9.09	19.4
Distance to tarmac road	Kilometers	7.72	7.90
Lagged value of non-land assets	Kshs ('000)	116	330
District mean value of agric prodn	Kshs ('000)	72.5	40.1
Agricultural Potential	Binary	0.56	0.50

No. of Observations=2648 N/B: 1 US $ was equivalent to ksh 80 as of 2004.
*'Other' here implies other informal business activities except piecemeal agricultural work.

The share of off-farm earnings in total household income varies greatly across regions. As expected, the lowland areas which define low agricultural potential areas are characterized by relatively high off-farm shares and low crop shares as compared to the highlands and the high potential maize zone (HPMZ) which define the high agricultural potential areas. This implies that more households in the marginal agricultural potential areas do look for alternative sources of income from the off-farm labor market to complement their low earnings from farming thus depicting a '*push*' factor in the decision to sell labor off the farm. A related result emerges from the proportion of households with a major cash crop. Regions where a higher proportion of households have a major cash crop and thus relatively high crop earnings and shares have generally lower off-farm shares (and earnings) and fewer households engaging in the off-farm labor market.

Table 3.2. Characteristics of Households by Agro-regional Zones (all households)

Agro-regional zones	Total income	Net crop income	Off-farm earnings	cash crop	crop share	off-farm share	% with off-farm work
Coastal Lowlands	148,563	45,730	89,406	0.31	0.31	0.58	0.95
Eastern Lowlands	165,030	51,437	88,314	0.24	0.38	0.42	0.85
Western Lowlands	75,235	27,578	31,368	0.30	0.78	0.33	0.72
Western Transitional	156,633	89,755	46,990	0.85	0.59	0.25	0.70
High Potential Maize Zone	207,607	89,861	69,431	0.43	0.46	0.30	0.70
Western Highlands	113,163	51,377	36,081	0.82	0.53	0.26	0.67
Central Highlands	202,452	104,129	63,685	0.91	0.59	0.24	0.66
Total	165,292	72,461	61,888	0.55	0.52	0.32	0.73

Source: Author's calculations

Though there is diversity across regions, the emerging picture is that supply of labor to the off-farm labor market likely compensates for the low returns to labor in agriculture and thus a form of livelihood for such households. It is therefore not a surprise that in some regions like the coastal and eastern lowlands, over 80 percent of households combine farming with off-farm work. An exception to this is seen with the western lowlands where we observe not only relatively lower participation and shares of off-farm income (probably due to relatively poor opportunities to earn income), but also exceptionally low mean total household income. This is however not surprising given that Nyanza province which predominantly forms the western lowlands has been ranked the poorest in the country (see Table A3.2 in the appendices) even below the ASAL North Eastern province.

Table 3.3 shows that both the poor and non-poor households derive a good proportion of their income from engaging in off-farm work (40-47) and the share increases steadily with income, a finding consistent with other studies from rural Africa (Reardon 1997; Tschirley and Benfica, 2001; Reardon et al., 2000). In contrast, and as expected, the share of crop income in total income decreases with income, though the only major jump is evident between the lowest quintile and all others. Considering the types of off-farm work, the majority of the households in the lowest quintile (88%) seem to be involved in informal business activities while very few of them (19%) have salaried jobs. The poor are also more likely to receive remittances.

Table 3.3. Characteristics of Households with Off-farm Work by Quintiles of Total Income

Income Quintile	Total Income (Ksh)	Land cultivated (Acres)	Share w/ major cash crop	Crop share in total income	Off-farm share in total income	Share with salaried wage income	Share with self employment income	Share received remittances
1 low	28,343	9	0.39	0.50	0.40	0.19	0.88	0.34
2	67,626	12	0.45	0.38	0.41	0.35	0.83	0.27
3	114,592	13	0.50	0.39	0.44	0.50	0.75	0.25
4	189,825	15	0.61	0.38	0.45	0.54	0.74	0.25
5 high	461,592	21	0.66	0.38	0.47	0.61	0.71	0.21
Total	184,632	14	0.53	0.40	0.44	0.46	0.77	0.26

Source: Author's study
N/B: Livestock shares excluded in this table

Although we find relatively high participation rates in off-farm work across all agro-ecological zones (over 60 percent even in the highlands), Table 3.4 shows some differences in long-term main season rainfall average and CV between those who participate and those that do not. Households that engage in off-farm work live in regions with lower mean rainfall and higher CV than non-participants. This pattern is duplicated for the two off-farm work types but also for those who received remittance income. In addition, those households that participate in off-farm work seem to come from regions with relatively low value of agricultural production. An exception here is salaried employment where the value of agricultural production is not significantly different for participants and non-participants.

Table 3.4. Rainfall Variables by Types of Off-farm Work

Type of off-farm work	Long-term main season rainfall mean	Main Season rainfall deviations	Main season rainfall SD	Main season rainfall CV	District mean value of agric production
Any off-farm work					
No	572***	-7.8	225	0.44***	76353***
Yes	529	-10.7	224	0.50	71032
Salaried employment					
No	547***	-6.9**	221**	0.47***	72681
Yes	528	-15.9	229	0.50	72020
Informal/business					
No	557***	-7.3	225	0.45***	75185***
Yes	528	-11.9	223	0.50	70379
Remittance					
No	548***	-6.0***	223*	0.47***	75008***
Yes	524	-19.2	227	0.51	66459
Total	541	-9.9	224	0.48	72461

Source: Author's study

The stars indicate the significance level of the difference in the respective pair of means test where *** significance at 1%, ** significance at 5% and * significance at 10% level.

The pattern of earnings from off-farm work is not very clear except with the long-term rainfall mean which shows a general increase in off-farm earnings (movement across quintiles) as the rainfall average decreases (Table 3.5). However, with the exception of the lowest quintile[43], off-farm earnings increase as rainfall SD (and hence CV) and the value of agricultural production increases.

[43] Lowest quintile includes non-participants which may likely alter the pattern.

Table 3.5. Rainfall Variables by Quintiles of Off-farm Income

Year	Quintiles of off-farm income	Long term main season rainfall mean	Previous main season rainfall deviations	Main season rainfall std dev	Main season rainfall coefficient of variation	District mean value of agric production
2000	1 (lowest)	583	25.4	223	0.42	82,649
	2	533	6.3	219	0.48	63,555
	3	533	6.7	219	0.48	77,591
	4	526	11.8	224	0.50	78,800
	5 (highest)	510	-24.1	234	0.53	81,927
	Total	541	7.4	224	0.48	78,108
2004	1 (lowest)	562	-40.9	226	0.45	70,076
	2	583	-2.4	209	0.41	64,713
	3	561	-29.4	209	0.43	65,247
	4	528	-16.3	232	0.52	65,043
	5 (highest)	483	-32.6	236	0.57	66,908
	Total	541	-27.3	224	0.48	66,814
Total	1 (lowest)	572	-7.8	225	0.44	76,353
	2	558	2.0	214	0.45	64,134
	3	546	-10.4	214	0.46	71,727
	4	527	-1.1	228	0.51	72,516
	5 (highest)	495	-28.9	235	0.55	73,406
	Total	541	-9.9	224	0.48	72,461

Source: Author's study

4. Model Specification and Estimation

4.1. Empirical Model

Labor supply functions are estimated to determine the factors that drive rural households to supply part of their labor to the off-farm labor market. Given that our data do not have information on time spent working off the farm, we use participation and earnings from the off-farm labor market to model off-farm labor supply decisions and households' response to agricultural productions risks. To ensure identification of the coefficients of interest, we control for household characteristics, human and physical endowments, characteristics of the rural economy and external factors that affect both the farm and off-farm sector.

