THREE ESSAYS ON MIGRATION, TECHNOLOGY ADOPTION AND INCOME DIVERSIFICATION

by

SAM KANINDA TSHIKALA

(Under the Direction of Esendugue Greg Fonsah)

ABSTRACT

This dissertation consists of three essays on migration, technology adoption and income diversification.

In the first essay we analyze farmers' adoption behaviors of improved maize over time in rural Kenya. We estimate a multivariate probit model using five years of data from the International Maize and Wheat Improvement Center (CIMMYT). We find that only 19% of farmers used improved maize seeds during 2002 - 2006 while 60% did not use them at all, and 21% used them for one or more years and then discontinued their use. Liquidity constraints, poverty, poor infrastructure and markets are among the causes of the low adoption rate in the region. Providing rural areas with financial services and adequate infrastructure may increase the probability of adopting modern technologies in the region under study as well as in many African rural areas.

The second essay examines the relation between migration, remittances, public transfers and the adoption of modern agricultural technology such as improved seeds and fertilizer. Using data from the World Bank we find that migration, remittances (both internal and external) and public transfers increase households' propensity of adopting modern technologies. However, the

probability of adopting modern agricultural technologies is higher for households with external migrants compared to those with internal migrants. Even though migration and remittances can help farmers reduce liquidity constraints and invest in more productive and risky activities, the provision of financial services in African rural areas is a key factor in the adoption of modern technologies in Africa.

The third essay assesses the impact of remittances and public transfers on income diversification in rural Kenya. The results show that household with internal and/or international remittances are more likely to invest in nonfarm activities. However, only farmers with international remittances are more likely to invest in livestock. If remittances are invested in nonfarm activities, migration will have a negative impact on the agricultural sector. The decrease in agricultural labor force may lower farm production and increase food insecurity. Therefore, policies must be implemented to improve the living conditions and increase agricultural productivity in rural areas.

INDEX WORDS: Migration, Remittances, Public Transfers, Agricultural, Technology Adoption, Income Diversification, Rural Development

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DOCTOR OF PHILOSOPHY

ATHENS, GEORGIA

2014

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DEDICATION

I dedicate this dissertation to my wife Eugenie Kapinga Mutombo; my children Samantha Kaninda, Raisa Kaninda, Junior Kazadi and Ryan Kaninda; my niece Christelle Kazadi; my brothers and sisters; my nephews and nieces.

ACKNOWLEDGEMENTS

First of all, I would like to thank my advisor and mentor Dr. Esendugue Greg Fonsah. You have been more than a professor and advisor to me. Thank you for believing in me and giving me the opportunity to pursue my PhD at the University of Georgia. I am very grateful for your support, your valuable advice and guidance.

I also want to thank Dr. Glenn C.W. Ames and Dr. Genti Kostandini for serving on my committee and sharing their time and expertise. Your contributions have been invaluable in improving the quality of this dissertation. I would like to extend my gratitude to the faculty and staff in the Department of Agricultural and Applied Economics for their mentoring and support.

My brothers Laurent Kazadi, Didier Mbuyi, Emmanuel Tshitundu, Pierrot Kazadi, Isaac Mukendi, and Francky Kadima; my sisters M.J Nsamba, Musau Kabanga, Aimé Muswamba, Angelique Kaseya, Isabelle Kabedi and Bilonda; my cousins Gode Mwambayi, Mary Mwambayi, Robert Mwambayi and Tom Mwambayi deserve a special thank. I am so indebted to everything you have done for me and I would like to take this opportunity to thank you for your support.

I am also thankful to my sisters in-law Hortense Kaja, Delphine Tyson, Betty Tshiala, Claude Mulanga and Arlette Bayila; and my brothers in-law Dominique Lusamba, Joseph Kalunga, François Kaboya for their support, advice and encouragements.

I am very grateful to my friends Jean Claude Tshibangu and his wife Nene Mushiya, Solange Masweka, Mike Musasa, Kwami Gati, Martin Komlanvi; Emmanuel Asguet, Metre

Mugombozi and Raymond Bossale. Thank you my dear friends for always being there whenever I needed help, advice, encouragement and comfort.

I also want to thank my priests Lavern Jackson, Reinhard Meister, Dieter Gaubatz and their families for their support, encouragement and prayers.

My life in graduate school at the University of Georgia could not have been easy and enjoyable without the help and the support of my friends and colleagues such as Sebastain Awondo, Dawit Mekonnen, Padmanand Madhavan Nambiar, Anne Mandich, Ting Meng, and Daniel Kanyam. Thank you so much my friends for sharing your time, your experiences and knowledge with me.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Agriculture is and will remain for many years an important sector for a sustainable development in developing countries in general and Africa in particular (Ouma and Groote, 2011). Agriculture is a key sector in economic growth, food security and poverty reduction in Africa. It is estimated that 80% of African population have agriculture as livelihood. In addition, 70% of the poorest people in Africa and 60% of the economically active population are employed in the agricultural sector (African Development Bank, 2010)

Although agriculture remains an important factor for a sustainable development, food security and poverty alleviation in Africa, the majority of countries in Sub-Saharan Africa have not yet met the conditions for a successful agricultural revolution. In addition, agricultural productivity in many of these countries lags far behind the rest of the world (Diao et al., 2006; Muzari, Gasti, and Muvhuzi, 2012). Pest and disease infection, drought, poor agricultural techniques and equipment, low soil fertility and poor infrastructures are among the major factors that affect productivity.

Given the importance of the agricultural sector in the economic growth and poverty reduction in many Sub-Saharan African countries, governments, donors and other world development agencies have been encouraging rural households to adopt modern farming technologies to increase and stabilize yields. However, due to risk and liquidity constraints and

the lack of financial markets that characterize the majority of rural African countries, many farmers do not have access to these technologies (Gine and Yang, 2009; Kudi et al., 2010)

In many developing countries in general and African countries in particular, rural and agricultural finance have kept low profile in the agenda of policy makers and donors (Zeller 2003). Rural areas have not been well served by financial institutions nor have they been effectively reached by financial services (Andrews, 2006). Policy makers have tried to improve financial markets in poor regions, but with disappointing results (Armendariz and Murdoch, 2005). Despite efforts, innovations, donors and policy makers' determination; providing financial services to rural poor is still a challenge in many developing countries

The lack of the provision of financial services (micro credits and insurance) to rural households has led many households to rely on informal financial services, friends and relatives to smooth their consumption, increase their productive capacity and mitigate risks. In addition, rural households have been relying on migration and remittances as an important source of revenue and risk diversification strategy (Zahonogo, 2011).

Many studies suggest that remittances can be considered as a substitute for formal or informal credit that may enable households to overcome liquidity constraints and invest in new technologies and activities (Stark and Bloom, 1985; Wouterse, 2010). Households with migrants can use remittances to protect themselves against credit and insurance market imperfections. In addition, by reducing risk and credit constraints migration and remittances can increase the use of new agricultural technologies (Quinn, 2009; Zahonogo, 2011).

By reducing risk and liquidity constraints, households with additional income from remittances can also invest in nonfarm activities in order to diversify their sources of

income and mitigate the risk related to agricultural activities (Lazarte-Alcala et al., 2011; Losch, Freguigresh, and White, 2011; Senadza, 2011).

1.2 OBJECTIVES

The goal of this dissertation is to analyze the adoption of modern agricultural technologies, determine if migration, remittances and public benefit transfers can help rural households reduce risk and liquidity constraints, invest in modern technologies, and diversify their sources of income in rural Kenya

1.3 ORGANIZATION OF THE STUDY

This dissertation consists of five chapters: Chapter 1, the introductory chapter, followed by three separate essays in chapters 2, 3 and 4; and chapter 5, the concluding chapter. The first essay analyzes farmers' adoption behaviors of improved maize in Kenya over five years. The second essay investigates the relation between migration, remittances, public benefit transfers and the adoption of modern agricultural technologies and the third essay examines the relation between remittances, public transfers and income diversification. Chapter 5 concludes.

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CHAPTER 2

TECHNOLOGY ADOPTION BEHAVIORS: EVIDENCE FROM MAIZE PRODUCERS IN DROUGHT PRONE REGIONS OF EASTERN KENYA

2.1 INTRODUCTION

Agriculture is and will remain an important factor for sustainable development in general and poverty reduction in particular in many developing countries for years to come (Ouma and Groote, 2011). It is one of the important sectors that can promote growth, overcome poverty and increase food security in developing countries. It is estimated that 70% of the poor in developing countries live in rural areas and 80% of them practice agriculture as livelihood (Muzari, Gasti and Muvhunzi, 2012; Smale, Byerlee and Jayne, 2011).Therefore, rural and agricultural development remain an imperative condition for a sustainable development and poverty reduction in low income countries (World Bank2008).

For the past three decades, agricultural productivity in Sub-Saharan Africa has been extremely low, causing an increase in poverty (Ouma and De Groote, 2011; Suri, 2011). Low productivity and low use of farm inputs, unreliable rainfall, drought, pest infection, crop disease, poor agricultural techniques and equipment, low soil fertility and poor infrastructure, are amongst the main factors that have affected yields.

Increasing yields of agricultural crops in general and staple crops in particular has been the target for many African governments as well as non-governmental world organizations. For many decades, these institutions have been promoting and diffusing new

agricultural technologies and high yielding crop varieties. This is the case of the development and the diffusion of improved seed varieties for staple crop production such as hybrid and open pollinated varieties (OPVs) of maize that aim to help farmer increase production and stabilize yields. These improved varieties have one or more of the following characteristics: drought, disease and pest resistant, low nitrogen and toxicity (De Groote et al., 2005)

As far as staple production is concerned, maize is an important staple food in many Sub-Saharan African countries. In Eastern Africa, maize and wheat are the two main staple crops, with maize being the major crop cereal in term of production and yields (Doss et al., 2003). Maize can also be used in brewing industries and livestock feed. In addition, maize is an important source of iron, vitamin B, protein, and minerals (Kudi et al., 2010).

In Sub-Saharan Africa, maize covers 25 million hectares, mainly in smallholder systems. Between 2005 and 2008, the total production by these smallholders was estimated at 38 million kilograms, primarily for subsistence. During the same period, maize represented an average of 27% of total cereal area and 34% of cereal production. However, from 1961 to 2008, maize has slightly dropped as a share of total area in primary crops in Sub-Saharan Africa (Smale, Byerlee and Jayne, 2011).

With an estimate of 88 million hectares of land that is not yet planted but suited for maize production, the potential for expanding maize production in Sub-Saharan Africa is huge (Kafle, 2010). Therefore, improving maize production is one of the most important strategies to fight food insecurity and reduce poverty in that part of the world (Kafle, 2010).

Being a major staple food crop across many Sub-Saharan African countries, maize production has been the target of support from governments, NGOs and other development agencies (Mugisha and Diiro, 2010). However, despite the emergence and diffusion of new

maize varieties, farmers' choice to adopt new varieties of maize remains a very critical decision. Over 70% of maize productions in the majority of the African countries are from smallholders using traditional methods of production with low crop yields (Muzari, Gasti and Muvhunzi, 2012). These small farmers do not use new technologies due to many factors such as the lack of information, unavailability of the technology, sometimes the returns of the technology, liquidity constraint and the risk related to the use of a new technology (Doss et al., 2003; Kudi et al., 2010)

In general, the adoption of a new technology by farmers is usually based on profitability and the risk associated with the technology. Many farmers who are risk averse will go from cheaper to more costly technologies (Kaliba, Verkuijl and Mwangi, 2000). In the case of maize varieties, farmers will generally adopt improved maize varieties that are stable in yields (Kafle, 2010) and avoid maize varieties that can cause food insecurity due to their high variability in yields. Furthermore, the decision of whether or not to adopt a new technology in general or use improved varieties of maize in particular is also based on farmer and household characteristics (size, age and gender of the household head, wealth, education of the household head, access to information, and availability of cash needed to access technology and labor). Other important technology characteristics include high yield, resistance to drought and pest infestation and clean seed (Doss et al., 2003; Doss, 2006).

Almost all the studies on technology adoption in developing countries in general and Sub-Saharan Africa in particular have focused on a static analysis of the determinants of technology adoption and its effects on yields. To our knowledge, no study has so far focused on the analysis of adoption of improved maize varieties over time or on the relation between adoption and area expansion in Sub-Saharan Africa. This paper contributes to the literature on

technology adoption by analyzing the adoption of improved maize varieties over time and the impact of adoption on area expansion in eastern Kenya.

2.1.2 PROBLEM STATEMENT

The growth in agriculture holds the key to the economic growth and development in many Sub-Saharan African countries. However, for the past three decades, agricultural productivity in this part of the continent has been the lowest in the world, leading to food insecurity and increase in poverty (Diao et al., 2006, Muzari, Gasti and Muvhuzi, 2012).

In order to help farmers increase production and stabilize yields, many African governments, NGO's and other development agencies have been promoting and diffusing new farming technologies and improved high yielding crop varieties. In the area under study, which is a drought prone region in eastern Kenya, the improved maize varieties used by the farmers are classified as hybrid and open pollinated cultivars (OPVs). These varieties do not only have the potential to increase yields, they are also drought resistant.

Despite the emergence and the diffusion of these new crop varieties, farmers' choice to adopt improved varieties remains a very critical decision. Inspite of some compelling success stories on the positive relation between the use of improved maize varieties and the increase in smallholder maize productivity, many farmers are still using traditional maize varieties (Johannes, Vabia and Malaa, 2010; Salasya et al., 2007; Kudi et al., 2010). The most significance concern at the moment is the low rate of adoption. It is against this backdrop that the literature was selected.

2.1.3 OBJECTIVES

The principal purpose of this study is to analyze farmers' adoption behaviors of improved maize varieties in eastern Kenya from 2002 to 2006. The study also examines the relation between the adoption of improved maize varieties and the expansion of the area under cultivation.

In addressing these issues, the study specifically seeks to:

1. Investigate the determinants of adoption of improved maize over time.
2. Determine if farmers who adopted improved maize in the first year, maintained status quo in the rest of the years.
3. Investigate if those who did not adopt improved maize production in the first year adopted in the subsequent or a particular time thereafter.
4. Determines if those who adopted improved maize production did increase, decrease or kept constant the area under maize cultivation.
5. Review policy implications based on findings.

2.1.4. STUDY AREA

This study focuses on the eastern province of Kenya. The province consists of nine (9) districts of which two (2) districts were selected for the study: the districts of Machakos and Makueni. These districts were selected based on the importance of maize production, the prevalence of large number of poor and the high frequency of drought (Muhammad et al., 2010). Based on the 2009 Kenyan census, the province has an estimated population of 5.7 million and covers an area size of 140,698.6 Km^2 or 54,324.0 sq mi. The districts of Machakos and Makueni have a combined total population of 1.9 million inhabitants.

In term of climate, the region has an arid to semi-arid climate which is the cause of drought in that part of the country. Makueni and Machakos are part of the larger semi-arid region with poor population, infrastructure and markets. For instance, 60 to 70 percent of the population are below the poverty line and rely on subsistence agriculture. Due to low density in term of paved roads, farmers have limited access to major markets. The majority of farmers in Machakos and Makueni sold their maize production to traders and middlemen who represent about 90% of buyers in Machakos and 96% in Makueni (Shiferaw, Obare and Muricho, 2006).

