BREAKING THE TRAP?
HYBRID MAIZE FOR HOUSEHOLD FOOD SECURITY:
A COUNTERFACTUAL ANALYSIS
FROM SOUTHERN AND CENTRAL MALAWI

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ABSTRACT

Malawi has changed her position from one of the most food insecure countries to one that is now able to export and donate maize for her neighbors. Subsidy of agriculture inputs and favorable rainfall in 2006/2007 growing season are two explanations of this. Nevertheless, whereas food security at the national level was achieved, some households are still experiencing lack of food.

This study concerns how the condition of food security is changed in the group of "new" adopters of hybrid maize and fertilizer. The term "new" refer to farmers who grow hybrid maize in 2006/2007 cropping season, while they did not grow in the 2005/2006 cropping season. Propensity score matching and difference-in-difference method are used in this study by utilizing two years longitudinal data of 154 households from Southern and Central Malawi.

This study first analyzes factors affecting hybrid maize and fertilizer adoption, followed by counterfactual analysis of the adoption of hybrid maize and fertilizer on land allocated for maize, yield per hectare, total harvest per household that will be translated to the income, and maize available per capita.

The result of the logit model of adoption shows that membership in a farmer organization and households' access to credit increase the probability that farmers will adopt the package, while female headed household have lower probability to adopt.

Our results indicate that adoption of hybrid maize would be able to prevent each household member from being hungry for 6-7 months. However, the result shows that growing hybrid maize is not profitable unless inputs are being subsidized, as farmers have a small amount of land. Dividing the households into some categories, we found that land constraint and female headed household will not benefit from uptake the package, while secondary education will boost the benefit.

Key words: Malawi, food security, adoption technology, fertilizer subsidy, hybrid maize, propensity score matching, difference-in-difference

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Ås, May 2008
Kartika Sari Juniwaty

Dedicated to:

My Father and Mother

My Brothers & Their Family

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LIST OF ABBREVIATIONS & ACRONYMS

ADMARC Agriculture Development and Marketing Corporation
ATET Average Treatment Effect on Treated
ATT Average Treatment Effect on Treated
CIA Conditional Independent Assumption
DFID Department for International Development
DID Difference-in-Difference
EIU Economics Intelligent Unit
FGD Focus Group Discussion
FAO Food and Agriculture Organizations
GDP Gross Domestics Product
GoM Government of Malawi
IHS Integrated Household Survey
MK Malawian Kwacha
PSM Propensity Score Matching

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Exchange Rate

MK141.1=US$1[1]

[1] As reported in EIU's Malawi Country Report July 2007.

CHAPTER 1
INTRODUCTION

1.1 BACKGROUND

The role of agriculture to provide food and main source of income for the poor become extremely important in the world where there are hundreds millions peoples experiencing lack of food and more than one billion people live below poverty (see e.g. de Janvry et al. 2000). Previous research has shown that the best way to increase the output of agriculture is by adopting new technology, i.e. intensification, as pressure on land and population growth has reduced the potential for more extensive agriculture (Alwang & Siegel 2003). In addition, the extensive agriculture becomes more impractical as the current concern of the negative impacts of deforestation and changing the land use on climate change (Kanninen et al. 2007).

Adoption one or more technology improvements, namely improved seed varieties, inorganic fertilizer, pesticides, modern irrigation, and soil conservation techniques, has been considered to contribute positively to agricultural output and eventually to the wellbeing of the farmers (Mendola 2005; Zeller, Diagne & Mataya 1998). Ideally, the best outcomes will be achieved through adopting combinations of new technologies that appropriate for specific agro-climatic and sosio-economic conditions in particular area. Nevertheless, variables such as investment, market failures, risk and information shape the outcomes of farmers' decision to apply new technology (Simtowe & Zeller 2006; Zeller, Diagne & Mataya 1998). Hence, favorable economic incentives from the government are needed for correcting the failure and encouraging farmer to adopt new technology that is important to boost agriculture output (Stiglitz 1986).

Malawi, one country that had long story of food insecurity, has changed her position currently. In addition to 2006/2007 favorable weather, fertilizer subsidy by Government of Malawi has been recognized for not only being able to increase the production to the highest record but also to provide some surplus that can be exported and donated to the neighbor countries. Furthermore, the surplus yield potential gain in export revenue that higher than the cost of subsidy itself.[2] EIU (2007) reported that the increase in maize harvest from 2006 to 2007 is 25% and there is 1.1 millions metric tonnes surplus of maize.