Education of head and spouse are used to proxy for human capital endowments. Evidence has shown that returns to education are higher in the off-farm labor market than on the farm (Fafchamps and Quisumbing, 1999), suggesting that a highly educated individual is more likely to supply labor off the farm. However, we would expect differential impacts of education, depending on the type of activities considered and the skill level they require. Thus we can hypothesize that households with highly educated members are more likely to supply part of their labor to the off-farm labor market, but more importantly that education will positively affect the probability of engaging in salaried activities and negatively impact on casual agricultural wage labor and other low wage and low return business activities.

Distance to the market or shopping centre is important as a proxy for both job availability and, conditional on getting a job, the cost of travel to the job. Net earnings will be dependent on the cost of travel to the job. Thus with wages W_O, the effective daily wage is given by $W_O - C(d,s)$, were C is the cost of getting to and from the job and is a function of distance (d) and condition of the transport system (s). Access to public assets like electricity and telephone within short distances could proxy for the condition of public infrastructure, which affects the cost of accessing the off-farm labor market.

Other factors that lower the returns from the farm could positively affect participation in the off-farm labor market. For instance, low agricultural potential areas are likely to encourage more diversification though mostly to low return activities (as a push), or migratory labor in the form of salaried employment which may have relatively lower risks. In addition, factors that increase the returns to the farm such as high output prices, increased agricultural productivity and presence of a cash crop may have negative impacts on labor supply to the off-farm market, at least in the short -term[44]. Physical assets do also provide capacity for the households to invest in off-farm work either for direct use or as collateral. For direct use, we would expect households with a high value of assets to invest heavily in high return businesses. The value of such non-land assets may not however have large impacts on salaried employment and low return businesses.

In developing the estimating equations, it is important to note that our sample data is such that off-farm earnings are only observed when the household decides to participate in the off-farm labor market. This setting results in a form of sample selection usually referred to as the *incidental truncation problem* (Wooldridge, 2002) thus indicating the need to account for the resulting non-random nature of the sample. The sample selection model defined in this paper follows Heckman (1979) and assumes that people self-select into off-farm employment and thus our observation of earnings in the data is dependent upon an initial labor market participation decision. If the reason some of the earnings data is unobserved was clearly exogenous, then a regression on the selected data would do as well.

However, in this case, it is likely that the probability that a household participates in the off-farm labor market is correlated with the level of earnings they receive. It is thus plausible to expect that some unmeasured attributes that allow a household to participate in the off-farm labor market may also help to increase the earnings that result from such participation. This may be especially so for high end wage labor activities where intelligence and ambition are important -- and very difficult to measure. In other words,

[44] In the long-run, high agricultural productivity may increase the size of the rural off-farm sector, as those with capacity for that type of activity respond to the demand created by a vibrant agriculture.

households engaging in the off-farm labor market may have some common (unobserved) characteristics that may in turn contribute to their earnings (Co et al., 2005).

Following the discussion above, the basic model for estimation consists of two equations based on the same data. First, we define the auxiliary selection equation as:

$$S^*_{it} = Z_{it}\delta + v_{it} \qquad (1)$$

where S^*_{it} defines a latent variable for the propensity of engagement in off-farm work. Though S^*_{it} is unobserved, it is possible to observe the household's participation choice such that:

$S_{it}=1$ if $(Z_{it}\delta + v_{it}) > 0$ (i.e. $L_O > 0$ and the household is observed to engage in off-farm employment), and

$S_{it}= 0$, otherwise

Z defines a vector of exogenous characteristic that influence participation decisions. Second, there is the outcome equation:

$$Y^*_{it} = X_{it}\beta + \varepsilon_{it} \qquad (2)$$

where Y^*_{it} is the latent variable that describes the intensity of participation in off-farm work. We observe and model Y_{it} (such that $Y = w_O L_O$) which is equal to Y^*_{it} only when $S_{it}=1$. X represents exogenous variables that affect the earnings from off-farm work.

Since the presence of selection bias in equation (2) can be viewed as a special case of an omitted variable problem, its consistent estimation requires us to account for the household's decision to engage in off-farm work or not. We follow Heckman's

(1976) computation of the conditional expectation of Y given that Y is observed ($S_{it}=1$) as:

$$E\ (Y|X,\ S_{it}=1) = X_{it}\beta + \rho_{\varepsilon v}\lambda\ (Z_{it}\delta) \qquad (3)$$

Where $\lambda(Z_{it}\delta) = \phi(Z_{it}\delta\ )/\Phi(Z_{it}\delta)$ and its coefficient represents an estimate of the covariance between ε and v, $\rho_{\varepsilon v}$ (Ermisch and Wright, 1994). Estimation of equation 2 above is thus consistently done by adding the last term in (3). Note that when $\rho_{\varepsilon v}= 0$, OLS regression provides unbiased estimates. When $\rho_{\varepsilon v} \neq 0$, the sample selection model described above allows us to use the information from households that did not work off the farm to improve the estimated parameters.

4.2. Estimation

The models described in the section above are estimated using the Heckman two-step procedure. A Probit selection model (1) is first estimated and the correction term (λ (.)) computed. Model (2) is then estimated using the selected sample with the correction term as an additional regressor to correct for self-selection into off-farm work.

Identification of β in the outcome equation (2) can be possible even if x=z due to the non-linearity of the selection bias correction term λ (.). However, if there is not much variation in the sample, having exactly the same variables in both the selection and the outcome equation may result in severe collinearity problems (as λ (.) is now just a function of x alone) thus affecting identification (Stolzenberg and Relles, 1997; Wooldridge, 2002)) as is characteristic of regressions with near multicollinearity. This implies that it's necessary for x to be a strict subset of z.

In this study, we use a binary variable for agricultural potential as an exclusion restriction[45]. Though the reliability of a particular exclusion restriction can be a subject of debate and perhaps is the major source of criticism of the Heckman two-step procedure, it is generally plausible to foresee the agricultural potential of a region acting as a 'push' factor to the off-farm labor market especially in the low marginal areas, but not directly impacting on the earnings achieved[46]. In fact, regression results of earnings on this variable turn out insignificant. However, given that this variable is also insignificant in the first stage of the salaried model, we include the 'number of female adults in the household' as an additional exclusion restriction for the salaried wage labor models. This exclusion seems fairly plausible given that less than 10 percent of females engage in salaried wage labor; the majority of females are in self employment and thus while their presence in the household may allow release of male labor off the farm, this is unlikely to have a major impact on the earnings received from wage labor.

Though the Heckman two-step estimator remains a common tool in empirical work, literature has documented some weaknesses that may be worth paying attention to (see detailed reviews in Puhani, 2000 and Stolzenberg and Relles, 1997). Thus, in addition to the two-step Heckman estimates, a full-information maximum likelihood estimation (MLE) was also carried out. Unlike the two-step method, the MLE procedure (if it converges) provides estimates that are more efficient and have other desirable properties of MLE[47].

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[45] This implies that agricultural potential is excluded in X.

[46] There may be some indirect impacts on earnings through differences in the dynamism of rural economies between high and low potential areas, but this effect would be partially captured by the village and district level variables.

[47] Although MLE requires stronger distributional assumptions (See Wooldridge, 2002 pp 566).

5. Econometric Results and Discussion

5.1. Participation in Off-farm Labor Market

Table 3.6 presents parameter estimates of the off-farm labor market participation decision. Four different models are estimated involving the entire off-farm work and also its disaggregation into wage labor and self-employment. A model for remittance income received by the household from friends and family members living away is also included to assess the role of migratory labor as a coping strategy to weather risks in these predominantly rural households.