Figure 2.1 indicates the locations Makweni and Machakos, the two districts under investigation

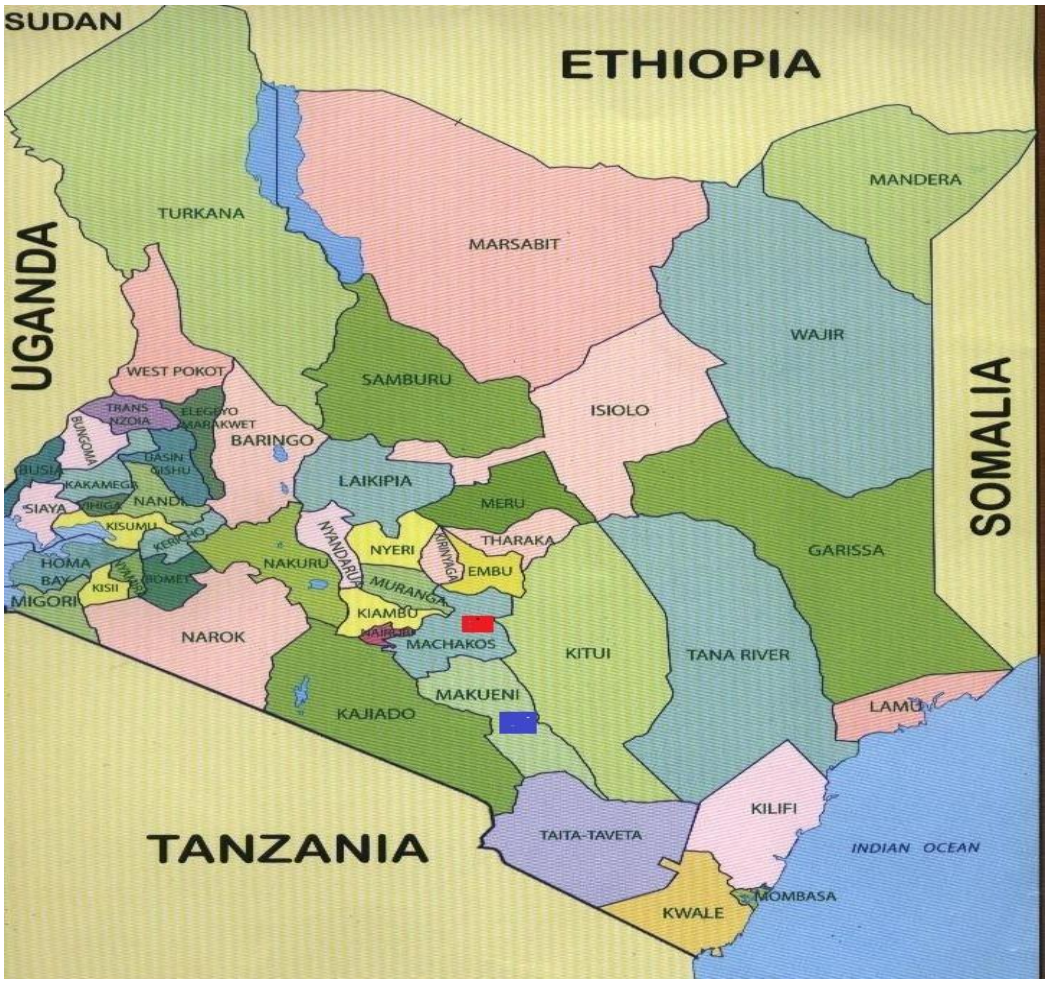

Figure2.1. Survey location, Machakos and Makweni

Machakos Makueni

2.2 LITERATURE REVIEW

Technology adoption is defined as the "degree of use of a new technology in long run equilibrium when a farmer has full information about the new technology and its potential" (Feder, Just and Zilberman, 1985). Based on this definition, the adoption of a new technology at the farm level indicates the realization of farmers' decision to use it in the production process (Kaliba et al., 2000)

There is a wide range of literature on the adoption of new agricultural technologies in Sub-Saharan Africa in general and the adoption of improved varieties of maize in particular. The very low adoption of improved varieties has been identified as the partial cause of low maize yield and food insecurity in many African countries (Salasya et al., 2007; Mwambu, Mwangi, and Nyangito, 2008; Langyintuo and Mekuria, 2008; Donkoh and Awuni, 2008; Abunga, Guo and Dadzie, 2012). However, understanding the factors of adoption is a key factor to the design and the implementation of successful policies and mechanisms to help farmers to adopt them (Suri, 2011; Dos et al., 2003; Mwambu, Mwangi and Nyangito, 2008).

The examination of the existing literature on technology adoption in Eastern Africa by Doss et al., (2003) has shown that depending on the location of study and the study objective, it is difficult to indicate one factor as a key determinant of the adoption of improved technologies. However, a wide range of economic, social, and physical aspects of farming may influence farmers' acceptability to adopt new technologies (Johannes, Vabi and Malaa, 2010).

Various studies have shown that the availability and the profitability of the technology, access to credit by relaxing households' liquidity constraints, and access to information are among the factors that influence farmers to adopt new technologies and improved maize varieties in Sub-Saharan Africa. In addition, socio-economic characteristics

such as age, gender, education, household size, land holding and wealth are also important determinants in the adoption of new technologies (Doss et al., 2003; Moser and Barrett, 2005; Salasya et al., 2007; Legese et al., 2009; Kaguongo et al., 2011; Johannes,Vabi and Malaa, 2010; Salasya et al., 2010; Derwisch, Kopainsky and Troeger, 2011; Mugisha and Diiro, 2010; Feleke and Zegeye, 2006).

Other studies have pointed out that farm size, farmer's learning abilities, (mostly learning through social network or extension contacts), observed and unobserved differences among farmers as well as across farming systems, and farmers' perception of new technologies are factors that explain the adoption of new technologies by farmers in developing countries (Kafle, 2010; Suri, 2011; Muzari, Gatsi and Muvhuzi, 2012; Jackson and Watts, 2002).

Furthermore, other studies have revealed that farmers with more land may have easy access to new technologies and the capacities to bear risk in case of technology failure (Johannes, Vabi and Malaa, 2010; Feder, Just and Zilberman, 1985; Nkonya, Schroeder and Norman, 1997). In addition, farmers with more education generally know more about the new technologies. Therefore, they can evaluate and interpret with efficiency the advantages and the disadvantages of the new technology (Wozniak, 1984).

The age of the farmer plays also an important role in the adoption of new technologies. However, the effect of age on the use of new technology is ambiguous. On one hand, the literature suggests that as farmers get older they become more conservative and less open to new ideas. On the other hand, it is also argued that they gain more experience and they are more able to use new technologies (Johannes, Vabi and Malaa, 2010; Voh, 1982)

As far as the impact of the use of improved varieties is concerned, the existing literature on technology adoption has found a positive correlation between the use of improved

maize varieties and high productivity, high yields and profitability (Johannes,Vabia and Malaa, 2010; Salasya et al., 2007; Derwisch et al., 2011; Mugisha and Diiro, 2010; Kudi et al., 2010; De Groote et al., 2011). However, in their study on the maize green revolution in Kenya, De Groote et al. (2005) argued that the increase in yields was due to the use of fertilizer. The use of improved maize varieties did not affect yields. Their results imply that in some areas, farmers using local varieties can still do as well as those using improved varieties without fertilizers.

The use of improved varieties of maize has also been associated with poverty reduction and food security (Johannes, Vabia and Malaa, 2010; Mwambu, Mwangi and Nyangito, 2008). Based on their results, these scholars argued that the extension of high yielding varieties of maize in the regions with high poverty constitutes an important strategy for poverty reduction and food security.

2.3 METHODOLOGY

2.3.1 DATA AND SOURCE

The data used in this study is part of the data collected by the International Maize and Wheat Improvement Center (CIMMYT) through the Drought Tolerant Maize for Africa (DTMA) initiative. This initiative joins the efforts of people, organization and projects supporting the development and dissemination of drought tolerant maize in 13 Sub-Saharan African countries (Erenstein et al., 2011). The purpose of the initiative is to decrease hunger and increase food and income security of resource-poor farm families in Sub-Saharan Africa through the development and dissemination of drought tolerant, well-adapted maize varieties. The data was collected in 2007; however, the survey asked farmers to provide the information on the adoption of improved seed and the different varieties used for the last five years.

This study uses the data collected from farmers' surveys in the eastern province of Kenya. The eastern province consists of 9 districts. From which the districts of Machakos and Makweni were chosen. From the two selected drought prone maize producing districts, a multi-stage random sample of farm households was selected with a number of random villages, 6 villages (Muisuni, Kangondo, Kikabuani, Kawethei, Kakuyuni and Kivaani) in Machakos and 10 villages (Wathu, Mukuyuni, Kyasini, Iuani,Makongo, Kilala, Kiuva, Utaati, Kithunthi and Nduu Ndune) in Makweni, were selected first and from these, a random sample of 175 farmers was taken in each district (Muhammad et al., 2010; Erenstein et al., 2011), resulting in a total sample of 350 farmers in 2007.

Due to missing information from some respondents, 50 observations were dropped from the original sample. Therefore, a sample of 300 farmers was used to address the study objectives in our analyses. Table 2.1 provides the descriptive statistics of the variables used in the empirical model.

Table 2.1: Descriptive statistics of variables used in estimation

	Description	Mean	Std Dev.
Adopt	Dummy,1= adopt improved maize, 0 = not	0.24	0.41
Gender	Dummy for Gender, 1= male, 0 = female	0.47	0.49
Age	Age of the household head	46.55	16.13
Married	Dummy for marital status, 1= married, 0 = not married	0.96	0.2
Education	Dummy for education of the household head, 1= post secondary school, 0 = other	0.08	0.28
Famer	Dummy, 1= the farmer belongs to the farmers' association, 0=not	0.34	0.47
Seeds	Amount of seed available to farmer (Kg)	11.31	9.62
Area	Area under improved maize	0.85	0.76
Yields	Maize yields (Kg/ha)	1104.50	1108.01
Drought	Dummy, 1= if the choice of improved maize is based drought resistant, 0 = other	0.11	0.32
Drought2001	Dummy, 1= If the farmer faced severe drought before 2002, 0 = not	0.19	0.39
Drought2002	Dummy, 1= If the farmer faced severe drought before 2003, 0 = not	0.12	0.33
Drought 2003	Dummy, 1= If the farmer faced severe drought before 2004, 0 = not	0.23	0.41
Drought 2004	Dummy, 1= If the farmer faced severe drought before 2005, 0 = not	0.14	0.3
Yield potential	Dummy, 1= if the choice of improved maize is based on yield potential, 0 = other	0.85	0.36
Drought risk	Dummy for drought risk perception,1= high 0 = low	0.14	0.34
Observations		300	

Source: Author's computation from CIMMYT data in 2007

On average, 24% of the respondents did adopt at least one improved maize variety during the five years, 47% were males, and the average age was 47 years. In addition 96% of the respondents were married, 8% had post secondary school education, 34% were members of farmers' associations and the average area under maize cultivation was 0.8 hectares. Eleven percent of the respondents chose improved seeds because they resist drought and 85% used them because of potential high yields. Furthermore, 19% of the respondents suffered from severe drought in 2001, 12% in 2002, 23% in 2003 and 14% in 2004. Given that the data set does not contain information on access to credit, access to seeds, which is represented by the amount of seeds available to farmers, was used in this study as a proxy for liquidity constraints. In addition, the variable size of the household is not used in this study because it was available only in 2006.

2.3.2 DATA ANALYSIS

Generally, due to the binary aspect of the dependent variable in technology adoption studies, Probit or Logit models are the most used depending on the distribution function chosen for the stochastic term. To determine the effect of adoption on yields or area cultivated, the simple Tobit model has been use by many researchers (De Groote et al., 2005; Kaliba, Verkujil and Mwangi, 2000). The Tobit model is the censoring model applied to the linear model with normal residuals. However, it may happen that the censoring variable is different from the variable of interest itself but still correlated with it. In the case of adoption, the error term in the selection equation may be correlated with the error term in the outcome model.

Furthermore, studies using the simple Tobit model ignore the consequence of missing farmer records that may result from data cleaning done by those collecting the data, farmer unwillingness to provide data, or farmers self-selecting into or out of the survey or study

which may lead to sample selection problem. Other studies have used the Heckman selection model (Mohammed et al., 2012), hurdle and double hurdle model (Legese et al., 2009) for the same purpose.

All the econometric models mentioned above have used cross sectional data and analyzed the adoption of modern of agricultural technologies at a particular time. On the contrary, the data set used in this study covers a period of five years. In other words, information on the use of improved seeds by farmers was collected for a period of five years. However, to analyze the adoption of a technology over time requires models that capture the potential interdependence between adoption decisions over time.

In order to capture the interdependence between the adoption decisions during the period under study (2002-2006), a multivariate probit (MVP) model is used in all the specific objectives of this study except for objective 5. The use of a multivariate probit model allows to simultaneously capturing the effect of explanatory variables in each of the different times, while allowing for the potential unobserved factors to be freely correlated (Teklewold, Kassie and Shiferaw, 2013). Furthermore, in order to examine the relation between adoption and the change in the area allocated to improved maize varieties, a panel data model will be used for our analyses. The choice of a panel model is justified by the nature of the data used in this study. Though the data set was collected in 2007, each farmer was asked to provide information on the use of improved seed for the last five years (2002 – 2006), which gives the collected data a panel structure. In addition, it allows capturing the variation or the change in the area under maize cultivation over time.

2.3.3 THEORETICAL FRAMEWORK

Adoption is defined by Feder et al. (1985) as the degree to which a new technology is used in long-run equilibrium when farmers have complete information about the technology and it's potential. Hence, adoption at the farm level indicates farmers' decision to use a new technology in the production process (Kaliba,Verkujil and Mwangi, 2000). Modeling farmers' decision to adopt a new technology constitutes a discrete choice.

Given that the objective of this paper is to analyze the adoption of new varieties of maize over time, a multivariate probit model is used. The use of this model captures the potential correlation between the adoption decisions over time. It also allows the estimation of the joint probability of adopting improved maize varieties by farmers who did not adopt them in the first year (2002) of the study and the joint probability of continuing or discontinuing the use of improved maize varieties by farmers who did adopt in the first year.

This study, assumed that the decision to adopt new maize varieties was correlated over time. In addition, almost all farmers who used improved varieties in the first year did not discontinue using them. In other words, the joint probability for farmers to discontinue using improved seeds is very low. Furthermore, it is expected that many farmers who did not use improved seeds in the first year, may be due to liquidity constraints or risk aversion, had the opportunity to use them over time. However, we expect that the joint probability of not adopting improved varieties by a farmer during the five years of study period (2002 to 2006) to be very low.