Despite the fact that this program has successfully bring about food security at macro level, the impact at the household level has not cleared yet.[3] This study attempts to provide counterfactual analysis of household food security in the groups of farmers who adopt both hybrid maize and fertilizer, the one that actually carried out the activity as it is expected when the subsidy is given out. By utilizing two years longitudinal data, we would be able to apply difference-in-difference method in combination with propensity score matching to have unbiased estimator. We are interested in the impact of hybrid maize and fertilizer adoption in 2006 on the harvest in 2007.

To provide a complete picture, this study will first analyze factors affecting hybrid maize and fertilizer adoption in 2006, followed by the impact evaluation of the uptake of the package on land allocated for maize, yield per hectare, and per capita maize available in the household.

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[2] EIU (2007) reported that for buying maize from Malawi, Zimbabwean government has a debt as much as US $ 120 millions, while the cost was US $ 70 millions as reported in DFID (2007).

[3] Ellis (1993) stated "*household is a social unit defined by the sharing of the same abode or hearth.*" Our unit of analysis is a household and apply the same assumptions with the one mentioned in Ellis (1993) that "*within the household resources are pooled, income is shared, and decisions are made jointly by adult household member.*" We use the term household and farmer interchangeably.

1.2 MALAWI, AGRICULTURE AND HYBRID MAIZE

A landlocked country of 13 millions people in Southern Africa, Malawi is one of the poorest countries in the world with the GDP per capita no more than US $ 150 (World Bank 2008). Similar with her neighbors in Southern Africa, the economy of Malawi is highly dependent to the agriculture sector which constitutes both estate and smallholder subsistence farmers. Agriculture contributes a third of GDP, and 90% of export revenue, with tobacco as the main export crop. In addition, agriculture employs more than 85% of labor force (World Bank 2003).

Smallholder subsistence farmers with less than 1 ha (hectare) of land in average, contribute 84% of agricultural output (World Bank 2003). Most of these smallholder farmers grow maize, as maize is the main staple food. The limited land ownership per household, however, contributes to small output and to poverty. In addition, rain-fed cultivation contributes to uncertainty of the output of the farm and increases risk of food insecurity. Most farmer household experience lack of food for one to 6 months before the new harvest comes which is known as "hungry season"(Smale, Heisey & Leathers 1995).

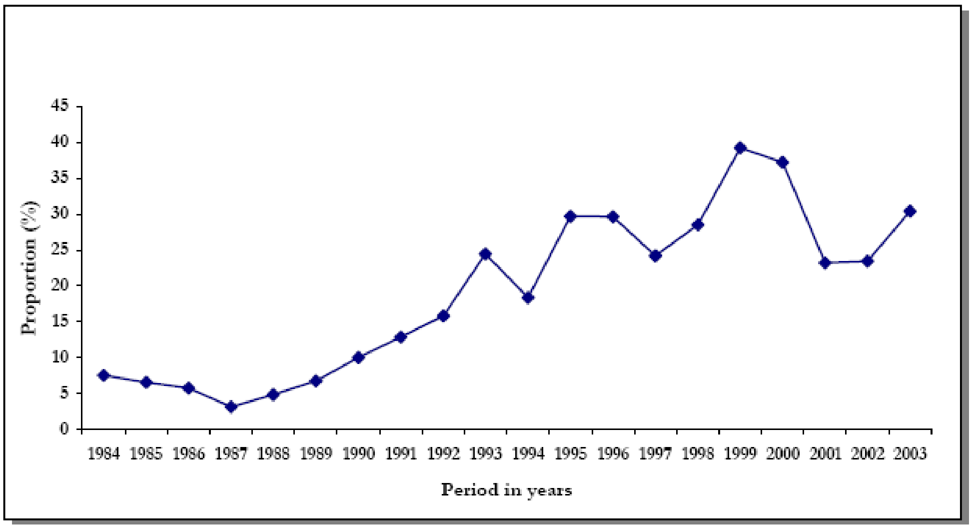
The impact of food insecurity *per se* can be considered as a hindrance to development as for adults, hunger will reduce productivity, while for children; hunger will impede the development of children's brain and body (World Food Programme 2006). Improper administration of this problem may create a vicious poverty both for short and long term as hunger is both the cause and result of poverty (Soubbotina & Sheram 2000). Hence, increasing agricultural productivity, especially maize in Malawian context, has been seen as the most proper way to break this trap both in macro or micro level.