The Heckman two-step procedure described in section 4.1 only serves to account for the initial self selection into (overall) off-farm work. However, as discussed by Co et al. (2005), it is possible to foresee a two-tier selection process where households first make decisions on whether to participate in the off-farm labor market or not; then, conditional on a positive decision to participate, a selection is made between salaried work and self employment. To account for the two self selection terms in the disaggregated salaried employment and the informal business models, the first stage selection model is estimated using a Bivariate Probit model. The computed correction terms are again included in the outcome equations.

In this study, we first estimated the usual two-step procedure for salaried work and self employment models and then used a bivariate probit to control for the two self-selection processes. The results of the latter are presented in Table A3.4 in the appendices. They indicate an insignificant correction term for off-farm work choice in both models and the coefficients are fairly comparable to the usual two-step Heckman. We thus present the results of the two-step procedure in the following results.

As discussed earlier, both the two-step Heckman estimates and those from the maximum likelihood estimation are presented for comparison purposes. In general, the results from the two estimation methods are comparable for all four (selection) models. This implies that there is not much efficiency lost with the two step procedure. This may not always be the case as we will see later in Table 3.7. The result is however not unexpected given that the main critiques of the two-step procedure focus on the manner in which the correction term is computed and used to correct for selection bias in the second stage. The results presented in Table 3.6 are for the selection equations and involve the whole sample of both participating and non-participating households.

Turning to the results, we first consider the effects of weather and agricultural risks to the participation decision. From Table 3.6, the long term mean rainfall of a region has significant effects on the decision by households to engage in off-farm work. Thus, households in areas with high rainfall regime are less likely to engage in any type of off-farm employment. This may be an indication of participation in off-farm work as a long-term strategy for households living in areas prone to rainfall shortages thus negatively impacting on farming activities. There is however an insignificant result on the remittance model implying that these households may not be relying on remittance income as a long term strategy to cope with anticipated weather risks.

However, these households do not respond to short term and unexpected rainfall shocks by adjusting their off-farm work engagements; our results show reliance on remittance income to deal with such unforeseen shocks to farming. The only exception to this is evidenced in Table A3.5 presented in the appendices showing a negative and significant coefficient on the shock variable for the agricultural wage labor participation regression. This exception is plausible given that these activities are fairly flexible[48] and require hardly any start-up capital.

While reinforcing each other, the above results show that these households use different coping mechanisms to deal with different sources of agricultural risks; participation in the off-farm labor market ex ante to deal with long-term weather risks and remittance income and participation in casual agricultural wage labor to deal with unforeseen rainfall shocks ex post. This latter result is plausible given that households may expect to recover from unforeseen shocks in the current period and are thus unlikely to consider long-term labor reallocations. The results for the overall off-farm work however seem to deviate from some earlier literature on this topic that shows increased participation in off-farm work in response to unexpected rainfall/agricultural shocks (Kochar 1999 and Rose 2001).

Further, households living in regions with a less productive agriculture have a higher probability of receiving remittance income but show no significant difference with respect to off-farm work decisions.

On the other results, we find that education of the head of household and spouse positively affects the probability of working off the farm. This result is maintained in salaried work model but is reversed in the self employment model, where higher education reduces the probability of households engaging in the informal business sector. As expected, this education impact is largest with participation in salaried work and indeed seems to be the one driving the education result in the overall off-farm work.

[48] Households can often regulate the labor supply to these activities as needed without much consequence.

Table 3.6. Regression Estimates of Off-farm Labor Market Participation Decision (Two-Step and MLE Heckman Models)

	Two-step Method				Maximum Likelihood estimation			
	All off-farm work	Salaried employment	Self-employment	Remittance	All off-farm work	Salaried employment	Self-employment	Remittance
Education of head	0.0160**	0.0536***	-0.0281***	0.0150**	0.0160**	0.0539***	-0.0281***	0.0150**
	(2.13)	(7.36)	(4.08)	(2.01)	(2.11)	(7.34)	(4.08)	(2.01)
Education of spouse	0.0185**	0.0237***	-0.0008	-0.0264***	0.0185**	0.0236***	-0.0008	-0.0263***
	(2.07)	(2.92)	(0.10)	(2.90)	(2.07)	(2.90)	(0.10)	(2.90)
Male headedness	0.2436***	0.1821**	0.2318***	-0.4907***	0.2436***	0.1849**	0.2314***	-0.4908***
	(3.02)	(2.09)	(3.03)	(5.98)	(3.02)	(2.12)	(3.03)	(5.99)
Age of head	-0.0532***	0.0321**	-0.0527***	0.0443***	-0.0532***	0.0315**	-0.0527***	0.0440***
	(3.45)	(2.03)	(4.01)	(2.66)	(3.43)	(2.01)	(4.01)	(2.62)
Age of head squared	0.0003**	-0.0004***	0.0003***	-0.0001	0.0003**	-0.0004***	0.0003***	-0.0001
	(2.10)	(2.76)	(2.63)	(0.59)	(2.09)	(2.74)	(2.63)	(0.57)
Number of adult males	0.0591***	0.0714***	0.0349*	-0.0051	0.0591***	0.0709***	0.0349*	-0.0048
	(2.91)	(3.78)	(1.95)	(0.26)	(2.90)	(3.75)	(1.95)	(0.25)
Number of female adults	0.0601**	0.0661***	0.0361*	0.0073	0.0601**	0.0723***	0.0360*	0.0071
	(2.57)	(3.21)	(1.80)	(0.35)	(2.57)	(3.39)	(1.80)	(0.34)
Previous main season r/fall dev	0.0001	-0.0000	-0.0000	-0.0010***	0.0001	-0.0000	-0.0000	-0.0010***
	(0.61)	(0.09)	(0.08)	(4.20)	(0.61)	(0.06)	(0.08)	(4.20)
Square of rainfall deviations	-0.0000	-0.0000*	0.0000	0.0000**	-0.0000	-0.0000*	0.0000	0.0000**
	(1.32)	(1.78)	(0.15)	(2.23)	(1.32)	(1.77)	(0.16)	(2.23)
Long-term main season avg r/fall	-0.0871***	-0.0532***	-0.0328*	-0.0187	-0.0871***	-0.0521***	-0.0326*	-0.0187
	(4.56)	(2.98)	(1.93)	(1.00)	(4.53)	(2.92)	(1.92)	(1.00)
Main season r/fall std dev	0.0098	0.0560	-0.0023	0.0025	0.0098	0.0567	-0.0021	0.0027
	(0.21)	(1.20)	(0.05)	(0.05)	(0.21)	(1.21)	(0.05)	(0.05)
Land cultivated	0.0035*	0.0022	0.0021	0.0020	0.0035*	0.0022	0.0021	0.0020
	(1.78)	(1.26)	(1.12)	(1.08)	(1.78)	(1.20)	(1.12)	(1.08)
Major cash crop	-0.1138*	-0.0674	-0.1196**	-0.0786	-0.1138*	-0.0689	-0.1192**	-0.0790
	(1.84)	(1.12)	(2.11)	(1.26)	(1.84)	(1.15)	(2.10)	(1.27)
Mean dist to elect & phone	-0.0195***	-0.0190**	-0.0120*	-0.0161*	-0.0195***	-0.0189**	-0.0120*	-0.0162*
	(2.65)	(2.57)	(1.74)	(1.80)	(2.65)	(2.56)	(1.72)	(1.80)
Distance to shopping centre	0.0027	-0.0004	0.0039***	-0.0008	0.0027	-0.0004	0.0039***	-0.0008
	(1.62)	(0.29)	(2.64)	(0.49)	(1.61)	(0.30)	(2.65)	(0.49)
Distance to tarmac road	0.0046	0.0019	0.0035	-0.0010	0.0046	0.0019	0.0035	-0.0010