As far as the determinants of the adoption of improved maize varieties are concerned, the study assumes, as in most of the studies, that farmers' decision to adopt improved

maize varieties depends on their socio-economic characteristics and identifiable characteristics of the technologies (Doss et al., 2003; Kaguongo et al., 2011).

2.3.3.1 THE MULTIVARIATE PROBIT MODEL

We follow Teklewold, Kassie and Shiferaw (2013); Cappellari and Jenkins (2006) to model the individual adoption decision:

Consider the i^{th} farmer $(i = 1, \ldots \ldots, N)$ facing a decision to adopt or not adopt the available technology. Let U_0 be the benefits from the use of traditional maize variety and U_1 the benefits from the adoption of the improved maize variety. A farmer will chose the improved maize variety if her/ his net benefit $Y_i^* = U_1 - U_0 > 0$. Where Y_i^* is a latent variable determined by observed farmer socio-economic and farm characteristics (X_i) as well as by unobserved characteristics (ε_i). Then,

$$Y_{im}^* = X_{im}'\beta_m + \varepsilon_{im} \quad for \quad m = 1, \ldots, M \tag{1}$$

Where m represents the total number of equations in the multivariate probit model. In the case of this study m = 5, representing the adoption decision of improved maize varieties in the five years. The unobserved preferences from equation (1) can be expressed as observed binary outcomes equation for each period, using the indicator function, as follows:

$$Y_{im} = 1 \; if \; Y_m^* > 0 \; and \; 0 \; otherwise \tag{2}$$

The error terms ε_m , $(m = 1, \ldots, M)$ are distributed as multivariate normal, each with a mean zero, and variance–covariance matrix Ω, where Ω has values of 1 on the leading diagonal, for identification of the parameters, and correlations $\rho_{jk} = \rho_{kj}$ as off-diagonal elements for $j, k = 1, \ldots, M$ and $j \neq k$ (Capillary and Jenkins, 2006).

The probabilities of adopting improved maize varieties are obtained by evaluating the multiple integrals, using numerical methods (Gedikoglu, 2013, Cameron and Travedi, 2005).The probability of adopting improved maize varieties all the years or outcomes is:

$$\int_{-\infty}^{X_1\beta_1}\int_{-\infty}^{X_2\beta_2}\dots\dots\int_{-\infty}^{X_M\beta_M}\emptyset(\varepsilon_1\varepsilon_2,\dots\dots\dots,\varepsilon_M)d\varepsilon_1 d\varepsilon_2,\dots\dots d\varepsilon_M \quad (3)$$

2.3.3.2 PANEL DATA MODEL

We use the panel model to examine the relation between the adoption of improved maize varieties and the area expansion (objective 5). The use of this model is justified by the panel aspect of the data set and the fact that the study aims to capture the change in area under maize cultivation over time. Following Dutsman and Rocina-Barrachina (2007), the panel model can be expressed as:

$$\Delta A_{it} = X_{it}\beta + \alpha_i + \varepsilon_{it};\ i = 1,\dots,N;\ \ t = 1,\dots\dots,T\ , \quad (4)$$

$$d_{it}^{*} = Z_{it}\gamma + \eta_i + \mu_{it};\ d_{it} = [d_{it}^{*} > 0] \quad (5)$$

Where ΔA_{it} represents the change in area under maize cultivation from year (t) to year (t-1), β and γ are the parameters to be estimated and, X_{it} and Z_{it} are vectors of time variant (age of the household head, amount of seeds planted and maize production per hectare) and time invariant (gender of the household head, marital status, whether or not farmer belongs to farmer association) covariates respectively. Time variant covariates include the age of the household head, the amount of seeds planted and production per hectare. In addition, d_{it} is an indicator factor which is equal to 1 if $d_{it}^{*} > 0$ and 0 otherwise. In case of this study, d_{it} is equal to 1 if a farmer adopted the improved variety and 0 if he/she did not.

2.4 RESULTS

The results from the multivariate probit estimation are presented in tables 2.2, 2.3 and 2.4. The estimated results for the impact of the adoption of improved maize varieties are reported in table 2.5.

Table 2.2: Multivariate probit estimation results of the adoption of improved maize

Dependent variable :Adoption of new maize varieties (1= yes,0 = no)										
	2002		2003		2004		2005		2006	
	Coef	Robust Sdr. Err	Coef	Robust Sdr. Err	Coef	Robust Sdr. Err	Coef	Robust Sdr. Err	Coef	Robust Sdr. Err
Gender	.052	.165	.165	.183	.511**	.230	-.062	.174	.218	.185
Age	-.03**	.005	-.005	.006	-.018*	.007	-.027**	.005	-.072**	.006
Married	.168	.449	-.178	.399	-.523	.501	-.291	.411	-.580	.448
Education	.433**	.213	.569**	.298	.788**	.349	.475	.294	.809*	.278
Famer's association (1= yes, 0 = no)	.03	.212	.372**	.184	.304**	.014	.541*	.200	.311**	.113
Seed (in kg)$^{\top}$	-.006	.004	.032**	.015	.079*	.019	.011***	.006	.045*	.013
Yield lag	-	-	.0017**	.0005	.005***	.0003	.007***	.0003	.007**	.0003
Area	-.161**	.078	.006	.098	-.089	.190	.118	.096	.074	.066
Drought resistant	.495	.575	1.02***	.579	1.754*	.652	.182	.509	1.196**	.501
Drought risk	-.192	.272	.194	.261	.342	.277	.412	.279	.273	.281
Yield potential	.826	.515	-.123	.396	-.248	.410	.349	.399	-.082	.372
Drought in 2001	.242**	.104	.498***	.234	.758*	.285	-.086	.227	.064	.263
Drought in 2002			.529**	.256	.106	.294	-.199	.241	-.299	.270
Drought in 2003					.678**	.263	.460***	.215	.386***	.122
Drought in 2004							.715**	.238	.473***	.217
Constant	-1.51**	.728	-.692	.608	.655**	.292	-.493	.650	.639*	.308
Observations	300		300		300		300		300	

*,**, and*** denotes significance at 1%, 5% and 10%, respectively

$^{\top}$ Amount of seeds available to farmer

The estimated coefficients in table 2.2 show that the age of the household head is negatively correlated with the propensity to use improved maize varieties during all the study period. This is consistent with the argument that, as farmers get older they become conservative and less likely to adopt improved technologies (Johannes, Vabi and Malaa, 2010; Voh, 1982). In contrast, more educated farmers and those who belong to farmers' associations are more likely to adopt new maize varieties as Wozniak suggests (1984), farmers with more education are able to evaluate the advantages and the disadvantages of new technologies.

Farmers who belonged to a farming association were more likely to adopt the new maize varieties. As members of the association, farmers can learn more about the new technology through interpersonal communication with peers and group leaders, extension services as well as observe farm demonstration and field days. Furthermore, through the association farmers get technical and financial supports that increase their ability to access seeds and use them efficiently.

In Eastern Kenya, the Cereal Grower Association (CGA) in partnership with the Kenyan Maize Development Program (KMDP) has been providing many services to its members; such as facilitating group action in input procurement, access to extension, marketing of their produce, and access to credit. Through extension services, the association has facilitated technology transfer through demonstration and field days. Besides the CGA, there is also the Producer Marketing Group (PMG) that helps members get better prices for their produces, access to inputs, and develop business skills (Shiferaw, Obare, and Muricho, 2006). As a result, the knowledge gained from this network increases farmers' propensity to adopt new technologies (Suri, 2011).

Furthermore, results in table 2.3 suggest that farmers who had access to more improved seeds and those who had good yields in the previous year were more likely to adopt new maize varieties in the following years. The access to more improved seed is used as a proxy for access to cash or credit in this study. Therefore, farmers without liquidity constraints are more likely to use new technologies. In addition, good yields in the previous year can encourage farmers to use more improved seeds in the following year.

Farmers who chose maize varieties for their resistance to drought, in addition to the maize variety not only because it improves yields but also it resists drought were more likely to adopt improved maize varieties. Even though the estimated coefficients in some of the years were not statistically significant, their signs were positive as expected. Since the area under study is a drought prone area, it was expected to have a positive relation between the adoption and the drought resistant aspect of the maize variety. In addition, the sign of the estimated coefficients related to drought risk were as expected even if the coefficients across all the years were not statistically significant. Furthermore, farmers who affirmed having severe drought in the past years were more likely to adopt the improved seeds.

However, it is surprising to notice that, although 85% of the respondents chose new maize varieties due to their potential to increase in yields, none of the coefficients related to this variable was statistically significant. In addition, in some years the estimated coefficients were negative. This result may explain why some farmers did discontinue the use of these varieties; maybe they were not satisfied with the yields. Furthermore, all the correlations coefficients in table 2.3 are positive and statistically significant. These results indicate that farmers' decision to adopt new maize varieties in the next year was correlated with the decision in the previous year.

Table 2.3. Correlation Matrix of farmers' adoption decision between years

	2002	2003	2004	2005	2006
2002	1.00				
2003	.855	1.00			
	(.0505)				
2004	.7854	.877	1.00		
	(.141)	(.069)			
2005	.770	.6795	.792	1.00	
	(.097)	(.080)	(.087)		
2006	.673	.612	.721	.815	1.00
	(.123)	(.084)	(.071)	(.050)	

As stated above, many studies on technology adoption have analyzed the determinants of technology adoption in general and the adoption of improved maize in particular. One of the main goals of this study was to analyze improved maize adoption over time. Table 2.4 contains the different joint probabilities on the adoption of improved maize over the period under study.

Table 2.4 Joint probabilities of farmers' adoption decision over the years

	Adoption of new maize varieties in year					
	2002	2003	2004	2005	2006	Probability
A	1	1	1	1	1	.19
B	1	1	1	1	0	0.013
C	1	1	1	0	0	0.003
D	1	1	0	0	0	.0.02
E	1	0	0	0	0	.0003
F	1	1	0	1	1	0.003
G	0	1	1	1	1	0.01
H	0	0	1	1	1	0.02
I	1	1	0	0	1	0.003
J	0	0	0	1	1	0.06
K	0	0	0	0	1	0.07
L	0	0	0	0	0	0.603

Adopt = 1 and not adopt = 0

Based on the results in table 2.4., the joint probability of adopting the improved varieties by farmers in all the five years was 19%. Based on the overall sample, this implies that only 57 farmers over 300 in the sample did use improved maize varieties during all the five years. However, based on 70 farmers who used improved seeds in the first year, 81.42% did use the

improved varieties during all the period under study. The joint probability for not adopting during all the period under study was 60.33%. This implies 181 farmers based on the entire sample and 78.6% based on the number of those who did not adopt in the first year.

If we represent the adoption and the non-adoption of new maize varieties by $y_k = 1$ and $y_k = 0$ respectively, where y is the adoption and k (k = 2002…, 2006) the year, the different joint probabilities can be expressed as:

Pr (y2002=1, y2003=1, y2004=1, y2005=1, y2006=1) = 0.19, which means that the probability of adopting new maize varieties during all the five years was 19%. The probability of not adopting improved maize in all the five years, Pr (y2002=0, y2003=0, y2004=0, y2005=0, y2006=0) was 60.33%. In addition, Pr (y2002=1, y2003=1, y2004=1, y2005=1, y2006=0) =0.013 represents the joint probability of using improved maize in the first four years and discontinue using in the fifth year was 1.33% and Pr (y2002=0, y2003=1, y2004=1, y2005=1, y2006=1) = 0.01, the joint probability of not adopting in the first year but adopt in the rest of the years. The rest of the results in table 2.4 can be interpreted following the same logic.

Equations (4) and (5) were estimated by the Wooldridge method (Dutsman and Rachina-Barrachina, 2007). Results in table 2.5 indicate that the change in area allocated to improved maize varieties was positively correlated with the increase in seeds and production per hectare. This result can be explained by the fact that farmers with more cash and less liquidity constraint are able to buy more seeds and allocate more land to new varieties than those with serious liquidity constraints. In addition, farmers who were satisfied with the yields allocated more land to improved seeds.

Farmers who were members of a farming association increased the area allocated to new varieties more than the non members. In fact, being a member of a farming association allows

farmers to learn more about the new varieties from their peers or association leaders. In addition, members can get technical and financial supports from the group. Furthermore, through the association, members can get easier access to inputs and outputs markets. As a consequence, they can be motivated to allocate more land to new varieties in order to produce more.

In contrast, the results in table 2.5 show that farmers with higher risk perception of drought have decreased the farming area under maize compared to those with low risk. In fact, Machakos and Makueni are part of the drought prone region of eastern Kenya. From the CIMMYT survey, drought was one of the major threats for maize producers in this part of Kenya. This can explain why farmers who have suffered from severe drought in past years have reduced the area allocated to new maize varieties even if some of these varieties are drought resistant.

Table 2.5 Estimated results of the impact of the adoption of new maize variety on area expansion

Dependent variable : Change in Area under maize production		
Variables	Coef.	Robust Std. Err
Gender of the HH. Head (1= male,0 = female)	.115	.192
Age of the HH. Head	-.007	.006
Marital status (1 = Married,0 = Single)	-.303***	.176
Education of the HH. Head	.693	.501
HH member of farmer Ass. (1= yes, 0 = no)	.168	.109
Seeds (Kg)$^{\top}$	.028*	.001
Production per hectare (kg)	0.064**	.002
Drought resistant (1= yes,0 = no)	.246	.306
Yield potential	.348	.247
Drought risk	-.214**	.108
Inverse mill ratio	.283	.079
Constant	.275	.283
Observations	69	

*, **, and*** denotes significance at 1%, 5% and 10%, respectively
HH: Household
$^{\top}$ Amount of seeds available to farmer

2.5 CONCLUSION

The low agricultural productivity in Sub-Saharan African countries has been a focus of many governments and non-governmental world organizations. For decades, these institutions

have been diffusing and promoting new agricultural technologies and high yielding crop verities to help farmers increase their production and stabilize yields. However, in many regions the overall rate of adoption remains low.

The purpose of this study was to analyze the adoption of improved maize varieties over time as well as the impact of the adoption of these improved varieties on the area expansion in the drought prone region of eastern Kenya.

Using data collected by CIMMYT in the district of Machakos and Makueni in Eastern Kenya, the empirical results indicate that: the age of the household head was negatively correlated with the propensity to use improved maize varieties, more educated farmers, those who belong to farmers' associations, farmers who had access to seeds, and those who had good yields in the previous year, were more likely to adopt new maize varieties. In addition, farmers who chose improved maize varieties due to their resistance to drought as well as farmers who suffered from severe drought in the past years were more likely to adopt new maize varieties.

Less than 20% of famers used improved maize varieties during all five years. Sixty percent did not use them at all, and 21% used them for one or more years and then discontinued. The study also found a positive correlation between access to improved seeds, production per hectare and increase in area allocated to new maize varieties. In addition, farmers who were members of a farming association increased their area under maize cultivation. In contrast, farmers with high risk perception of drought have decreased their area allocated to new maize varieties compared to those with low risk perception.