As the reliance of Malawians on maize is extremely high, one of the highest consumption per capita of maize countries in the world (Smale, Heisey & Leathers 1995), maize is the most important crop in Malawi. Much effort has been performed by the government in order to increase the production of this staple food which comprises direct intervention to provide the economic incentive to grow higher yield varieties of maize and support research activities that strengthen farmer practically.

The intervention to provide economic incentive for farmers has been performed since independence in 1964. Nevertheless, in the first two decades of independence, agriculture polices were implemented in favor to the estate sector. Starting from late 1980, government started to provide incentive for smallholder farmer (Smale 1995). The policies regarding agriculture sector for smallholder comprise subsidizing fertilizer and seed, controlling prize, and channeling marketing (Chirwa 2005b; Øygard et al. 2003). Nevertheless, the policies has changed overtime in order to conform with donor's requirement that bring about disincentive effect on agricultural production for some years (Chirwa 2005b; Harrigan 2003; Smale et al. 1998).[4] Hence, the impact of the policies on agricultural growth and food production were diverse year by year (Harrigan 2003).

The changing of incentives for growing improved varieties is reflected in the share of maize land allocated for hybrid maize production. Simtowe & Zeller (2006) reported that there was steady increase in the proportion of maize land that allocated for hybrid maize cultivation between 1987 and 1993. After the collapse of the credit system and crop failure in 1993, the share started to be fluctuated. Simtowe & Zeller (2006) showed the trend as in the graph below:

Figure 1: Share of maize land allocated to hybrid maize production



Source: Simtowe and Zeller (2006) p.5

[4] Chirwa (2005) mentioned the periods as pre-reform, reform, and post-reform period. Reform period had happened when Government of Malawi adopted Structural Adjustment Programs which one of the conditions of joining the program was removal subsidies including the subsidy for agricultural sector.

Considering agriculture production and food security as the key priority, Government of Malawi has realized the importance of the fertilizer subsidy as economic incentive for smallholder maize growers in the country. Hence, they moved on with the subsidy, even when they should disagree with the donors (EIU 2007). After harvesting in 2007, world noticed that the fertilizer subsidy performed by the Government of Malawi has a remarkable result. Malawi is not only being able to fulfill the need of maize for domestic consumption but also to export the surplus to the food deficit neighbor country.

Furthermore, agricultural research has produced improved hybrid seed. One remarkable output of research efforts in Malawi is the establishment of hybrid MH17 and MH 18 with a semi-flint texture that differs from the previous hybrid that have dent texture that increase willingness of farmers, that previously reluctant, to grow hybrid maize. In addition, MH17 and MH 18 result more in pounding process and fewer loss in the storage (McCann 2005). In term of performance, these two types of hybrid seeds have performed well to increase yield 50-70% more than local maize, even without any fertilizer (Smale et al. 1998). In case fertilizer applied, hybrid maize can increase yield twice as much as local maize per kg fertilizer applied (Smale et al. 1998). Additionally, farmer's knowledge and practice has been strengthen as well trough the research output that would be able to recommend quantity and type of fertilizer to be applied in specific area to get optimal yield (Blackie et al. 1998).

Based on the conditions above, one could think that the necessary conditions for encouraging farmer to grow hybrid maize and perform well in the maize production have been satisfied (Smale 1995). Nevertheless, the fact that less than 50% of the farmers grew hybrid maize and only 40% of maize land allocated for hybrid maize,[5] force us to think that these conditions is not sufficient enough to encourage more farmers to grow hybrid maize. On the other hand, having more farmer and more land allocated for growing hybrid maize and apply fertilizer on it, is necessary to achieve the goals to increase agriculture productivity and food security, as stated as the first key priority in Malawi Growth and Development Strategy (MGDS) (GoM 2006).

[5] Based on our 2 years longitudinal data set of 351 households, there were more or less 47% of the households growing hybrid maize in 2005/2006 and 2006/2007 cropping season; while 42% and 38.10% of land maize was allocated to hybrid maize in 2005/2006 and 2006/2007 cropping season respectively.