Table 3.6. contn: Regression Estimates of Off-farm Labor Market Participation Decision (Two-Step and MLE Heckman Models)

	(1.05)	(0.44)	(0.86)	(0.23)	(1.05)	(0.44)	(0.86)	(0.23)
Value of assets	-0.0002*	-0.0003**	-0.0000	-0.0003**	-0.0002	-0.0003**	-0.0000	-0.0003**
	(1.92)	(2.42)	(0.62)	(2.24)	(1.50)	(2.39)	(0.59)	(2.24)
District value of agric production	-0.0004	-0.0008	0.0002	-0.0019**	-0.0004	-0.0008	0.0002	-0.0019**
	(0.53)	(0.98)	(0.21)	(2.17)	(0.53)	(0.95)	(0.21)	(2.17)
Agricultural potential	-0.2958***	0.0330	-0.3734***	-0.2186***	-0.2958***	0.0278	-0.3745***	-0.2184***
	(4.56)	(0.53)	(6.28)	(3.38)	(4.47)	(0.44)	(6.29)	(3.38
year dummy	0.0646	0.0560	0.0355	-0.2077***	0.0646	0.0585	0.0353	-0.2080***
	(1.02)	(0.91)	(0.61)	(3.23)	(1.02)	(0.95)	(0.61)	(3.24)
Constant	2.7861***	-1.5787***	2.3467***	-1.8248***	2.7861***	-1.5896***	2.3451***	-1.8175***
	(5.81)	(3.57)	(5.83)	(3.57)	(5.78)	(3.60)	(5.82)	(3.54)
Observations	2648	2648	2648	2648	2648	2648	2648	2648

Robust z statistics in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%

Source: Author's study

The negative and significant coefficient on education of head in the self employment participation regression can be explained by the fact that most of these business activities in the rural areas consist of low return petty trade businesses which require minimal formal education. This finding is reinforced by a further disaggregation of the salaried and self employment models as shown in Table A3.6 in the appendices. This table shows that higher education reduces the probability of participating in low return business activities; the coefficient on high return businesses is positive but insignificant.

It is however possible that education of head and spouse could be correlated with omitted unmeasured characteristics which may have influence on the participation and earnings from off-farm work. This is more likely for salaried employment models, hence a likely upward bias on the respective coefficients. The fact that these coefficients remain positive and significant is however consistent with previous literature and our expectations. While we expect the sign and significance to remain the same, the magnitude of the coefficients may however change. Thus, our interest in this study is on the direction and significance of the effects; we make no policy implications based on the magnitude of such impacts.

The results show that households with a more educated head of household are more likely to receive remittances, but, controlling for the education of head; those with highly educated spouses are less likely to receive remittances. This result is a bit puzzling as we would expect a negative coefficient on both variables and hence is a subject for further investigation. The negative coefficient on spouse may be explained by the fact that a highly educated person may also be working in the local town and is less likely to receive remittances from those working in other areas.

As expected, a male headed household is more likely to work off the farm but less likely to receive remittances as compared to a female headed household. Also, the number of adults in the household increases the probability of a household engaging in off-farm work (more labor to share out) but has no effect on the probability of the household receiving remittances.

Land cultivated has a positive and significant effect on the overall off-farm work but remains insignificant in both the disaggregated models and remittances. The positive result can be explained by the fact that households with more land cultivated (and hence higher total household incomes as shown in Table 3.2) may have the capacity to invest in the off-farm labor market. This result is partially driven by the fact that households in low potential areas (with high off-farm earnings and shares) own and cultivate more land than their counterparts in the high potential areas.

Consistent with expectations, the presence of a major cash crop reduces the probability that a household will engage in off-farm work, especially in self-employment (though the coefficient is negative in all the models). Also, we find that households with a higher value of assets tend to have a lower probability of engaging in salaried employment and are less likely to receive remittances. As expected, the greater the distance to important amenities like electricity and telephone, the less likely that households will participate in the off-farm labor market. This is because there may not be a sufficient pull element to draw labor out of the farm.

5.2. Determinants of Earnings from Off-farm Work

Table 3.7 presents the regression results of the off-farm earnings models. We again present the Heckman two-step and MLE estimates. Comparing the two estimation procedures, the models for overall off-farm work and remittances have comparable estimates. The self-employment model shows fairly close estimates, while the salaried work regressions show significant differences between the two estimates. The differences in the two salaried work models can be explained by the likely higher selection bias in salaried employment, given that these are usually desirable activities and individuals' clearly self-select into such. Although the coefficient of the correction term for the salaried earnings equation is not clearly significant, the general results of the correction term across all models are clearly consistent with the pattern described above; the selection term on both the salaried and self-employment models is close to being significant while the remittance and overall off-farm work are clearly insignificant.

Further, the results of the Wald test for correlation between equations (1) and (2) indicate that the null hypothesis of independent equations is clearly rejected in the salaried employment model (see Table A3.3 in the appendices). Rejection of the null hypothesis implies that the residuals in the two equations are correlated and hence the need for joint estimation.

We now concentrate on the MLE estimates for the discussion of results. As with the participation models, we find that a rainfall shock does not significantly affect the earnings from off-farm work, reinforcing the finding from the participation regressions that these households do not make significant short term off-farm labor supply adjustments in response to unexpected rainfall shocks. However, conditional on

Table 3.7. Determinants of Earnings from Off-farm Work

	Two- step Method				Maximum Likelihood Estimation			
	All off-farm work	Salaried employment	Self-employment	Remittance	All off-farm work	Salaried employment	Self-employment	Remittance
Education of head	3.4663***	2.3124	-0.0058	0.9087***	3.4663***	4.3918***	-0.5345	0.9000***
	(2.68)	(1.02)	(0.00)	(3.19)	(2.67)	(4.78)	(0.41)	(3.56)
Education of spouse	3.7578***	4.1025***	0.3468	0.4381	3.7578***	4.8771***	0.4162	0.4551
	(3.46)	(2.91)	(0.34)	(1.02)	(3.57)	(4.09)	(0.41)	(1.42)
Male headedness	4.0925	-34.0188**	12.3968	-6.6476	4.0925	-26.4519**	15.8024*	-6.3810**
	(0.39)	(2.37)	(1.34)	(1.31)	(0.46)	(2.23)	(1.72)	(2.50)
Age of head	3.0228**	2.6470	1.4594	0.1651	3.0228***	4.3659***	0.6362	0.1315
	(2.26)	(1.20)	(1.16)	(0.26)	(2.61)	(2.86)	(0.67)	(0.35)
Age of head squared	-0.0281***	-0.0119	-0.0148	0.0010	-0.0281***	-0.0319**	-0.0103	0.0011
	(2.88)	(0.50)	(1.50)	(0.27)	(2.97)	(2.38)	(1.22)	(0.37)
Number of adult males	9.5481***	1.9655	6.4499**	1.0932	9.5481***	5.3201*	7.1865***	1.0965*
	(3.34)	(0.43)	(2.56)	(1.64)	(3.66)	(1.87)	(2.94)	(1.69)
Number of female adults	5.4588*		-1.0030	0.6172	5.4588**		-0.0927	0.6166
	(1.95)		(0.36)	(1.03)	(2.04)		(0.03)	(1.04)
Previous main season r/fall dev	0.0217	0.0138	0.0345	-0.0048	0.0217	0.0126	0.0284	-0.0042
	(0.85)	(0.48)	(1.35)	(0.41)	(0.86)	(0.43)	(1.10)	(0.57)
Square of rainfall deviations	-0.0002*	-0.0000	-0.0002	-0.0000	-0.0002*	-0.0001	-0.0002	-0.0000
	(1.75)	(0.22)	(1.39)	(1.26)	(1.78)	(0.87)	(1.16)	(1.47)
Long-term main season avg r/fall	-8.1027***	-3.5764	-5.7359***	-1.3725**	-8.1027***	-5.5595**	-6.2109***	-1.3556**
	(3.33)	(1.15)	(2.94)	(2.10)	(4.06)	(2.32)	(3.50)	(2.21)
Main season r/fall std dev	10.3423*	7.2973	1.2061	1.1249	10.3423*	9.6130*	2.1699	1.1412
	(1.68)	(1.16)	(0.19)	(0.88)	(1.69)	(1.68)	(0.33)	(0.92)
Land cultivated	0.0889	-0.3220	0.4062	0.0930	0.0889	-0.2124	0.4444	0.0917
	(0.25)	(1.12)	(1.44)	(0.81)	(0.25)	(0.82)	(1.63)	(0.87)
Major cash crop	-3.7691	-11.3754	11.4591*	-0.0189	-3.7691	-14.2821*	8.5264	0.0309
	(0.58)	(1.26)	(1.72)	(0.01)	(0.60)	(1.69)	(1.44)	(0.01)
Mean dist to elect & phone	1.0585	1.7811*	1.0708	-0.3606	1.0585	1.0305	0.7662	-0.3486*
	(1.17)	(1.75)	(1.14)	(1.25)	(1.36)	(1.29)	(0.88)	(1.66)
Distance to shopping centre	0.1609	0.1775	0.1639	-0.0455	0.1609	0.1654	0.2017	-0.0451
	(0.92)	(0.71)	(1.06)	(1.23)	(0.94)	(0.67)	(1.40)	(1.27)
Distance to tarmac road	-0.2681	-0.8485**	-0.5925	0.0568	-0.2681	-0.8321**	-0.4082	0.0554