The results on the low adoption rate of improved maize varieties in this part of Kenya found in this study are similar to the results found by Bett et al., (2006) and Muhammad et al., (2010). A study by Bett et al., (2006) revealed that the adoption of improved maize varieties has

been very low in arid and semi-arid land of eastern Kenya despite the high number of improved varieties released in that part of the country. In addition, Muhammad et al. (2010) found that despite the efforts dedicated to the promotion of high yield varieties over the last four decades, the adoption of improved maize has been very low in the eastern province of Kenya.

The low rate of adoption of improved maize varieties in this part of Kenya can be attributed to poverty, poor infrastructure and markets, low selling prices, and liquidity constraints. Households do not have access to credits due to lack of collateral, lack of credit facilities in the vicinities, distance to the source of credit and lack of knowledge of sources of credits (Muhammad et al., 2010).

2.6 POLICY IMPLICATIONS

In order to help rural households in this part of the eastern province of Kenya, it is important to invest more in roads to facilitate farmers' access to markets and reduce transportation costs. In addition, government and development organizations have to develop plans, strategies and mechanisms to help households access to inputs and outputs markets, reduce the interference of middlemen, and get access to agricultural credits in order to stimulate the adoption of improved seeds.

Although the results from this study cannot be generalized to Kenya or to the entire African continent, the high percentage of farmers who did not adopt the new maize varieties and the drop out of some farmers must be a concern for researchers and all parties involved in the promotion and the diffusion on new agricultural technologies in this part of Kenya in particular and the Sub-Saharan Africa in general. Future studies and research can investigate the adoption in other parts of the continent where new farming technologies in general and high yielding crop

varieties have been introduced but the adoption rate and the agricultural productivity are still very low.

Furthermore, besides the risk and liquidity constraints, more studies may try to analyze in depth the determinants of non adoption of new farming technologies as well as why some farmers have discontinued using them. If liquidity constraint is the major problem as mentioned in several studies on technology adoption in Sub-Saharan Africa, governments, donors, researchers and other development agencies may need to devise new plans and strategies, based on the socio-economic realities of Sub-Saharan African countries, in order to implement and restore the financial markets in rural areas (Kudi et al., 2010; Gine and Yang, 2009; Dupas and Robinson, 2013).

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CHAPTER 3

MIGRATION, REMITTANCES, PUBLIC TRANSFERS AND TECHNOLOGY ADOPTION: THE CASE OF CEREAL PRODUCERS IN KENYA

3.1 INTRODUCTION

The adoption of improved technologies for staples crop production in many developing countries in general and Africa in particular, represents an important means to increase agricultural productivity, promote economic growth and improve the well-being for millions of households (Doss et al., 2003; Dos, 2006; Johaness, Vabi and Malaa, 2010). In addition, improved technologies that lead to agricultural production efficiency represent an important component of any rural development strategy (Langyintuo and Mekuria, 2008).

A wide range of literature on the determinants of the adoption of new agricultural technologies in developing countries has revealed that access to credit has a huge impact on the adoption of these technologies by rural farmers. The provision of microcredit is widely perceived as an effective strategy for promoting the adoption of improved technologies (Simtowe and Zeller, 2006).

In countries where rural financial or credit market exists, poor households with binding liquidity constraint or households with little or no saving may access to micro-credit, purchase costly inputs and adopt new technologies. In addition, access to credit can increase the households' (especially for those who are risk averse) ability and willingness to invest in more risky activities in general and technologies in particular (Eswaran and Kotwal, 1990).

However, in many developing countries liquidity constraint is more severe in rural areas where farming is the principal activity for the majority of households (Winter-Nelson and Temu, 2005). Access to credit in these areas remains one of the major constraints in the adoption of new agricultural technologies (Dercon and Christiaensen, 2011; Kudi et al., 2010; Gine and Yang, 2009; Dupas and Robinson, 2013). Given that poor rural households do not have or have limited access to credit, extending land under cultivation is more feasible than using fertilizer or improved seeds varieties (Diagne, Zeller, and Sharma, 2000; Losch, Freguingresh, and White, 2011).

For many decades, the economic development of rural areas has lagged behind in low income countries. Rural and agricultural finance have kept low profile in the agenda of policy makers and donors (Zeller 2003). Rural areas have not been well served by financial institutions, nor have they been effectively reached by financial services during the past decades (Andrews, 2006). Policy makers have tried to improve financial markets in poor regions, but with disappointing results (Armendariz and Murdoch, 2005). Direct subsidized agricultural credit projects implemented in developing countries in 1960s and late 1970s as well other programs or plans implemented to boost rural activities and help rural households graduate from poverty have failed or shown their limits (Adams and Vogel, 1986).

Nevertheless, there has been a shift in rural and agricultural financial policies since 1980s with the creation of and the promotion of microfinance institutions (MFIs) which are, so far, the most innovative in striving to serve the poorest and the populations in remote areas (Zeller, 2003; Andrews, 2006; Nagarajan and Meyer, 2005;Winter-Nelson and Temu, 2005). However, in most low income countries microfinance institutions (MFIs) offer just a small share of entire rural financial services.

Despite efforts, innovations, donors and policy makers' determination, providing financial services to rural poor is still a challenge in many developing countries. Meanwhile, the majority of rural households in developing counties in general and Africa in particular, continue to rely on informal credit markets, family members, friends and neighbors to increase their productive capacities, share risks, and smooth consumption over their life cycle (Diagne, Zeller and Sharma, 2000).

For decades, rural households have been relying on migration and remittances which are an important source of revenue and a diversification strategy for many poor households in developing countries (Zahonogo, 2011). Given the level of poverty, remittances sent by migrants in their countries of origin constitute an important part of private capital in these countries. Zahonogo (2011) and Quinn (2009) argue that households with migrants can use remittances to protect themselves against credit and insurance market imperfections. In addition, by reducing risk and credit constraints, migrations and remittances can increase the use of new agricultural technologies (Quinn, 2009).

Remittances are viewed by the new economics of labor migration (NELM) theory as a substitute for formal or informal credit that may enable households to overcome liquidity constraints and invest in new technologies and activities (Wouterse, 2010). Currently, international remittances constitute the second largest source of external finance after foreign direct investments in developing countries. In addition, they represent twice as large as the official foreign aid to developing countries (Bettin and Zazzaro, 2012; De Haas, 2006).

Moreover, in order to help rural households cope with different risks and encourage them to invest in agricultural activities in areas where households have liquidity constraints and have

no access or have limited access to microcredit, governments in some countries (e.g. Malawi, Kenya, Mali, and Madagascar) have been providing transfers in term of money or subsidies.

The impact of migration and remittances on the adoption of new agricultural technologies has been investigated by Quinn (2009) using data from Mexico and Mendola (2006) using data from Bangladesh. However, to our knowledge, despite the significant number of migrants and the importance of remittance flows in African countries, no known study has examined whether or not migration and remittances can help African rural households reduce risk and credit constraints and invest in modern agricultural technologies.

This study analyzes the relation between migration, remittances, public transfers and technology adoption in rural Kenya.

3.1.1 PROBLEM STATEMENT

Agricultural productivity in Sub-Saharan Africa is the lowest in the world leading to food insecurity and increase in poverty. For the past three decades, government and nongovernmental world organizations have been promoting and diffusing new agricultural technologies in general and high yielding crop varieties in particular to help farmers increase production and stabilize yields. However, despite efforts from government and nongovernmental world development organizations, many farmers do not have access to these modern technologies. In many rural areas, the lack of credit and insurance markets are the major causes of the non adoption or the low rate of adoption of these technologies (Gine and Yang, 2009; Kudi el al., 2010; Dupas and Robinson, 2013).

In many developed countries where rural financial or credit markets exists, rural households with binding liquidity constraints or households with no savings can access micro-

credit and invest in modern agricultural technologies. However, in developing countries in general and Sub-Saharan Africa in particular, liquidity constraint is more severe in rural areas where farming is the principal activity for the majority of households (Winter-Nelson and Temu, 2005).The lack of rural financial markets in many Sub-Saharan countries has led households to rely on informal credit markets, friends and family members in order to increase their production capacities, share risks, and smooth consumption over their life cycle (Diagne, Zeller and Sharma, 2000).

Furthermore, rural households have been relying on migration and remittances as a source of revenue and a diversification strategy for decades. According to the new economics of labor migration theory, migration and remittances can help rural households in developing countries reduce risk and liquidity constraints. In addition, remittances are viewed as a substitute for formal and informal credit. Therefore, remittances can help rural households overcome liquidity constraints, cope with risk and invest in new agricultural technologies in developing countries (Wouterse, 2010). However, given the flow of remittances to African countries: Do migration and remittances help rural households reduce risk and liquidity constraints? In other words, do rural households with migrants and remittances invest in new farming technologies?

3.1.2 OBJECTIVES

This study analyzes the relation between migration, remittances, government transfers and the adoption of new farming technologies in Kenya. Specifically, the study seeks to:

1. Investigate whether or not migration, remittances and government transfers can help rural households reduce risk and credit constraints and adopt new technologies such as improved seeds and fertilizer.

2. Determine other factors that influence the adoption of these technologies.

3.2 LITERATURE REVIEW

Remittances are money or goods that are transmitted to households back home by those working away from their communities of origin. They include both international and internal person to person transfers of both money and in-kind resources, often sent by migrant workers to their relatives and or family members in their respective countries (Plaza, Navarrete, and Ratha, 2012).

For decades, remittances have been an important source of income for many households in developing countries in general and rural households in particular. Over the last decades, the amount of international remittances sent in developing countries has considerably increased from US$68 billion in 1990, to US$325 billion in 2010 (Imai et al., 2012; Bettin and Zazzaro, 2012; Anyanwu, 2011).

During the same period, the total amount of remittances sent to Africa increased from $9.1 billion in 1990 to nearly $40 billion in 2010 which represents approximately 2.6 percent of Africa's gross domestic product (Mohapatra and Ratha, 2011). Moreover, though smaller in magnitude, internal remittances are also an important component of rural livelihoods in those countries (Garip, 2012; Reardon, 1997).

The impact of migration and remittances on the standards of living of recipient households and communities has been widely and empirically investigated. Many empirical studies have found a positive relation between remittances sent by migrant workers to relatives and poverty reduction as well as recipients' livelihood. In addition, remittances have improved food security in many rural households (Babatunde and Martinetti, 2011). Furthermore, remittances can increase access to health and educational services. (Bettin and Zazzaro, 2012;

Yang, 2008; De Haas, 2006; Adams and Page, 2005; Ncube and Gomez, 2011; Blosh, 2008). They can also be used as insurance in case of unexpected events (Ponsot and Obegi, 2010). Studies also suggest that that remittances have a positive impact on aggregate investments, employment and income (Bjuggren, Dzansi and Shukur, 2010; Glytsos, 2002).

Although remittances can have a positive impact on the livelihood of recipient families, their impact on sustainable and long-term economic growth has been a big debate over the past decades.

On one hand, some scholars argue that migration leads to the withdrawal of human capital and the breakdown of traditional, stable villages, communities and regional economies (De Haas, 2006). In addition, migration discourages the economic growth of migrant countries given that remittances are not spent or invested in productive activities but in luxury and other consumption goods (De Haas, 2006; Rubenstein, 1992).

On the other hand, according to new economics of labor migration (NELM) scholars, migration and remittances play a big role in developing countries. They represent an important source of investment capital in countries where households do not have or have limited access to credit and insurance markets (Richter, 2008; Wouterse, 2010). In addition, remittances can be considered as a solution to liquidity constraint which can allow households to invest in productive activities and promote growth (De Haas, 2006; Taylor, 1999; Garip, 2012). Remittances can also enhance growth by boosting capital accumulation, increasing labor growth and total factor productivity (Imai et al., 2012).

Other studies on the impact of migration and remittances on the wellbeing of recipient households include the study by Ang (2009) and Yang (2008) in the Philippines, Wouterse and Taylor (2008) in Burkina Faso, and Miluka et al., (2010) in Albania. Ang (2009) found that

remittances had a positive impact on economic growth at the national level but not on rural development. However, findings from Wouterse and Taylor (2008) suggest that continental migration had a positive relation and intercontinental migration had no relation with farm technical efficiency in cereal production. The failure of international migration to transform cereal production from traditional to modern is attributed to an imperfect market environment. Miluka et al. (2010) suggest that families with migrant workers work fewer hours in agricultural production. In addition, migrant households do not appear to invest in productivity-enhancing and time saving farm technologies in crop production.

As far as the impact of migration and remittances on technology adoption is concerned, the existing literature (especially the NELM) suggests that migration and remittances can help rural households reduce risk and credit constraints and invest in new and risky agricultural technologies. The credit and risk hypotheses have been tested by Quinn (2009) in rural Mexico. However, using data from rural Bangladesh, Mendola (2006) tested only the risk hypothesis. In Quinn (2009), results supported more the credit hypothesis. Mendola (2006) found that only international migration had an impact on the adoption of high-yielding seed varieties.

3.3 METHODOLOGY

3.3.1 THEORETICAL FRAMEWORK

Many rural households in developing countries in general and Sub-Saharan Africa in particular are poor and do not have or have limited access to financial markets. Studies have shown that access to credit in rural areas remains one of the major constraints in the adoption of new technologies (Dercon and Christiaensen, 2011; Kudi et al., 2010; Gine and Yang, 2009; Dupas and Robinson, 2013).

The conceptual frame work for this study is based on the New Economics of Labor Migration theory (Stark and Bloom, 1985). According to this theory, migrants play the role of financial intermediaries enabling rural households to overcome the constraints based on their ability to achieve the transition from familial to commercial production. In addition, migration constitutes a means for rural household to overcome liquidity constraint (Zahonongo, 2011).

Based on this theory, researchers on migration, remittances and agricultural investments are motivated by the risk and credit hypotheses (Quinn, 2009). According to the risk hypothesis (e.g. Stark and Bloom, 1985; Taylor and Wyatt, 1996), migration is a strategy adopted by households to ensure against the risk of agriculture failure. In case of agriculture failure, due to the adoption of a new technology, migrants can send money to their families to compensate for agricultural losses. As a result, risk adverse rural households with migrants can be motivated to invest more in new agricultural technologies.

However, the credit hypothesis suggests that remittances are the crucial factor as they provide the necessary funding to credit constrained households to purchase new technologies (Quinn, 2009). Based on these hypotheses, if credit and risk constraints are severe and migration enables families with migrants to overcome them, we expect in this study the number of migrants and remittances per household to be positively related to the probability of adopting new technologies.

Furthermore, credit constraint can also be relieved through domestic initiatives. In addition to remittances, rural households can get help from government and non-government organizations in term of money or subsidies to help them invest in new agricultural technologies. If this is the case, we also expect that government transfers will increase the probably to adopt agricultural technologies.

3.3.2 DATA SOURCE

The data used for this study is from the household survey conducted by the World Bank in partnership with the French Cooperation and the International Fund for Agricultural Development (IFAD).The survey was conducted through the RuraLStruc Program between 2007 and 2008 in seven countries (Mali, Senegal, Kenya, Morocco, Madagascar, Nicaragua, and Mexico). This study focuses on Kenya

The main objective of the RuraLStruc Program was to provide a better understanding of the implication of liberalization and economic integration for agriculture and rural development in developing countries. It also illustrates the situation of rural economies in terms of income, diversification and overall transformation (Losh, Freguingresh, and White, 2011).

The sampling process for the surveyed households followed a multistage systematic random sampling procedure. The first stage was the selection of regions or districts for the survey. From the regions selected, a multi-stage random sample of farm households was selected with a number of random localities to be surveyed selected first and from these, a number of random households, targeting a sufficient number of households per locality allowing representativeness at local level. The choice of selected regions was based on the importance of agricultural activities, market access, size, population density and, the ability to illustrate different rural household situations (Kirimi et al., 2010).

The regions selected were Nakuru North, Nyando and Bungoma. From these regions, 904 randomly selected households were surveyed in 27 villages (Kirimi et al., 2010). 300 households were surveyed in Nakuru North, 301 in Nyando and 301 in Bungoma. However, after data cleaning, a sample of 873 was presented in the Ruralstruc report. Therefore, the sample used in this study for Kenya consists of 873 households.

The three surveyed regions are presented on Figure 3.1. The Nyando region is part of the Kisumu district.

Figure 3.1: Survey Location : Nakuru, Bugoma and Kisumu

Nakuru **Kisumu** **Bungoma**

Table 3.1: Number of Households with Migrants and Remittances

Type of migration	frequency	% of HH with Remittances(out of HHs with migrants)
No Migration	657	
Local migration	183	97.81
International migration	33	96.97
Total	873	

Source: Author's computation from RuraLStruc data

From table 3.1, 216 households or 25% of the total sample had migrants; 183 of them had local or domestic migrants and 33 had migrants abroad. Local migrants are those who moved to the capital or to other big cities in the country.

Table 3.2: Descriptive statistics of variables used in estimation

Variables	Mean	Std.dev
Adoption of new technologies (1= yes, 0 = no)[a]	.58	.49
Number of local migrants per household	1.64	1.59
Number of international migrants per household	.86	1.51
HH with Local Remittances (1= yes, 0 = no)[b]	.25	.49
HH with International remittances(1= yes, 0 = no)[c]	.05	.15
HH with public transfers (1= yes, 0 = no)[d]	.07	.08
Gender of the HH head(1= male,0 = female)	.80	.39
Total active males in the household	1.85	1.36
Total active females in the household	1.83	1.27
Number of children in the household	2.61	2.16
Age of the household head	49.08	13.81
Annual household revenue (Kenyan Shilling)	23619	25140
Household with marketing contract(1= yes,0 = no)	.11	.315
Household uses mutual or unpaid labor(1= yes,0 = no)	.11	.32
Household has access to animal plough(1= yes,0 = no)	.47	.49
HH head has secondary school education (1= yes,0 = no)	.08	.27
HH head has post secondary school education (1= yes,0 = no)	.08	.28
Land owned(hectares)	.76	1.31
% of Land under farming (hectares)	.92	1.39
% of Land under irrigation (hectares)	.07	.48
Cattle owned	3.01	3.54
Household has access to tractor (1= yes,0 = no)	.16	.36
Household is very poor (1= yes,0 = no)	.58	.49
Migration percentage	.02	.01
Household size	7.04	2.80
Household head is a member of social network (1= yes,0 = no)	.57	.49
Easy access to transport (1= yes, 0 = no)	.43	.49
Dependency ratio	.83	1.06
Observations	873	

Source: Author's computation from RuralStruc data; HH: Household

[a] New farming technologies are defined as improved seeds and/or fertilizer

[b,c] Due to many outliers in the values of remittances received by farmers, a binary variable Was used instead

[d] Public transfers are monetary or cash transfers to rural households

From table 3.2, almost 59% of the households used improved seeds and/or fertilizer. Households with migrants had on average 2 international and/or local migrants. Based on the entire sample size, 20.5%, of the households received local remittances while 3.66% received remittance from abroad. In addition, 7.4% of them received public transfers. Public transfers are subsidies (cash

transfers) provided by the central or local government as a support to rural households and their economic activities (Losh, Freguin-Gresh and White, 2011)

Furthermore, 80.7% of the respondents were males and households had on average 2 active adult males and 2 active females. In addition, the average household size was 7 people and the average age of the household head was 49. In addition, 11.3% of households sold their products through market contracts, 11.6% used mutual or unpaid labor and 47.9% had access to animal traction and 16.2% of these households had access to tractor. Almost 9 % and 8.2% of household heads have secondary and post secondary education, respectively. Seventy six percent of households owned land and 92.5% of owned and rented land was under farming. In addition, 58.2% of them were classified as extremely poor.

3.3.3 DATA ANALYSIS

This study uses a three-stage least squares model for the empirical analyses to address all the study objectives. This model was selected in order to address the potential endogeneity problem that may arise from using migration and remittances as explanatory variables.

A major concern in the majority of the analyses of the casual impact of migration and remittances is endogeneity (Nguyen and Punamarisi, 2011). Given that the error terms and the explanatory variables are likely correlated due to several reasons such as reverse causality (e.g. Households may decide to adopt modern technologies first and then use migration as a source of income or vice versa the opposite), omitted variable or sample selection bias (remittances maybe correlated with other sources of income not included in the estimation. In addition, the survey may have left out some households with more migrants and remittances), running a simple OLS

of household outcomes with migrations and remittances as explanatory variables could give biased estimates of the impact.

For instance, in the analysis of the impact of migration and remittances on household income, endogeneity problem arises from the fact that migration and remittances are jointly determined with other activities or sources of income (Brown and Leeves, 2007, Zhu et al., 2011).

To solve the endogeneity problem, researchers have used many strategies. One of the potential solutions is the use of panel data to perform fixed effects or first difference estimation Nguyen and Purnamarisi, 2011). Researchers also use instrumental variables, which are variables that are correlated with the endogenous variable, but not correlated with the outcome (Abdulai and CrileRees, 2001). In the case of migration, remittances and the adoption of agricultural technologies, variables used as instruments must be related to the variables they are instrumenting (migration and remittances in this case) and they should not have explanatory power with regards to the variable of interest in the analysis, which is the adoption of the technology (Quinn, 2009).

Various instruments have been used by researchers to deal with endogeneity in the study of the impact of migration and remittances. Brown and Leeves (2007) used predicted rather than actual number of migrants for each household as instrument in their analysis of migration, remittances and household income in Fiji and Tonga. In addition, highest educational level in the household and family chain migration were used by Mendola (2006) as instruments in his study on the relation between remittances and technological change in rural Bangladesh

Furthermore, Nguyen and Purnamarisi (2011) have used historical migration network, which is the percentage of households in a region or village that had migrants in the past, in their study on migration and remittances on child outcomes and labor supply. The choice of the

historical network is that large initial migration network can lower the cost of subsequent migration, through information or through financing, and thus induce more migrations. The idea behind this instrument is that past migration networks do not influence the household outcome directly other than through their likelihood of having migrant members.

In his study on migration and remittance in Mexico, Garip (2012) used the interaction between community migration prevalence and distance to the U.S. border as instrument. According to the author, the intuition for using this instrument is that individuals living far from the border face higher costs to migration. This cost should be lower in communities with high migration prevalence, as prior migrants provide useful information or help.

Other instruments such as migration contacts, the percentage of adults from community with migration experience, the number of migrants in the household, the dependency ration (the number of non-workers divided by the numbers of workers in the household), the proportion of returned migrants among non-migrants, and whether the head of the household has ever migrated as well as the distance between the household location and nearest paved road have been used to deal with migration and remittance endogeneity (Quinn, 2009; Zhu et al., 2011).

3.3.3.1 THREE STAGE LEAST SQUARES MODEL

Following Quinn (2009), the probit model that tests the impact of migration, remittances and transfers can be expressed as:

$$\Pr(S_i \neq 0 | X_i, M_i, R_i, T_i) = \phi(X_i\beta_1, M_i\beta_2, R_i\beta_3, T_i\beta_4) \quad (1)$$

Where S_i is a binary variable representing the adoption decision for each household; M_i and R_i are the total number of migrants and the amount or remittances received by household, respectively. X_i is a vector of other variables that may influence the adoption decision such as

farm and household socio-economic characteristics. T_i represents public transfers and, ϕ is the standard cumulative normal distribution. In this study, R_i is a binary variable indicating whether or not a household has received remittances.

If we assume that migration and remittances are exogenous, a probit model can be estimated to capture the impact of migration, remittances and public transfers on the adoption of the technology. The probit model can be expressed as

$$S_i = \beta_0 + \beta_1 X_i + \beta_2 M_i + \beta_3 R_i + \beta_4 T_i + \varepsilon \quad (2)$$

If the above assumption is violated, a three-stage least squares model will be estimated by indentifying instrumental variables for M_i and R_i. In the first and second stages, an OLS or a Probit equation is estimated, depending on the nature of the endogenous variable, for each endogenous variable. In our case since the variable for remittances is binary, a probit model will be estimated for the remittances equation and OLS for the migration equation. The two equations can be expressed as:

$$M_i = \beta_0 + \beta_1 X_i + \beta_2 T_i + \beta_3 Z_i + \varepsilon \quad (3)$$

$$R_i = \gamma_0 + \gamma_1 X_i + \gamma_2 T_i + \gamma_3 W_i + \varepsilon \quad (4)$$

Where Z_i and W_i are the vectors of instruments for M_i and R_i respectively.

In the third stage, the predicted values of M_i and R_i($\widehat{M}_i$ and $\widehat{R}_i$) from equations (3) and (4), are included as explanatory variables in the probit equation, equation (2), instead of M_i and R_i.Therefore, equation (2) can be express as:

$$S_i = \delta_0 + \delta_1 X_i + \delta_2 \widehat{M}_i + \delta_3 \widehat{R}_i + \delta_4 T_i + \mu \quad (5)$$

The gain from using the 3SLS model is that the errors in equation (5) are corrected for the covariance between the migration and the remittances equations.

3.3.2.2 INSTRUMENTS

The choice of instruments in this study is based on the existing literature and the different instruments used in previous studies on migration and remittances (Quinn, 2009; Mendola, 2006; Zhu et al., 2011).

The set of instruments used for migration in this study includes: the migration percentage, which is the percentage of adults from community with migration experience; household access to transportation, family chain migration represented by the presence in the household of more than one long term migrant, and the membership of the household head in the family with migrants to a social network (other than agricultural production network). Furthermore, the number of migrants in the household and the dependant ratio (the number of non-workers divided by the numbers of workers in the household) are used as instruments for remittances. These variables do not directly influence the household adoption behaviors, but through migration and remittances.

The number of adults in communities with migration experience is more likely to have a positive impact on migration. In addition, social networks, between village neighbors and within families, are more likely to reduce migration costs. Furthermore, people with migration experience, within and outside the family, are more likely to move and settle better where they go (Mendola, 2006). With easy access to transportation, people can easily move to different locations.

3.4 RESULTS

The estimated results of the impact of migration on technology adoption are presented in table 3.3. Table 3.4 presents the results of the effect of remittances on technology adoption. Furthermore, the estimated results of the impact of migration and remittances on technology

adoption are presented in table 3.5. Tables 3.3 and 3.4 also contain results from different tests for the validity of the instruments used to address endogeneity issues from migration and remittances.

Test results in tables 3.3 and 3.4 suggest that both migration and remittance variables are endogenous. In addition, the F-statistic from all the first stage regressions is very high, implying that our instruments are not weak. The validity of the instruments is also confirmed by the Hansen's over identification test.

Table 3.3: Impact of migration on the adoption of new farming technologies

Dependent variable: adoption of new farming technologies						
	2SLS		2SLS		3SLS	
Variables	Coef	Rob. Std. Err	Coef	Rob. Std. Err	Coef	Rob. Std. Err
Internal migration (migrants per HH)	.192**	.087			.308	.183
International migration (migrants per HH)			.616*	.264	.862**	.320
Gender (1= male, 0 = female)	.559*	.144	.264***	.149	.583*	.148
Active Male in Household	.110**	.052	.0005	.038	.111***	.063
Active females in Household	.127**	.058	.045	.079	.132**	.056
Number of children in Household	.0009	.028	.002	.023	-.0001	.028
Age of Household Head	.003	.005	-.0008	.003	.003	.006
Annual revenue of Household	.144**	.068	.140**	.067	.150**	.068
HH with Marketing Contract (1= yes, 0 = no)	.973*	.197	.564**	.218	.990*	.214
HH use mutual or unpaid labor	.317**	.154	-.058	.111	.385***	.161
HH has access to Animal Plough (1= yes,0 = no)	-.444*	.117	-.183	.142	-.467*	.118
HH head finish elementary school (1= yes,0 = no)	.097	.204	.037	.107	.102	.204
HH head finish high school or Univ (1= yes,0 = n0)	.219	.238	-.268	.243	.293	.399
Land owned (hectares)	-.018	.147	.156	.135	-.039	.233
Land under farming (hectares)	-.107	.132	-.202	.142	-.093	.199
Irrigated land (hectares)	.197***	.119	.097	.076	.290**	.121
Number of cattle owned	-.081*	.017	-.041***	.024	-.083*	.018
HH has access to tractor (1 = yes, 0 = no)	-.013	.203	.079	.131	.012	.228
HH with public transfers (1= yes, 0 = no)	.004***	.002	.003***	.001	.004***	.002
Household is poor (1= yes, 0 = no)	-.171***	.070	-.316**	.106	-.393**	.174
Constant	-1.413	.599	-.418	.668	-1.506	.593
Number of Obs	*873*		*873*		*873*	
Chi-Squared	*244.15*		*251.58*		*234.52*	
Wald test for exogeneity	$\chi^2(1)$=*13.87* *(P-value = 0.0001)*		$\chi^2(1)$=*11.2* *(P-value = 0.0001)*			
Weak IV tests	*F(4,873)=65.82* *(P-value = 0.0000)*		*F(4,873)=39.67* *(P-value = 0.0000)*			
Hansen's J chi2(3)	*1.8918 (p-value = 0.189)*		*1.59 (p-value = 0.232)*			

*,**,and*** denotes significance at 1, 5 and 10%, respectively; HH: household

The 2SLS results from table 3.3 show that both internal and international migrations are positively correlated with technology adoption. However the joint estimation of the effects of the two types of migration shows that only international migration is positively correlated with the adoption of modern technologies. These results support the risk hypothesis.