Table 3.7. contn: Determinants of Earnings from Off-farm Work

	(0.63)	(2.00)	(1.41)	(0.63)	(0.67)	(1.97)	(1.00)	(0.64)
Value of assets	0.1941**	0.0736**	0.2222***	0.0126**	0.1941**	0.0623**	0.2125**	0.0128**
	(2.47)	(2.50)	(2.74)	(2.04)	(2.48)	(2.41)	(2.57)	(2.39)
Value of agric production	0.1963**	0.0671	0.3221***	0.0190	0.1963**	0.0418	0.2985***	0.0206
	(2.09)	(0.69)	(3.30)	(0.64)	(2.18)	(0.44)	(3.04)	(0.99)
year dummy	-10.3276*	-8.7670	-7.9918	-6.3402**	-10.3276*	-6.7335	-9.7183	-6.2161***
	(1.68)	(1.16)	(1.27)	(2.33)	(1.69)	(0.95)	(1.53)	(3.51)
Correction term (z1)	-3.8164	-82.0409	-36.6681	-0.7399				
	(0.10)	(1.37)	(1.15)	(0.06)				
Constant	-73.6401*	63.1840	1.1591	1.4693	-73.6401**	-52.3405	11.6117	3.3578
	(1.89)	(0.51)	(0.03)	(0.05)	(2.05)	(1.03)	(0.34)	(0.25)
Observations	1937	882	1524	789	2648	2648	2648	2648
R-squared	0.29	0.23	0.33	0.09				

Robust t statistics in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%

Source: Author's study

participation, households in regions with lower rainfall regimes tend to earn more from off-farm work than do their counterparts in the high rainfall areas. These results are consistent with the pattern observed in Table 3.5 that shows increasing off-farm earnings as the long term main season rainfall decreases. This argument is plausible given that a household's adaptive strategy in such drought prone areas would be to increase (and stabilize) total incomes through their off-farm activities.

As discussed in section 2.1, a region with a low rainfall regime will generally imply lower off-farm wage rates (compared to high rainfall regimes), but an overall reduction in earnings would imply at least two things: 1) presence of a relatively elastic supply curve implying a proportionately higher reduction in household labor supply in response to decreasing off-farm wages and/or 2) a less than proportionate increase in labor supply in a declining wage rural economy.

The results in Table 3.7 also show that, controlling for rainfall patterns, households living in rich agricultural areas tend to earn more from self employment and hence overall off-farm work. This latter finding is suggestive of the fact that dynamic rural agricultural economies may contribute to a flourishing off-farm labor market by providing raw materials necessary for off-farm work, especially informal businesses. In addition and as earlier discussed, regions with a rich agricultural base may imply increased demand for off-farm goods and services thus increasing incomes of participating households.

As with the participation models, education of both the head and spouse positively affects salaried earnings and overall off-farm earnings, but has no significant impact on earnings from self employment. The earnings from off-farm work increase with age, but only up to a certain point (54 years) beyond which they start declining. This result seems to be driven by salaried income as the combined effect of age is not significant in the self-employment model nor does it affect the amount of remittance income received. This result may be indicative given that most public employment in Kenya has a retirement age of 55 years.

Unlike in the participation models, land cultivated and distance to electricity and phone have no significant influence on the earnings from off-farm work. However, households living farther away from the tarmac road do seem to earn less from wage labor. Conditional on participation, households with high value of assets earn more from the off-farm labor market.

6. Summary and Conclusions

The results of this study reveal the existence of ex ante off-farm labor supply responses to anticipated weather risks to agricultural production for rural households in Kenya. The results show that households living in regions with a lower rainfall regime have a higher probability of participating in the off-farm labor market and, conditional on participation, earn more from their engagements in off-farm work. This result shows participation in off-farm work as a long-term coping strategy for these rural households in response to anticipated weather risks to their agricultural operations.

For short-term unexpected rainfall shocks, these households seem to rely primarily on increased remittance income from migratory labor and petty agricultural wage activities. We find no significant adjustments in overall off-farm engagement in response to such unexpected shocks. This result is broadly consistent with earlier findings (in Essay 2) that show insignificant effects of remittance income on input use and intensification; this current paper shows that these funds are instead used for short-term adaptation to shocks.

For a given mean rainfall, and holding all other factors constant, households in regions with a more productive local agriculture, though less likely to participate in the off-farm labor market, tend to earn more from it (especially in the informal business sector) when they do participate. This result can be explained from the effective demand created for off-farm goods and services from the high earnings from such vibrant agricultural areas. This finding is consistent with the concept of structural transformation that elucidates the need for a productive agriculture to enable growth in the off-farm sector.

The results of this study also indicate the importance of disaggregating off-farm work into specific activity types that unveil a lot of differences otherwise masked by analyzing the overall off-farm work choice. In addition, the differences in the results between the two-step procedure and MLE for salaried employment speak to the need for using appropriate estimation methods so as to draw appropriate conclusions. It is important to test the independence of the selection and outcome equations before proceeding to the well known Heckman two-step method.

Consistent with earlier studies, we find that education increases the probability of working off the farm, and also increases the earnings derived from such participation. This positive education effect found in salaried labor and high return businesses further emphasize the importance of education in getting the poor out of low return petty informal businesses and enabling access into remunerative off-farm work types.