Table 3.4: Impact of remittances on the adoption of new farming technologies

Dependent variable: adoption of new farming technologies						
	2SLS		2SLS		3SLS	
Variables	Coef	Rob. Std. Err	Coef	Rob. Std. Err	Coef	Rob. Std. Err
HH with internal remittances (1= yes, 0 = no)	.0493*	.002			.086**	.003
HH with international remittances (1= yes, 0 = no)			.014***	.006	.217	.193
Gender (1= male, 0 = female)	.628*	.124	.453**	.174	.583*	.148
Active Male in Household	.114*	.043	.090***	.046	.111***	.063
Active females in Household	.016	.056	.150**	.066	.132**	.056
Number of Children in Household	-.002	.024	-.020	.023	-.0001	.0288
Age of Household Head	-.008	.005	.009**	.004	.003	.005
Annual revenue of Household	.112***	.062	.150***	.065	.150**	.068
HH with Marketing Contract (1= yes, 0 = no)	.855*	.174	.677**	.303	.990*	.214
HH use mutual or unpaid labor	.197	.141	.229	.149	.385***	.161
HH has access to Animal Plough (1= yes,0 = no)	-.311**	.117	-.403**	.137	-.467*	.117
HH head finish elementary school (1= yes,0 = no)	.005	.180	.103	.162	.102	.204
HH head finish high school or Univ. (1= yes,0 = no)	.254	.194	.037	.248	.293	.399
Land owned (hectares)	-.041	.120	-.104	.145	-.039	.233
Land under farming (hectares)	-.061	.112	.084	.169	-.093	.199
Irrigated land (hectares)	.085	.099	.071	.126	.290**	.121
Number of cattle owned	-.067*	.015	-.075**	.026	-.083*	.017
HH has access to tractor (1= yes, 0 = no)	-.040	.162	.071	.181	.012	.228
HH with public transfers (1= yes, 0 = no)	.004**	.002	.031***	.001	.004***	.002
Household is poor (1= yes, 0 = no)	-.261*	.101	-.423*	.155	-.393**	.174
Constant	-1.026	.558	-1.475	.616	-1.506	.593
Number of Obs	*873*		*873*		*873*	
Chi-Squared	*187.17*		*175.68*		*232.36*	
Wald test for exogeneity	$\chi^2(1)=17.59$ *(P-value = 0.000)*		$\chi^2(1)=15.968$ *(P-value = = 0.000)*			
Weak IV test	*F(2,873)=20.903, P-value= 0.000*		*F(2,873)=28.964 P-value= 0.000*			
Hansen's J chi2(1)	*1.68185 (p = 0.215)*		*.106584 (p = 0.798)*			

*,**,and*** denotes significance at 1, 5 and 10%, respectively
HH: household

Based on the 2SLS results in table 3.4, both internal and international remittances are positively related to technology adoption, implying that households with either internal or international remittances were more likely to adopt new technologies. However, the 3SLS results in the table reveal that only internal remittances are positively correlated with technology adoption.

Table 3.5: Impact of migration and remittances on the adoption of new farming technologies

Dependent variable: adoption of new farming technologies				
	Internal migration and remittances		International migration and Remittances	
Variables	Coef	Rob. Std. Err	Coef	Rob. Std. Err
Migration (migrants per HH)	.179**	.085	1.224**	.412
HH with remittances (1= yes, 0 = no)	.004**	.002	.103**	.042
Gender (1= male, 0 = female)	.594*	.149	.512*	.145
Active Male in Household	.151**	.054	.035	.056
Active females in Household	.091	.060	.058	.064
Number of Children in Household	.016	.029	.022	.030
Age of Household Head	.0003	.005	.003	.005
Annual revenue of Household	.1502**	.069	.183**	.069
HH with Marketing Contract (1= yes, 0 = no)	1.024*	.201	1.191*	.211
HH use mutual or unpaid labor	.323***	.155	.237	.157
HH has access to Animal Plough (1= yes,0 = no)	-.431*	.119	-.364**	.123
HH head finish elementary school (1= yes,0 = no)	.116	.204	.119	.203
HH head finish high school or Univ (1= yes,0 = no)	.296	.245	-.093	.274
Land owned (hectares)	.098	.157	.454**	.176
Land under farming (hectares)	-.384***	.158	-.614**	.188
Irrigated land (hectares)	.267**	.121	.307**	.129
Nb. Of Cattles owned	-.082*	.017	-.086*	.017
HH has access to tractor (1= yes, 0 = no)	-.057	.205	.008	.208
HH with public transfers (1= yes, 0 = no)	.004***	.002	.005**	.002
Household is poor (1= yes, 0 = no)	-.311***	.157	-.383*	.161
cons	-1.334	.607	-1.085	.620
Number of Obs	*873*		*873*	
Chi-Squared	*231.68*		*227.73*	

*,**, and*** denotes significance at 1, 5 and 10%, respectively
HH: household

The 3SLS results in table 3.5 confirm that internal migration and remittances as well as international migration and remittances are positively correlated with technology adoption. These results support both risk and credit or liquidity constraint hypotheses. In addition, the results from all the empirical specifications show a positive correlation between public transfers

and technology adoption, implying that households with public transfers were more likely to adopt new technologies.

The gender of the household head, the annual revenue of the household, the use of marketing contract and, the area of irrigated land are also positively related to the propensity of adopting the new technologies across all the specifications. In fact, the objective of each farmer is to produce and sell his or her product in order to make profit. Farmers who have access to output markets and those receiving higher prices for their production will be willing to produce and sell more in order to increase their revenues. Therefore, the additional revenue can help them reduce their liquidity constraints and increase their propensity to adopt new technologies.

Furthermore, farmers with marketing contracts have an arrangement with a processing or a marketing firm. Under the arrangement, the processing or the marketing firm agrees to purchase the harvest at predetermined prices. In addition to the purchase of the harvest, the purchaser may provide production support in term of inputs and technical advice (Strohm and Hoeffler, 2006). In contrast, very poor households, households with more cattle and households with access to animal Plough were less likely to adopt the new technologies. However, we expected a positive relation between access to animal plough and technology adoption. In fact, only farmers with more land can use animal plough. Therefore, they may be more likely to adopt new farming technologies.

The average marginal effects in table 3.6 show that the probability of adopting new agricultural technologies would increase by 0.0392 with an additional internal migrant and 0.3055 with an additional international migrant. In other words, for one additional migrant within the country, the household probability of adopting new farming technologies would increase by 3.92% and 30.55% for an additional migrant abroad. Furthermore, the probabilities of adopting

new farming technologies were 0.1% and 7.55% higher for a household with internal and external remittances, respectively, compared to one without remittances.

Table 3.6: Average marginal effect of migration and remittances on the adoption of new farming technologies

Dependent variable: adoption of new farming technologies				
	Internal migration and remittances		International migration and Remittances	
Variables	Marginal effects	Std. Err.	Marginal effects	Std. Err.
Migration (migrants per HH)	.039**	.013	.305**	.098
HH with remittances (1= yes, 0 = no)	.0011**	.0005	.075**	.001
Gender (1= male, 0 = female)	.147*	.035	.126*	.035
Active Male in Household	.026***	.013	-.008	.014
Active females in Household	.022	.014	.014	.016
Number of Children in Household	.004	.007	.006	.008
Age of Household Head	.008	.001	.0006	.0013
Annual revenue of Household	.037**	.017	.039***	.017
HH with Marketing Contract (1= yes, 0 = no)	.254*	.047	.294*	.048
HH use mutual or unpaid labor	.075**	.038	.058	.038
HH has access to Animal Plough (1= yes,0 = no)	-.107*	.029	-.090**	.030
HH head finish elementary school (1= yes,0 = no)	.028	.050	.029	.050
HH head finish high school or University (1= yes,0 = no)	.073	.060	-.023	.067
Land owned (hectares)	.024	.039	.112**	.043
Land under farming (hectares)	-.071***	.039	-.152**	.046
Irrigated land (hectares)	.056***	.030	.076**	.032
Number of cattles owned	-.020*	.004	-.021*	.004
HH has access to tractor (1= yes, 0 = no)	-.014	.051	.002	.051
HH with public transfers (1= yes, 0 = no)	.001**	.0005	.0012**	.0006
Household is poor (1= yes, 0 = no)	-.049**	.024	-.077***	.034

*,**, and *** denotes significance at 1, 5 and 10%, respectively
HH: household

3.5 CONCLUSION

The adoption of new farming technologies represents an important means to increase productivity and improve the well being of millions of poor households in developing countries. However, due to risk and liquidity constraints, many farmers in Sub-Saharan Africa have very

limited access to these technologies. Risk and liquidity constraints remain the main reasons that prevent many farmers from benefiting from these technologies.

The objective of this study was to investigate whether or not migration, remittances and government transfers may help rural households reduce risk and liquidity constraints in rural Kenya. Using data from the World Bank Ruralstruc project, the empirical results show that Kenyan households with internal migration and remittances or international migration and remittances as well as government transfers were more likely to adopt new farming technologies. These results support both risk and liquidity constraints.

The results in this study show that migration and remittances might help households reduce risk and liquidity constraints in the regions under study. The impact of migration on the economic development in general and rural areas in particular must be one of the major concerns of Sub-Saharan African leaders.

3.6 POLICY IMPLICATIONS

Future research can be extended to other African countries and regions in order to capture the real impact of migration on rural and agricultural development. In regions where remittances have a positive impact on the development of rural activities in general and agricultural activities in particular, governments and other development organizations have to devise mechanisms and strategies to help rural households reduce the transactions cost related to remittances by implementing money transfer services close to the beneficiaries. In addition, other African countries with inadequate transportation infrastructures can also experiment with mobile transfer, MPESA, implemented in Kenya since 2007(Datta, Ejakait and Odak, 2008; Ongoto, 2013).

Furthermore, many microcredit institutions in developing countries in general and Sub-Saharan Africa in particular do not offer financial services to poor households because of the lack of collateral, moral hazard, adverse selection and other transaction costs. Therefore, in rural areas or regions where farmers receive remittances regularly, microcredit institutions can work with these farmers in order to provide them microloans and other financial services. Microcredit institutions can convince households to deposit their remittances directly into a bank account. Farmers who agree to do so can then receive microloans in term of improved seeds, fertilizer and other technologies as well as services.

However, the low percentage of households with migration and remittances in our sample is an indication that though migration might help rural households, it should not be considered as a solution to the credit and liquidity constraints faced by rural households. In addition, increase in migration may cause shortage of labor or the abandonment of farming activities in many rural areas which may reduce agricultural production, increase food insecurity and poverty. Therefore, governments and non-governmental world organization involved in the diffusion and promotion of modern farming technologies must devise strategies and plans to restore or provide rural areas with financial services.

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CHAPTER 4

ANALYSIS OF THE IMPACT OF REMITTANCES AND PUBLIC TRANSFERS ON INCOME DIVERSIFICATION IN RURAL AFRICA: A CASE STUDY OF KENYA

4.1 INTRODUCTION

Income diversification is an important livelihood strategy for rural households in developing countries in general and Africa in particular (Wouterse and Taylor, 2008). Rural households no longer rely on one source of income or hold all their wealth in the form of one single asset or use their assets in one activity (Barret and Reardon, 2000). On the contrary, they tend to diversify their sources of income by voluntarily exchanging their assets and allocating them across various activities in order to achieve an optimal balance between expected returns and risk exposure (Barret at al., 2005).

Rural households diversify their sources of income for many reasons or motives. The different motives can be expressed in term of "Push and Pull" factors (Wouterse and Taylor 2008; Dimova and Sen, 2010). The push factors include; risk reduction, response to diminishing factor returns in any given use, reaction to crisis and liquidity constraints. The pull factors are related to improved infrastructure, better markets, and the realization of strategic complementarities between activities such as crop-livestock integration, proximity to urban areas that create opportunities for income diversification.

Given the degree of poverty, the risk levels of households (risks related to climate, pests, prices or market access) are a major issue and major determinants of their livelihood strategies.

Households facing high level of risk in their agricultural activities often seek off farm income. Through diversification, rural households may expand their activities by investing in nonfarm sectors, increase income or reduce its variability. In addition, diversification of sources of income is used by many rural households as a risk management strategy (Losch, Freguigresh, and White, 2011; Senadza, 2011).

Income diversification can be made possible with the increase of total household income which helps households overcome liquidity constraints and invest in nonfarm activity. In addition, income diversification can be induced by greater wealth in the local economy. However, in many rural households in developing countries, mostly in Africa, liquidity constraints are a major problem (Winter-Nelson and Temu, 2005). The majority of farm households does not have or have limited access to credit markets which limits their ability to invest in more risky and lucrative activities or diversify their sources of income (Diagne, Zeller and Sharma, 2000). In addition, poor households have fewer opportunities in non-cropping activities due to their lack of capital which makes it difficult for them to diversify away from subsistence agriculture.

For decades, rural households have been relying on migration and remittances as a strategy to overcome liquidity constraints. Remittances have become an important source of income for rural households with liquidity constraints and with little or no access to insurance and credit markets (Black et al., 2006; Babatunde, 2008; Shaw, 2010) In their study of remittances and income diversification in rural Bolivia, Lazarte-Alcala et al. (2011) found that households with remittances tend to diversify more than those without. Their results confirm the hypothesis that remittances can relax credit constraint usually faced by rural farmers. In addition, remittances represent an important source of income and a strategy against food insecurity, low

agricultural production, risks and instability of farming activities (Vergas et al., 2008; Lucas, 2007).

Through migration and remittances, rural family labor is no longer limited to farming activities. Studies on the relation between remittances and rural development suggest that remittances can be used as insurance in case of adverse income shock (Wouterse, 2010). In addition, households with remittances can invest in more risky and productive activities (De Haas, 2006). Households with remittances may invest in agricultural as well as non agricultural activities. Rural household that invest in agricultural activities may choose to invest in staple as well as non-staple production.

Given the key role of income diversification can play in stabilizing income and alleviating rural poverty, governments in developing countries have become increasingly interested in promoting increased output diversification (Abdulai and CroleRees, 2001).Therefore, in addition to remittances, rural households in some developing countries also receive public transfers in term of money or subsidies in order to overcome liquidity constraint and engage in more productive activities.

Studies on income diversifications in Africa have shown that rural households have been investing in nonfarm activities in order to sustain their livelihood (Losch, Freguigresh, and White, 2011; Barrett, Reardon, and Webb, 2001; Ellis, 2000). Haggblade et al., (2010) argue that in rural Sub-Saharan African countries, income from nonfarm activities represents 35% to 50% of the total household income. Many studies have highlighted the role that migration and remittances can play in reducing risk and credit constraints faced by rural households in developing countries (Black et al., 2006; Lazarte-Alcala et al., 2011; Wouterse and Taylor, 2008; Taylor, Rozelle, and Brauw, 2003). According to these studies, households with migrants and

remittances can invest in more risky and profitable activities, particularly in non-farm sector, in order to diversify their sources of income.

The relation between migration, remittances and new technologies in Africa has been analyzed by Wouterse and Taylor (2008) using data from Burkina Faso. Their study tested the risk hypothesis by examining the impact of migration on income diversification. This study analyses the impact of remittances and public transfers on income diversification in Kenya.

4.1.1 PROBLEM STATEMENT

Income diversification constitutes an important livelihood strategy for rural households in developing countries in general and Sub-Saharan Africa in particular. Many rural households diversify their sources of income by investing in non-agricultural activities. In addition, diversification is used by rural households as a risk management strategy (Lucas, 1997; Demissie and Legese, 2013).

For households with liquidity constraint, income diversification can be made possible with increases in total household income. However, for many rural households in Sub-Saharan Africa, liquidity constraint is a major problem. The majority of households does not have or has limited access to financial markets, which limit their ability to diversify their sources of income and invest in non-cropping activities.

For decades, many rural households have been relying on migration and remittances as a strategy to overcome liquidity constraint. Remittances represent a strategy against low agricultural production, risk and instability of farming activities. Remittances can also be used as insurance in case of adverse income shock. However, there is a huge debate on the use of remittances and their impact on economic and rural development.

On one hand, the new economics of labor migration (NELM) theory views remittances as a substitute for formal or informal credit. Therefore, remittances can help poor households overcome liquidity constraint and invest in more risky and productive activities (Wouterse, 2010). On the other hand, some researchers argue that remittances sent to developing countries are not spent or invested in productive activities but in luxury and other consumption goods. Therefore, they have very little impact on economic development in general and rural development in particular (De Haas, 2006; Rubenstein, 1992).

Based on these divergent points of view, the important question is whether or not remittances can help households in rural Kenya to invest in non-cropping activities such as livestock, trade, commerce and small manufacturing.

4.1.2 OBJECTIVES

The primary purpose of this study is to examine the effect of remittances and public transfers on the propensity of rural households to diversify their income through non-cropping production or activities.

Specifically the study tries to:

1. Investigate if remittances and government transfers can help rural households overcome liquidity constraints by investing in non-crop production or activities such as livestock and nonfarm activities such as trade, commerce and small manufacturing.
2. Determine if household income diversification is a means of survival or a means of wealth accumulation.

4.2 LITERATURE REVIEW

Income diversification can be defined as the process of switching from low value crop production to a higher value crop, livestock, and nonfarm activities such as trade, commerce and small manufacturing (Ibrahim et al., 2009). In addition, diversification refers to the allocation of production assets among different income-generating activities, both on-farm and off-farm (Abdulai and CroleRees, 2001). Furthermore, rural livelihood diversification is seen as a process of constructing a diverse portfolio of activities and social support capabilities for survival (Mutenje et al., 2010).

The development and the trend in rural income diversification in developing countries have been the focus of many researchers over the past decades. Many studies have analyzed the different motives for rural households to diversify their sources of income (Lucas, 1997; Wouterse and Taylor, 2008; Demurger, Fournier and Yang, 2009). Lucas (1997) pointed out that rural households diversify away from agriculture because of the lack of crop insurance and shortage of liquidity. According to Demurger, Fournier and Yang (2009), rural households adjust their activities to exploit new opportunities created by market liberalization or to cope with livelihood risks.

For Wouterse and Taylor (2008), "the motives for diversification can be explained in term of push and pull factors." Push factors are related to risk reduction while pull factors are associated with the rural households' effort to exploit strategic complementarities between activities, such as crop-livestock integration. In addition, Barrett and Reardon (2000) indicate that risk reduction, realization of economies of scope, response to crisis and liquidity constraints are amongst the motives of diversification. Furthermore, rural households diversify their activities because their resources allocated to agricultural production decrease in relation to the

returns from using them in non-agricultural activities (Schwarze and Zeller, 2005). Rural household also diversify their activities, particularly nonfarm, to cope with the risk of crop failure (Demissie and Legese, 2013).

Other studies have focused on the relation between diversification, households' assets and rural development. Ibrahim et al. (2009) found that income and crop diversification can raise income and reduce poverty among rural households. In their study on income diversification in Nigeria, Babatunde and Qaim (2009) argued that the majority of households were fairly diversified and 50% of total rural households' income was from off-farm sources. In addition, richer households were more diversified than poorer ones.

Furthermore, in their study on Indonesia, Shwarze and Zeller (2005) found that there is a link between non-farm income and total household income. Therefore, poor households have less access to non-farm activities than better-off households. These findings confirm the fact that liquidity constraints constitute a major obstacle for poor rural household to diversify their activities and invest in more productive activities.

For many decades, rural households have been relying on migration and remittances as source of income and a way to overcome liquidity constraints (Taylor, Rozelle, and Brauw 2003). Migration constitutes by its self a way to diversify income in rural areas. Seasonal migration off-farm to engage in wage employment and provision of agriculture services is an important source of off-farm income for rural households (Asmah, 2011). According to Giesbert (2007), and Sana and Massey (2005), migration and remittances are generally viewed as an important component of diversification strategies that intends to cope with risky environments in developing countries.

Lazarte-Alacal et al. (2012) indicate that remittances play an important role through the provision of liquidity that helps rural households invest in more productive activities and nonfarm sectors. In addition, migration and remittances have been used to maximize and diversify income, minimize risks and loosen liquidity constraints and reduce poverty (Vargas et al., 2008; Marchetta, 2013; Azzari et al., 2006; Escobal, 2001; Senadza, 2011).

4.3 METHODOLOGY

4.3.1 THE CONCEPTUAL FRAMEWORK

The conceptual framework for this study is based on the new economics of labor migration (NELM) and the Sustainable Livelihoods Frameworks (SLF). According to the SLF, in different contexts, sustainable livelihoods are achieved through access to a variety of assets which are combined in the pursuit of different livelihood strategies to achieve certain outcomes such as increased incomes (Ellis, 1998). Access to physical, natural, economic, human and social capital assets can encourage and help rural households engage in farm or nonfarm activities or both (Scoones, 1998).

On the other hand, the NELM theory assumes that migration can reduce the push to diversify for risk reasons. In addition, if households perceive new activities as risky and they cannot invest in these activities due to liquidity constraints, migration through remittances can help rural households overcome these constraints and stimulate income diversification (Wouterse and Taylor, 2008).

Base on the above theories, we expect that households with migrants, remittances and/or public transfers will invest in more risky and diversified activities. Therefore, migration,

remittances and public transfers will have a positive impact on income from non-cropping production.

As far as income diversification is concerned, if diversification is motivated or viewed as a survival strategy by households, the relation between household income diversification and household's income will be negative. Poor households will be likely to diversify more than richer. However, if diversification is seen as a wealth accumulation strategy, the opposite will occur (Dimova and Sen, 2010).

4.3.2 DATA AND SOURCE

The data used for this study is from the household survey conducted by the World Bank in partnership with the French Cooperation and the International Fund for Agricultural Development (IFAD). The survey was conducted through the RuraLStruc Program between 2007 and 2008 in seven countries (Mali, Senegal, Kenya, Morocco, Madagascar, Nicaragua, and Mexico). This study focuses on Kenya.

The main objective of the RuraLStruc Program was to provide a better understanding of the implication of liberalization and economic integration for agriculture and rural development in developing countries. It also illustrates the situation of rural economies in terms of income, diversification and overall transformation (Losch, Freguingresh, and White, 2011).
The sampling process for the surveyed households followed a multistage systematic random sampling procedure.

The first was the selection of regions or districts for the survey. From the regions selected, a multi-stage random sample of farm households was selected with a number of random localities to be surveyed selected first. From the selected regions, a number of random

households were selected, targeting a sufficient number of households per locality allowing for representativeness at local level. The choice of these regions was based on the importance of agricultural activities, market access, the size and population density and the ability to illustrate different rural household situations (Kirimi et al., 2010).

The regions selected in Kenya were Nakuru North, Nyando and Bungoma. From these regions, 904 households were randomly selected and surveyed in 27 villages (Kirimi et al., 2010). In Nakuru North, 300 households were surveyed, 301 in Nyando and 301 in Bungoma. The surveyed regions are presented in Figure 4.1. The Nyando region is part of the Kisumu district.

Figure 4.1: Survey Location: Nakuru, Bugoma and Kisumu

Nakuru

Kisumu

Bungoma

After data cleaning, a sample of 873 households was presented in the RuraLstruc report. However, due to missing information, the sample used in this study consists of 782 households. The data set contains information on household characteristics and composition, quality of housing, household main and secondary economic activities, agricultural equipment, labor force, diversification index, on and off-farm activities, crop production, livestock, marketing contract for crop and livestock, expenditures, evolution of food security, migrations, remittances, public subsidies, use of new technologies (fertilizer and improved seeds), income from farm and non-farm activities, staple and non-staple production, social capital, assets and agricultural production factors. Table 4.1 contains the descriptive statistics of the key variables used in the empirical model.

Table 4.1: Descriptive statistics of variables used in estimation

Variables	Mean	Std. Dev.
Gender of the household head (1= male, 0 = female)	.807	.394
Off-farm activities (1= yes,0= no)	.758	.342
Livestock activity (1= yes,0 = no)	.525	.329
Number of internal migrants	1.04	1.59
Number of external migrants	.412	.325
Household with internal remittances (1= yes,0 = no)	.256	.423
Household with international remittances (1= yes,0 = no)	.071	.130
Household size - number of persons	7.04	2.80
Total number of adults	5.05	2.39
Total number of Children < 15 years old	2.61	2.16
Age of household head	48.1	13.8
Household head has completed primary education	.144	.351
Household head has secondary education	.087	.282
Land owned (in hectares)	.708	1.30
Number of cattle head	3.01	3.54
Area of land irrigated (in hectares)	.069	.482
Household received public transfers (1= yes, 0 = no)[a]	.040	.089
Household is poor [a] (1= yes,0 = no)	.581	.493
Observations	782	

Source: Author's computation from RuraLStruc data

[a] Public transfers are monetary or cash transfers to rural households

From Table 4.1, 80 percent of household heads were males. Fourteen percent of household heads had completed or some primary education and 8.7% had completed or some secondary education. The average age of the household head was 48 years and 71% owned land. In addition, 4% of household received public transfers and 58% were extremely poor. Almost 75 percent of the households surveyed had non-farm income and 52.5 invested in livestock production. The average size of the household was seven people and the average number of adults in the household was five.

Furthermore, 25.6% and 7.1% received internal and external remittances, respectively. Internal remittances in this study are defined as remittances sent by migrants from the capital and other big cities within the country. External remittances are remittances sent by migrants who are outside the country. In addition, 4% received public transfers. Public transfers are subsidies to very poor households. The majority of these households depend on subsistence agriculture. In addition, they do not or have limited access to financial, labor, input and output markets. The purpose of these transfers is to help rural households with liquidity constraints invest more in income-generating investments (Davis, 2014).

In this study, public transfers refer to cash transfers provided by the central or local government to support rural households and their economic activities in Kenya. (Losh, Freguin-Gresh, and White, 2011)

4.3.3 DATA ANALYSIS

This study uses a bivariate probit model to determine the impact of remittances and public transfers on non-cropping activities. The choice of this model is based on the binary nature of the dependent variable, which is whether or not households invested in non-crop income generating

activities. In addition, the variable remittance, which is also a binary variable, may be endogenous: Therefore, a bivariate probit model is appropriate in this case. In addition to the bivariate probit model, a two-stage least squared model was estimated in order to compare the results and assess the validity of the instruments.

Following Wouterse and Taylor (2008), household preferences are represented by the following utility function:

$$U = Eu(G, L_e, X) \quad (1)$$

Where *G* represents the vector of goods consumed by the household L_e is leisure and X is a vector of household characteristics. Household utility is maximized subject to the income constraint expressed as:

$$C = \sum_i Y_i + R_E\,(M_E) + R_I(M_I) + P_T \quad (2)$$

Where Y_i represents the net income from cropping (c) and non-cropping (nc) activities. Non-cropping activities production include; livestock, nonfarm activities such as trade, commerce, and manufacturing. R_E and R_I denote external and internal remittances, respectively. These remittances are function of M_E and M_I which are the stock of external and internal migrants per family. P_T represents public transfers to households. The net income received by the household from crop production can be expressed as:

$$y_c = P_c g_c(L_c; A) + \eta_c \quad (3)$$

Where $\mathrm{L_c}$ represents the labor used by the household in cropping production, *A* is a vector of household assets, $\mathrm{P_c}$ is the price of crop output and, $\eta_c \sim N(0, \sigma_c^2)$ represents the stochastic term of cropping production. Households may gain income from non-cropping production only if they overcome the entry constraint denoted by K_{nc} such that:

$$y_{nc} = [P_{nc} g_{nc}(L_{nc}; A) + v_{nc}(L_{nc}; A)\eta_{nc}] | K_{nc} \quad (4)$$

Where y_{nc} is the net income from non-cropping production, P_{nc} the price of non-cropping output production, L_{nc} represents the labor used in non-cropping production, and K_{nc} the entry constraints which include the initial capital in the production of non-cropping goods. η_{nc} is the stochastic component of non-cropping production $\left(\eta_{nc} \sim N(0, \sigma_{nc}^2)\right)$; and $v_{nc}(L_{nc})$ is the effect of the intensity of labor investment on production risk.

It is assumed that $K_i = 0$, otherwise the entry constraint can be expressed as a function of the different household assets as well as M_E and M_I which represent the number of internal and external migrants. The available liquidity the household posses as investment is a function of household wealth. The available maximum wealth, W^{max}, that households have, is a function of the assets related to migration and non-migration assets, Z_k :

$$\sum_{nc} K_i \leq W^{max}, W^{max} = g_w(M_E, M_I, Z_k) \quad (5)$$

In case of perfect labor market, labor lost due to migration can be replaced by hired workers. In addition, labor available will not constitute a constraint on household production activities. On the contrary, labor availability for production and migration will be constrained by the household labor supply in case of imperfect labor market as:

$$\sum_i L_i \leq T - M_E - M_I - L_e \quad (6)$$

The opportunity cost of labor in production in this case will be represented by a household specific shadow wage. Other things being equal, this shadow wage will increase with the labor allocated to migration by the household which may create a trade-off between migration and household production (Wouterse and Taylor, 2008).

Both activity choice and activity income can be influenced by migration. Therefore, if we ignore the endogeneity of activity choice, the estimates of coefficients in the activity income regression may be biased. Following Abdulai and Crolerees (2001), a household will invest in

an activity if the expected utility from this activity is greater than not engaging in any activity, subject to a capital constraint. In case of liquidity constraints, only households that are able to overcome the entry constraints (K_{nc}) may allocate labor to non-cropping production. However, in case of non binding capital constraint, households will allot a marginal unit of labor to non-cropping production if: $E\left[u_c \frac{dC}{dl_{nc}}\right] | \frac{W^{max}}{K_{nc}} \geq E\left[u_c \frac{dC}{dL_c}\right]$ (7)

Where u_c is marginal utility, l_{nc} and l_c represent labor allocated to non-cropping and cropping activities, respectively.

4.3.3.1: THE BIVARIATE PROBIT MODEL

Following Lazarte-Alacal et al., (2012), let Y_1^* and Y_2^* be the surplus associated with diversification and the value of an intended remittance respectively. Then,

$$y_1 = \begin{cases} 1 & if \quad y_1^* > 0 \\ 0 & otherwise \end{cases} \quad (8)$$

y_1^* is not observable, y_1 which is the observable variable denotes the presence of income from non-cropping activities in the household. Similarly,

$$y_2 = \begin{cases} 1 & if \quad y_2^* > 0 \\ 0 & otherwise \end{cases} \quad (9)$$

We observe y_2 only if the consumer surplus of remitting is positive.