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APPENDICES

APPENDICES

TableA1. Classification of TAMPA Sample by Agro-regional Zones

Agricultural potential	Agro-regional zones	Agro-ecological zone	District	No. of hhs
Low potential	Coastal Lowlands	Coastal lowland	Kilifi	53
			Kwale	25
		Total		78
	Eastern Lowlands	Coastal lowland	Taita Taveta	10
		Lower midland 3-6	Kitui	17
			Machakos	21
			Makueni	37
			Mwingi	32
		Upper midland 2-6	Makueni	35
		Total		152
	Western Lowlands	Lower midland 3-6	Kisumu	94
			Siaya	67
		Total		161
	Western Transitional	Lower midland 1-2	Bungoma	44
			Kakamega	111
		Total		155
	Marginal Rain Shadow	Lowland	Laikipia	39
	Total			585
High potential	High Potential Maize Zone	Upper midland 2-6	Bungoma	35
			Kakamega	24
			Nakuru	24
			Trans Nzoia	54
		Lower highland	Bomet	35
			Nakuru	76
			Narok	24
			Uasin Gishu	51
		Upper highland	Uasin Gishu	39
		Total		362
	Western Highlands	Upper midland 0-1	Kisii	78
			Vihiga	53
		Total		131
	Central Highlands	Upper midland 2-6	Muranga	48
			Nyeri	40
		Upper midland 0-1	Meru	81
			Muranga	18
		Lower highland	Nyeri	59
		Total		246
	Total			739
Total				1324

Source: Author's study

TableA1.1. Simple Regression Results of Distance Variables on Household Income

Distance variable	Coefficient	p-value
Distance to tarmac road	0.00062	0.516
Mean distance to input seller	0.0010	0.778
Distance to shopping centre	0.0012	0.288
Distance to extension service	-0.00024	0.837
Distance to electricity	0.00023	0.719
Distance to telephone	0.000033	0.934
Mean dist to electricity & phone	0.00062	0.617
Household had electricity	.000110	0.000
Household had telephone	.000042	0.000

Source: Author's study

Table A1.2. Mobility of Households across Income Quintiles

		2004 Income Quintiles				
		1	2	3	4	5
	1	128 (9.7)	65 (4.9)	39 (2.9)	22 (1.7)	10 (.8)
2000 Income Quintiles	2	62 (4.7)	79 (6.0)	55 (4.2)	45 (3.4)	24 (1.8)
	3	29 (2.2)	65 (4.9)	84 (6.3)	54 (4.1)	33 (2.5)
	4	33 (2.5)	33 (2.5)	56 (4.2)	76 (5.7)	67 (5.1)
	5	12 (.9)	23 (1.7)	31 (2.3)	68 (5.1)	131 9.9)

Author's study
N/B: Figures in parenthesis are percent of households in total sample.

Table A1.3. Results of the First Stage Regression and Over-id test

Dependent variable	LID		LID* Education	
	Coefficient.	Std. Error	Coefficient.	Std. Error
Δ Distance to tarmac road	-0.41	1.45	-12.99	12.37
Δ Mean distance to input seller	3.19**	1.43	1.54	9.99
Δ Distance to shopping centre	-0.11	0.41	-1.51	3.58
Δ Distance to extension service	0.74	1.99	-11.17	17.43
Δ Mean dist to electricity & phone	-4.42	2.98	-21.33	25.93
Δ Age of head	-1.19	2.19	-37.98	40.40
Δ Age of head squared	0.01	0.02	0.19	0.26
Δ Education of head	-6.67***	2.51	189.22***	25.85
Δ Gender (male headedness)	27.53	17.68	447.15*	244.19
Δ % adults working off farm	-25.40*	15.76	-90.12	124.81
Δ Land cultivated	-0.88	1.16	-15.06	11.61
Δ Number of livestock owned	-0.26	0.23	-1.72	2.43
Δ Number of adult males	2.81	5.44	76.71*	45.76
Δ Number of adult females	0.48	4.65	-11.47	45.43
Δ Months head at home	0.68	1.50	-5.82	14.88
Δ Group Membership	-4.50	9.37	-45.46	111.71
Year dummy	127.46***	13.25	660.13***	133.04
Instruments				
Lagged Income level	-0.87***	0.07	-4.01***	1.10
Lagged income*education	0.04***	0.01	0.33***	0.11
Lag mean rainfall deviation	-2.64***	0.86	-20.84***	7.11
Joint sig of Instrument set				
F-statistics	55.93		6.93	
p-value	0.0000		0.0001	
Over-id Test				
Chi-square statistic		0.089		
p-value		0.7649		

Source: Author's study

TableA1.4. Comparison with different Education Levels

	1 Continuous Education	2 With primary	3 With secondary	4 With College education
LID	0.49*	-0.08	0.13	0.04
	(1.80)	(0.20)	(0.53)	(0.20)
LID*education	-0.15*	0.10	-1.43*	-1.19*
	(1.94)	(0.09)	(1.93)	(1.94)
Δ Distance to tarmac road	-1.16	0.69	0.44	0.19
	(0.48)	(0.35)	(0.21)	(0.10)
Δ Mean distance to input seller	-2.32	-0.81	-0.47	-0.68
	(1.29)	(0.50)	(0.34)	(0.52)
Δ Distance to shopping centre	-0.34	-0.07	-0.17	-0.16
	(0.66)	(0.16)	(0.39)	(0.37)
Δ Distance to extension service	-0.34	1.22	1.81	1.44
	(0.12)	(0.41)	(0.66)	(0.57)
Δ Mean dist to electricity & phone	6.79**	7.27	5.71*	6.52**
	(2.05)	(1.53)	(1.75)	(2.24)
Δ Age of head	-0.36	2.56	2.03	1.32
	(0.08)	(0.85)	(0.77)	(0.54)
Δ Age of head squared	-0.01	-0.02	-0.02	-0.01
	(0.26)	(0.59)	(1.09)	(0.75)
Δ education of head	40.50**			
	(2.23)			
Δ primary education		-22.65		
		(0.12)		
Δ secondary education			354.60**	
			(2.19)	
Δ college education				321.63**
				(2.33)
Δ Gender of head (male headedness)	57.46	-7.13	40.30	28.57
	(1.26)	(0.15)	(1.29)	(1.09)
Δ % adults working off farm	96.75***	98.67***	106.48***	103.33***
	(4.19)	(4.85)	(4.97)	(5.19)
Δ Land cultivated	-0.77	1.56	-0.11	0.39
	(0.51)	(0.64)	(0.12)	(0.42)
Δ Number of livestock owned	0.91***	1.28***	1.21***	0.78*
	(3.73)	(3.00)	(5.39)	(1.77)
Δ Number of adult males	19.02*	8.54	14.54**	12.21*
	(1.94)	(1.07)	(2.05)	(1.90)
Δ Number of adult females	9.45	12.43**	10.46*	9.37*
	(1.54)	(2.47)	(1.91)	(1.77)
Δ Months head at home	-3.73	-2.92	-2.62	-3.01*
	(1.51)	(1.64)	(1.31)	(1.69)
Δ Group Membership	4.69	11.45	5.61	1.71
	(0.34)	(0.83)	(0.48)	(0.17)
year dummy	11.66	-29.84	-8.60	-9.38
	(0.32)	(1.34)	(0.45)	(0.51)
Observations	1324	1324	1324	1324

Robust t statistics in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Source: Author's study

Table A2.1. Mean Off-farm Shares by Region and Agricultural Zone

Region/Zone	% of households with Off-farm work	Means shares of off-farm in total income (%)
Region		
Eastern Lowlands	88	52
Western Lowlands	78	49
Western Transitional	72	34
Western Highlands	74	36
Central Highlands	73	34
Agricultural Zone		
Low	80	46
High	72	35
Total	76	40

Source: Author's study

Table A2.2. Likelihood Ratio (LR) Test for the Tobit Formulation Hypothesis

Model	LR value	P-value
Models I (Aggregated Off-farm)		
Fertilizer	231.12	0.0000
Hybrid Seed	-131.30	1.0000
Models II (Disaggregated Off-farm)		
Fertilizer	236.79	0.0000
Hybrid Seed	-124.52	1.0000

Source: Author's study

Table A2.3. Likelihood Ratio (LR) Test for Joint Vs Separate Estimation

Model	LR value	P-value
Models I (Aggregated Off-farm)		
Fertilizer	53.76	0.0000
Hybrid Seed	223.54	0.0000
Models II (Disaggregated Off-farm)		
Fertilizer	48.89	0.0000
Hybrid Seed	215.75	0.0000