The equation for diversification can be expressed as:

$$y_1^* = y_2^* \lambda_1 + x_1 \beta_1 + \mu_1 \quad (10)$$

Equation (10) shows that the decision to invest in non-cropping activities may be determined by the decision to send remittances. In addition, y_2^* may be endogenous. Therefore, the following binary endogenous variable model can be used:

$$y_1 = 1[x_1 \beta_1 + \lambda_1 y_2 + \mu_1 > 0] \quad (11)$$

$$y_2 = 1[x\beta_2 + \mu_2 > 0] \quad (12)$$

Where 1[ ] represents the indicator function that takes the value of 1 if a household invested in non-cropping activity in equation (11) and if remittances are received by a household in equation (12), respectively. X is the vector of exogenous variables, it includes all the variables that affect the diversification decision (x_1) as well as factors that affect the decision to remit (x_2). In addition, (μ_1 μ_2), which represents the error vector, is not correlated with all the exogenous variables and it is distributed as bivariate normal with mean zero, each with unit variances, and correlation $\rho = \text{Corr}$ (μ_1 μ_2). In case of endogeneity that may arise from using y_2 as regressor, estimating equation (11) alone will produce biased results. Therefore, it is necessary to estimate equation (11) together with equation (12) using a bivariate probit model.

4.4 RESULTS

Equations (11) and (12) were estimated via maximum likelihood and two-stage least squared (2SLS). In the bivariate probit model the number of migrants per household and the dependency ratio were included as regressors in the remittances equation but excluded from the activity choice equation. In addition, the two variables were used as instruments in the linear probability model. The two activities analyzed in this study are livestock and nonfarm activities. The results from the bivariate model are presented in tables 4.2 and 4.3.

The results in table 4.2 show that households with internal and/or external remittances were more likely to invest in non-farm activities. In addition, households with more members as well as more adults were more likely to seek income from non-farm activities. In fact, income diversification may have a negative impact on farming activities due to the loss of labor and other sources. This situation may impact more small families than big families or households

with more productive adults. Therefore, it would be easier for households with more potential family labor to seek income outside of farming activities.

Table 4.2: Bivariate probit estimation of the impact of remittances on non-farm activity in rural Kenya

Dependent variable: household has nonfarm activities (1 = yes,0 = no)				
Activity choice equation	Coef	Robust Std. Err	Coef	Robust Std. Err
Household received Internal remittances (1= yes,0 = no)	1.178*	.104		
Household received External remittances (1= yes,0 = no)			1.221*	.246
Household Size	.693**	.284	.541**	.223
Number of Adults	.108**	.042	.075**	.036
Number of children	-.046	.045	-.041	.040
Age household head	-.015**	.007	-.006	.005
Household head with primary education(1=yes,0=no)	-.041	.187	-.079	.1716
Household head with secondary education(1=yes,0=no)	.043**	.008	.527***	.236
Land (hectares)	-.214**	.063	-.122**	.047
Number of Cattle	.061**	.020	.048**	.018
Irrigated land (Hectare)	.633	.449	.543	.409
Household with public transfer (1= yes, 0 = no)	.905*	.213	.704**	.280
Household is extremely Poor (1=yes,0=no)	-.990*	.165	-.830*	.146
Constant	1.990*	.350	1.6992*	.301
Remittances equation	HH received Internal remittances(1=yes, 0=no)		HH received external remittances (1=yes, o=no)	
Household Size	.108**	.035	.175**	.053
Number of Adults	.017	.037	.184	.131
Number of children	-.034	.051	-.222	.255
Age household head	.011**	.005	.047***	.027
Household head with primary education(1=yes,0=no)	-.100	.166	.768***	.272
Household head with secondary education(1=yes,0=no)	.672**	.268	1.583***	.710
Land (hectares)	.0691	.046	.225	.152
Number of Cattle	.033**	.015	.062**	.030
Irrigated land (Hectare)	.086	.094	.051	.159
Dependency Ratio	.057**	.019	.154**	.038
Number of migrants	.426*	.049	1.738*	.662
Constant	-2.06*	.293	-1.823*	.232
Number of observations	*782*		*782*	
Log likelihood	*-545.39*		*-486.44*	
ρ *and* $p-$ *value of* $H_0 = 0$	-.2760 (0.4524)		*-.698(0.000)*	

*,**,*** denotes significance at 1%, 5% and 10%, respectively ; HH: Households

Furthermore, household heads with higher levels of education were more likely to invest in non-farm production. According to Lazarte-Alacal et al. (2012), households with higher level

of education have better chances for nonfarm employment and earn higher wages. In addition, they are more likely to be successful in their businesses and tend to be more productive farmers. The positive coefficient of the public transfers variable shows that households with public transfers were more likely to seek income out of farming activities. In addition, the positive correlation between the number of cattle and households with non-farm activity reveals that households with more cattle were more likely to invest in non-farm activities.

In contrast, the negative coefficient of the variable land indicates that households with more land were less likely to diversify or seek income outside of farming activities. In addition, very poor households diversified less than better-off households. This result is consistent with that of Babatunde and Qaim (2009) as well as Shwarze and Zeller (2005) who found in their respective studies on Nigeria and Indonesia that poor households have less access to non-farm activities than better-off households. Therefore, wealthier households were more diversified than poor ones. Furthermore, this result indicates that diversification is viewed more as a means of improving their well-being than a survival strategy by households in this part of Kenya.

Table 4.3: Bivariate probit estimation of the impact of remittances on Livestock activity in Kenya

Dependent variable: household has livestock activities (1= yes,0 = no)				
Activity choice equation	Coef	Robust Std. Err	Coef	Robust Std. Err
Household received Internal remittances(1=yes,0=no)	.037	.275		
Household received External remittances(1=yes,0=no)			.188**	.052
Household size	.079***	0.037	0.053**	0.014
Number of adults	.070**	.030	.070**	.029
Number of children	-.027	.031	-.028	.031
Age household head	.017*	.004	.017*	.004
Household head with primary education(1=yes,0=no)	.086	.193	.315**	.152
Household head with secondary education(1=yes,0=no)	.325**	.154	.101	.192
Land (hectares)	-.007	.045	-.005	.044
Cattle	.027***	.016	.028***	.016
Irrigated land (Hectare)	.003	.098	.003	.095
Household with public transfer(1=yes, 0=no)	-.221	.465	-.238	.462
Household is extremely Poor(1=yes,0=no)	-.566*	.108	-.562*	.107
Constant	-.410*	.246	-.421***	.244
Remittances equation	HH received Internal remittances(1=yes, 0=no)		HH received External remittances(1=yes, o=no)	
Household Size	.037**	0.016	0.025**	0.02
Number of Adults	.013	.037	.181***	.104
Number of children	-.028	.051	-.240	.216
Age household head	.012**	.005	.034	.022
Household head with primary education(1=yes,0=no)	-.102	.166	1.748*	.790
Household head with secondary education(1=yes,0=no)	.673**	.266	1.517*	.767
Land (hectares)	.070	.046	.1421***	.076
Cattle	.033**	.015	.063***	.036
Irrigated land (Hectare)	.085	.094	.109	.121
Dependency Ratio	.089**	.020	.212**	.051
Number of migrants	.427*	.048	2.510*	.625
Constant	-2.057*	.291	-2.510*	.832
Number of observations	*782*		*782*	
Log likelihood	-547.442		-456.598	
$\boldsymbol{rho\ and\ p-value\ of\ H_0 = 0}$	-.04823 (0.576)		-.2987 (0.051)	

*,**,*** denotes significance at 1%, 5% and 10%, respectively

Based on the estimated results for livestock activity, which are presented in table 4.3, only households with external remittances were more likely to invest in livestock activity. The size of the household and the number of adults in the household were also positively correlated with the household propensity to invest in livestock activity. In addition, household heads with

higher level of education and households with more cattle were more likely to invest in livestock activity. In contrast, very poor households diversified less compared to better-off households. Tables 4.4 and 4.5 contain the results from two stage least squares (2SLS) and the average partial effects of remittances on non-farm and livestock activities.

The estimated results from the linear probability model in table 4.4 are the same as those from the bivariate probit model. Households with internal and/or external remittances were more likely to invest in non-farm activities. However, only households with external remittances were more likely to invest in livestock activities. In addition, the number of adults in the household and the age of household head were positively correlated with household propensity to invest in livestock activities. Furthermore, household heads with higher education level and those with more cattle were more likely to invest in livestock activity. Conversely, very poor households were less likely to invest in livestock activity (Table 4.4)

Table 4.4: Impact of Remittances on Livestock and Non-farm Activities (2SLS estimation) in Kenya

	Nonfarm Activities		Livestock	
Variables	Coef	Robust Std. Err	Coef	Robust Std. Err
Household received Internal remittances(1=yes,0=no)	.222**	.072	.061	.101
Household received External remittances(1=yes,0=no)	.290**	.022	.118**	.040
Household size	-.032	.022	.061***	.032
Number of adults	.045***	.021	.041**	.013
Number of children	-.036***	.016	.030	.027
Age household head	.003**	.001	.006*	.002
Household head with primary education(1=yes,0=no)	.080	.195	-.200	.273
Household head with secondary education(1=yes,0=no)	.040***	.019	.157***	.077
Land (hectares)	-.032**	.011	-.0006	.015
Number of cattle	.008**	.004	.011**	.005
Irrigated land (Hectare)	.037	.025	.018	.035
Household with public transfer(1=yes, 0=no)	.057	.137	.034	.192
Household is extremely Poor(1=yes,0=no)	-.720*	.202	-.199*	.035
Constant	1.020*	.202	.386	.284
Number of observations	782		782	

Table 4.4 (Continued)

	Internal remittances			
Tests	Statistics	P-value	Statistics	P-value
Hausman	4.623***	0.078	.117	0.736
Sergan	.243	0.622	1.911	0.166
Weak instruments(F-statistic)	54.02		52.87	
	External remittances			
Hausman	9.761*	0.0008	10.087*	0.0002
Sergan	.085	0.769	1.359	0.243
Weak instruments	32.95		39.66	

*, **, *** denotes significance at 1%, 5% and 10%, respectively

Table 4.4 also presents the results from the different tests for the validity of the instruments used to address remittances endogeneity. Except for internal remittances in livestock equation, based on the Hausman test for endogeneity, the p-value indicates that both internal and international remittance variables are endogenous. In addition, the F-statistic from all the first stage regressions is very high (greater than 10), implying that our instruments are not weak. The validity of the instruments is also confirmed by the Hansen's overidentification test.

The average partial effects of remittances on non-farm and livestock activities presented in table 4.5 show that, except for the effect of internal remittances on non-farm activities, the effects of remittances on the different activities from 2SLS model were greater that the effects from the bivariate probit model. Based on the bivariate probit model, the probability of investing in non-farm activities was 18.16% and 23.8% higher for households with internal and external remittances, respectively, compared to households without remittances. The corresponding probabilities from 2SLS model were 22.2% and 29.0%, respectively. Furthermore, the probability of investing in livestock activity was 6.85% and 11.85% higher for households with external remittances than that of households without remittances in the probit model and 2SLS model respectively. The difference in the average marginal effects between the bivariate and the linear probability models can be attributed to the small proportion of households receiving remittances, which is 25.6% for internal remittances and 7, 1% for external remittances in the

case of this study. These households are located at the tail of the probability distribution (Lazarte-Alcala et al., 2012)

Table 4.5: Average marginal effect of remittances on activity choice

	Nonfarm activities		Livestock	
	Internal Remittances	External remittances	Internal Remittances	External remittances
Bivariate Probit	.1816*	.238*	.01063	.0685**
	(.0296)	(.016)	(.195)	(.0198)
2SLS	.2227**	.29**	.0619	.1185**
	(.0722)	(.02286)	(.1014)	(.0405)

*, **, *** denotes significance at 1%, 5% and 10%, respectively
Standard errors are in parentheses

4.5 CONCLUSION

Income diversification constitutes an important livelihood strategy for rural households in developing countries in general and Sub-Saharan Africa in particular. Many rural households diversify their sources of income by investing in nonagricultural activities. In addition, diversification is used by rural households as a risk management strategy

The purpose of this study was to examine the effect of remittances and public transfers on the propensity of rural households to diversify their income through non-cropping production or activities. Using data collected by the World Bank in rural Kenya, the estimated results from the bivariate and 2SLS models show that households with internal and/or external remittances were more likely to seek income from nonfarm activities. However, only households with external remittances were more likely to invest in livestock activities.

The average partial effects of remittances on activity choices indicate that household propensity to seek non-cropping income was higher for households with external remittances than those with internal remittances. In addition, poor households diversified less than better-off

households, implying that diversification is viewed more as a means of wealth accumulation than a survival strategy in this part of Kenya.

4.6 POLICY IMPLICATIONS

Given the imperfection in the financial markets in the majority of rural developing countries in general and sub-Saharan Africa in particular, remittances are viewed by rural households as a way to mitigate farming activities risk. However, if remittances are not invested in cropping activities in order to compensate the loss of labor associated to migration, it may lead to the decrease in agricultural production, which may lead to food insecurity and increase in poverty. Therefore, the development of capital markets and crop insurance programs may help rural households invest more in farming activities and reduce rural migration. In addition, the development of rural infrastructure, rural markets and the improvement of the living conditions of rural populations should be a priority in the development agenda of policy makers.

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CHAPTER 5

CONCLUSIONS

The main objective of this dissertation was to analyze the behaviors of rural households in the adoption of modern agricultural technologies and assess the impact of migration, remittances, government transfers on the adoption modern agricultural technologies and income diversification in rural Kenya.

In the first essay related to farmers' technology adoption behaviors, we found that the adoption rate of improved maize in the area under study was very low over the study period. We found that only 19% of farmers did use improved seed during all the period under study. Sixty percent did not use at all and 21% did use in some of the years and then discontinued. Liquidity constraints, high percentage of population under the poverty line, poor infrastructures and markets are among the causes of the low adoption rate in the region. Providing rural areas with financial services and adequate infrastructures may increase the probability of adopting modern technologies in the region under study as well as in many African rural areas.

The second essay investigated the relation between migration, remittances, government transfers and the adoption of modern agricultural technologies such as improved seeds and fertilizer. The empirical results show that households with migrants, both within and outside of the country, and/or public transfers were more likely to adopt modern agricultural technologies. In other words, having migrants in or outside of the country increased their propensity to adopt modern technologies. However, only households with external remittances were more likely to

adopt modern technologies. Even though migration and remittances can help farmers reduce liquidity constraints and invest in more productive and risky activities, the provision of financial services in rural areas of Africa is an important factor in the adoption of modern technologies in rural Africa.

From the third essay, in which we analyzed the relation between remittances, government transfers and income diversification, we learned that households with internal and/or international remittances were more likely to invest in nonfarm activities. However, only households with international remittances were more likely to invest in livestock activities. If remittances are invested in nonfarm activities, migration will have a negative impact on the agricultural sector. The loss and the decrease in agricultural labor force may lower production and increase food insecurity. Therefore, policies must be implemented to improve the living conditions and increase agricultural productivity in rural areas.