Source: Author's study

Table A2.4. Fertilizer and Hybrid Seed Use by "users" and "non-users" of each Input

Year	Fertilizer	% of households	% using hybrid seed	Mean hybrid seed use/acre	Value of hybrid seed use/acre (Ksh)	Hybrid Seed	% of households	% using fertilizer	Mean fert use/acre	Value of fertilizer use/acre (Ksh)
	Non-users	.67	.13	6.79 (5.77)	713 (580)	Non-users	.65	.11	21.52 (33.80)	616 (947
2000	Users	.33	.79	9.15 (8.88)	954 (923)	Users	.35	.74	42.65 (40.25)	1288 (1560)
	Total		.35	8.55 (8.26)	892 (854)	Total		.33	38.20 (39.86)	1146 (1476)
	Non-users	.60	.07	6.63 (5.44)	881 (681)	Non-users	.72	.23	26.80 (31.53)	785 (872)
2004	Users	.40	.59	6.78 (5.17)	924 (722)	Users	.28	.85	50.82 (50.35)	1665 (2827)
	Total		.28	6.76 (5.20)	917 (715)	Total		.40	40.95 (45.1)	1303 (2280)
	Non-users	.64	.10	6.74 (5.64)	769 (618)	Non-users	.69	.17	25.2 (32.2)	735 (896)
Whole sample	Users	.36	.68	8.02 (7.43)	939 (832)	Users	.31	.79	46.6 (45.5)	1469 (2264)
	Total		.31	7.75 (7.10)	903 (794)	Total		.36	39.7 (42.8)	1233 (1962)

Source: Author's calculation

N/B: Figures represent input use among those households using and those in parenthesis are the respective standard deviations

Table A2.5. Probit Model Results for the Combined Fertilizer and Hybrid Seed Use

Variable	Estimate	Std Error
Price of Fertilizer	-.0082	.0136
Price of Hybrid	-.0022	.0044
Price of other seed	.0005	.0014
Price of Maize	.0563***	.0193
Cash crop	.1265	.0938
Cash Income	.0009*	.0005
Off-farm Income	.0036	.0046
Mean Distance (input seller)	-.0683***	.0118
Season/Region	1.0301***	.1142
Agric Potential	1.4409***	.1246
Primary education	.1000	.0987
Age of head	-.0086***	.0031
Gender of head	.1485	.1146
Group membership	.5551***	.1618
Period dummy	.1458	.1538
Interactions		
Off-farm*primary	.0023	.0018
Off-farm*Agric Potent	.0014	.0019
Off-farm*Group	-.0065	.0045
Constant	-2.204***	.9030

Note: *** significance at 1% ** significance at 5% and * significance at 10% Note: *** significance at 1%

Source: Author's study

Table A2.6. Wald Test for the Combined Effects in the Fertilizer and Hybrid Seed Models (Disaggregated Off-farm)

	Adoption Model			Level Model		
Variable	Combined Effect	Wald Stat	p-value	Combined Effect	Wald Stat	p-value
Fertilizer Models						
Primary education	-.1464	.00	.9780	-.1299	1.35	.2461
Agric potential	3.7803	44.19	.0000	1.1287	145.50	.0000
Group Member	.6632	9.01	.0027	.2534	5.85	.0156
Hybrid Seed Models						
Primary education	-.2316	1.77	.1834	-.0660	.23	.6327
Agric potential	2.1531	69.85	.0000	0.5952	33.37	.0000
Group Member	.5854	8.21	.0042	.1669	2.61	.1061

Source: Author's study

Table A3.1. Tegemeo Agro-regional Zones

Zone	District
Coastal Lowlands	Kilifi, Kwale
Eastern Lowland	Taita, Kitui, Machakos, Makueni, Mwingi
Western Lowland	Kisumu, Siaya
Western Transition	Bungoma,Kakamega
High Potential Maize Zone	Bungoma, Kakamega, Bomet,Nakuru, Narok, Tranzoia, Uasin-Gishu
Western Highland	Vihiga, Kisii
Central Highland	Muranga, Nyeri, Meru
Marginal Rain Shadow	Laikipia

Table A3.2. Poverty Disparities across and within Provinces in Kenya

Province	Poverty Rates (% of hhs below poverty)		
	Constituencies		Overall
	Richest	Poorest	
Nyanza	43	80	65
North eastern	59	70	64
Western	50	72	61
Eastern	34	76	58
Coast	30	84	57
R/Valley	43	64	48
Nairobi	31	59	44
Central	16	43	31
Overall			58

Source: Republic of Kenya (2005)

Table A3.3. Results of the Wald test for the Correlation between the Selection and Earnings Equation

Model	Chi-value	P-value
Overall off-farm	0.05	0.8267
Salaried wage	7.99	0.0044
Self-employment	1.17	0.2352
Remittances	1.67	0.4359

Source: Author's study

Table A3.4. Bivariate Probit Heckman Results for Salaried Wage and Self-Employment

	Participation		Earnings	
	Salaried employment	Self-employment	Wage intensity	Earning intensity
Education of head	0.0521***	-0.0270***	2.3548	1.1647
	(7.32)	(3.99)	(1.11)	(0.71)
Education of spouse	0.0234***	0.0003	4.1356***	0.8382
	(2.86)	(0.04)	(2.96)	(0.76)
Male headedness	0.1978**	0.2269***	-34.6277**	16.3288
	(2.28)	(2.98)	(2.34)	(1.48)
Age of head	0.0246*	-0.0493***	2.9492	1.1102
	(1.68)	(3.68)	(1.37)	(0.94)
Age of head squared	-0.0003**	0.0003**	-0.0150	-0.0139
	(2.53)	(2.28)	(0.70)	(1.48)
Number of adult males	0.0761***	0.0332*	1.7384	7.7664***
	(3.95)	(1.85)	(0.37)	(2.64)
Number of female adults	0.0698***	0.0350*		0.2170
	(3.41)	(1.71)		(0.08)
Previous main season r/fall dev	-0.0000	0.0000	0.0154	0.0350
	(0.17)	(0.06)	(0.52)	(1.37)
Square of rainfall deviations	-0.0000	0.0000	-0.0001	-0.0002*
	(1.56)	(0.02)	(0.33)	(1.70)
Long-term main season avg r/fall	-0.0542***	-0.0314*	-3.7270	-7.7823***
	(3.07)	(1.84)	(1.11)	(2.77)
Main season r/fall std dev	0.0502	0.0051	7.4801	0.3054
	(1.08)	(0.12)	(1.21)	(0.05)
Land cultivated	0.0024	0.0021	-0.3212	0.4294
	(1.40)	(1.15)	(1.06)	(1.56)
Major cash crop	-0.0631	-0.1340**	-11.8299	11.8584*
	(1.07)	(2.40)	(1.27)	(1.74)
Mean dist to elect & phone	-0.0206***	-0.0109	1.8426*	0.6584
	(2.88)	(1.58)	(1.75)	(0.63)
Distance to shopping centre	-0.0004	0.0037**	0.1828	0.1683
	(0.29)	(2.48)	(0.71)	(1.09)
Distance to tarmac road	0.0027	0.0028	-0.8628**	-0.5024
	(0.64)	(0.70)	(2.02)	(1.17)
Value of assets	-0.0003**	-0.0001	0.0722**	0.2199***
	(2.57)	(0.95)	(2.50)	(2.73)
Value of agric production	-0.0012	0.0002	0.0834	0.3183***
	(1.43)	(0.23)	(0.82)	(3.27)
Agricultural potential	0.0401	-0.3807***		
	(0.65)	(6.61)		
year dummy	0.0520	0.0213	-8.5362	-5.7927
	(0.85)	(0.37)	(1.12)	(0.84)
Correction term for off-farm decision			6.4250	82.3761
			(0.14)	(0.84)
Correction term for salary/self employment decisions			-84.4160	-83.1007
			(1.44)	(1.11)
Constant	-1.3692***	2.2737***	56.5766	8.1403
	(3.30)	(5.54)	(0.49)	(0.23)
Observations	2648	2648	882	1524

Robust z statistics in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%

Source: Author's study

Table A3.5. Disaggregated Results for Agricultural Wage Labor and other Informal Business Off-farm Work

	Agricultural wage Labor		Other Informal Business work	
	Participation	Earnings	Participation	Earnings
Education of head	-0.0449***	0.1251	-0.0156**	-0.8762
	(3.83)	(0.34)	(2.28)	(0.62)
Education of spouse	-0.0215*	-0.6017	0.0082	0.3585
	(1.81)	(1.58)	(1.03)	(0.32)
Male headedness	0.1681	-7.5170	0.2078***	20.4143*
	(1.61)	(1.53)	(2.72)	(1.92)
Age of head	-0.0359**	-0.5599	-0.0362***	0.6170
	(2.23)	(1.25)	(2.73)	(0.57)
Age of head squared	0.0002	0.0025	0.0002	-0.0108
	(1.64)	(0.74)	(1.59)	(1.15)
Number of adult males	-0.0127	2.7593***	0.0497***	7.5271***
	(0.50)	(2.94)	(2.79)	(3.05)
Previous main season r/fall dev	-0.0006**	0.0050	-0.0000	0.0407
	(2.01)	(0.56)	(0.07)	(1.38)
Square of rainfall deviations	0.0000	-0.0000	-0.0000	-0.0002
	(1.12)	(0.58)	(0.72)	(1.03)
Long-term main season avg r/fall	-0.0908***	-0.8030	-0.0201	-6.1804***
	(3.73)	(1.04)	(1.18)	(3.07)
Main season r/fall std dev	0.0159	-1.5996	0.0232	3.5446
	(0.23)	(0.77)	(0.53)	(0.48)
Land cultivated	-0.0055*	0.1185	0.0032	0.4948
	(1.94)	(1.23)	(1.61)	(1.58)
Major cash crop	-0.0935	-0.8143	-0.0827	8.9432
	(1.19)	(0.32)	(1.46)	(1.40)
Mean dist to elect & phone	-0.0082	0.3324	-0.0066	0.7583
	(0.91)	(0.66)	(0.95)	(0.79)
Distance to shopping centre	-0.0013	0.1258	0.0037***	0.2244
	(0.72)	(1.36)	(2.58)	(1.38)
Distance to tarmac road	0.0174***	-0.0959	-0.0030	-0.4619
	(3.55)	(0.46)	(0.75)	(1.01)
Value of assets	-0.0019**	0.0095	-0.0000	0.2162***
	(2.50)	(0.49)	(0.05)	(2.66)
Value of agric production	-0.0020*	0.0542*	0.0005	0.3223***
	(1.88)	(1.68)	(0.60)	(2.94)
year dummy	-0.3343***	3.0434	0.0681	-9.9171
	(4.35)	(1.03)	(1.17)	(1.41)
Number of female adults	0.0272		0.0303	
	(1.00)		(1.53)	
Agricultural potential	0.3028***		-0.4684***	
	(3.47)		(7.87)	
Constant	0.9073*	44.5807***	1.4083***	6.3351
	(1.74)	(2.69)	(3.48)	(0.16)
Observations	2648	2648	2648	2648

Robust z statistics in parentheses; * significant at 10%; ** significant at 5%; *** significant at 1%

Source: Author's study

Table A3.6. Disaggregated Salaried Wage and Self Employment Models (Participation)

	Low wage labor	High wage labor	Low return business	High return business
Education of head	0.0091	0.0996***	-0.0348***	0.0071
	(1.12)	(12.01)	(4.70)	(0.95)
Education of spouse	-0.0073	0.0437***	-0.0109	0.0116
	(0.79)	(4.82)	(1.33)	(1.39)
Male headedness	0.3199***	-0.0527	0.1874**	0.2164**
	(3.28)	(0.52)	(2.42)	(2.42)
Age of head	0.0145	0.0422***	-0.0457***	-0.0135
	(0.85)	(2.58)	(3.55)	(1.01)
Age of head squared	-0.0003*	-0.0003**	0.0003**	0.0000
	(1.83)	(2.00)	(2.27)	(0.40)
Number of adult males	0.0428**	0.1017***	0.0354**	0.0471**
	(2.05)	(4.97)	(1.97)	(2.50)
Previous main season r/fall dev	0.0002	-0.0002	-0.0003	-0.0001
	(0.88)	(0.76)	(1.19)	(0.24)
Square of rainfall deviations	-0.0000*	-0.0000	0.0000	0.0000
	(1.84)	(0.79)	(0.45)	(0.05)
Long-term main season avg r/fall	-0.0570***	-0.0310	-0.0205	-0.0599***
	(2.91)	(1.57)	(1.20)	(3.34)
Main season r/fall std dev	0.0340	0.0777	-0.0251	0.0071
	(0.65)	(1.51)	(0.55)	(0.15)
Land cultivated	0.0014	0.0005	-0.0012	0.0052***
	(0.69)	(0.26)	(0.69)	(2.58)
Major cash crop	-0.0926	0.0355	-0.1275**	-0.1290**
	(1.38)	(0.53)	(2.24)	(2.08)
Mean dist to elect & phone	-0.0279***	-0.0017	-0.0114	0.0052
	(3.22)	(0.20)	(1.63)	(0.71)
Distance to shopping centre	-0.0024	0.0008	0.0005	0.0036**
	(1.44)	(0.46)	(0.34)	(2.39)
Distance to tarmac road	0.0050	-0.0028	0.0022	-0.0037
	(1.08)	(2.67)	(0.56)	(1.74)
Value of assets	-0.0006**	-0.0001	-0.0005***	0.0002*
	(2.17)	(0.80)	(3.49)	(1.74)
Value of agric production	-0.0014	-0.0005	-0.0003	0.0023***
	(1.46)	(0.55)	(0.38)	(2.63)
year dummy	0.2703***	-0.1711**	-0.0292	0.0280
	(3.93)	(2.43)	(0.50)	(0.43)
Number of female adults	0.0481**	0.0820***	0.0508**	0.0260
	(2.13)	(3.66)	(2.55)	(1.57)
Agricultural potential	0.0124	0.0540	-0.4354***	-0.1507***
	(0.17)	(0.76)	(7.33)	(2.91)
Constant	-0.9591**	-3.4182***	2.0516***	-0.4652
	(1.99)	(7.24)	(5.12)	(1.14)
Observations	2648	2648	2648	2648

Source: Author's study

TableA3.7. Characteristics of Households with and without Off-farm Work

Type of off-farm work	Status	Total income	Crop income	Value of assets	Land cultivated	Crop share	Education of head
Off-farm	Non-participants	113380	75724	159475	11	0.86	4.8
	Participants	184346	71262	156023	14	0.40	6.9
Salary	Non-participants	137512	72596	144421	13	0.62	5.3
	Participants	220913	72189	182036	14	0.32	8.4
Self-employment	Non-participants	150351	74945	170470	12	0.66	6.5
	Participants	176708	70561	146619	13	0.42	6.3
Remittance	Non-recipients	176345	76597	162198	14	0.54	7.0
	Recipients	139246	62713	144585	13	0.47	4.9

Author's study