Hence, identifying the characteristics of hybrid and fertilizer adopters as well as the impact of this adoption package at household level is important to formulate policies that effective to increase hybrid maize production. In addition, assessing the impacts of the adoption is critical for both micro and macro level. First, at the micro level, it provides understanding how much hybrid maize adoption contributes to increase the yield and farmers' condition of food security. Second, at macro level, it provides foundation for calculating benefit and cost of the intervention that will contribute to the efficiency and effectiveness of the policies in the future.

1.3 RESEARCH QUESTIONS

Based on consideration above, this study attempts to answer research questions as presented below:

1. What are the special characteristics of hybrid maize growers?
2. If farmer decide to grow hybrid maize, is the proportion of land allocated for maize production changed? If yes, how much?
3. If farmer is a "new adopter" of hybrid maize and he applied fertilizer on the crop, how many kilograms of yield gain per hectare will farmer benefit?
4. If farmer is a "new adopter" of hybrid maize and he applied fertilizer on the crop, to what extent will farmer be able to secure food availabile for each member of household?

The term "hybrid maize" in this study refers to the seed that the farmer considers to be hybrid. However in many cases this may include next generation seed, which is not strictly hybrid (Doss 2003). In addition, what we mention as "new adopter" here is farmer who didn't plant hybrid maize in the 2005/2006 cropping season but they grew hybrid in 2006/2007 and applied fertilizer on this crop.[6] Nevertheless, it is possible that this "new adopter" had adopted hybrid maize before 2005/2006 cropping season, so they are not strictly new adopter.

[6] In some occasion, the term "package" is used to describe the fertilizer and hybrid maize. Both terms are use interchangeably.

Based on agriculture household models in combination with the sustainable livelihoods as the theoretical framework, this study presents how the decision are taken by farmers to adopt hybrid maize, and how this decision is translated into the outcome: *land allocated for maize, maize yield per hectare and maize available per capita*, and how the outcome is translated to lift up some farmers from food insecure situation. Counterfactual analysis will be adopted as the methodology as well as propensity score matching and difference-in-difference method to eliminate the bias that might emerge as adoption decision might be not a random process.

1.4 OBJECTIVES

The objectives of this study are:

1. To identify special characteristics of the hybrid maize adopters in order to know the constraint of non-hybrid growers.
2. To calculate the impact of the adoption the package for the adopter in order to know how much the additional of income and food from the adoption.
3. To contribute to limited amount of literatures regarding the impact of adoption of hybrid maize and fertilizer in Malawi.

1.5 ORGANIZATION OF THE STUDY

There are 5 chapters covered in this study. Following this first chapter of introduction, theoretical and empirical framework of the technology change, both capturing the determinants and the impacts of it will be presented. In the same chapter, growing hybrid maize will be pictured in the broader context as one of the livelihood strategies in the sustainable livelihoods framework. Subsequently, in chapter 3, the data and descriptive statistics of the sample will be presented and followed by the methodology showing interrelation among formulation of impact evaluation problem, the propensity score matching, and difference-in-difference method. Result and discussion will be presented in the subsequent chapter followed by the conclusion in chapter 5.

CHAPTER 2
THEORETICAL & EMPIRICAL FRAMEWORK

This chapter presents the theoretical and empirical framework lying behind factors influencing farmers' decision to grow hybrid maize as well as the impact of adoption on the outcomes. Subchapter 2.1 will present the agriculture household model that incorporate technology adoption and discuss the yield related issue as well as present the hypotheses that will be tested regarding adoption decision. Subsequently, subchapter 2.2 will present the theoretical background; how changes will occur as farmers decide to grow hybrid maize that can be seen from the changes in land allocated for maize production both in term of size and proportion, the yield per hectare of land allocated for maize and the food available for each member of the household. In addition, this theoretical background is supported by some empirical works that have been performed in Malawi.

2.1 AGRICULTURE HOUSEHOLDS MODEL OF HYBRID SEEDS ADOPTION[7]

Modeling technological change within economic sense has been performed since more than half a century ago starting by paper by Griliches (1957). Onwards, there are abundant models that try to explain adoption behavior, most of them concern on the production side only, or otherwise they stated that production decision is done by farmers before the consumption decision (see e.g. Hiebert 1974). Nevertheless, farmers especially in the developing countries have different condition from the one in developed countries. Farmers in the developing countries have special characteristics that they act both as producer and consumer from the crops and labor that they produce resulting the development of agriculture household models (Singh, Squire & Strauss 1986). Most of farmers produce food and consume it at the same time and has the subsistence requirement that should be fulfilled.

[7] The theoretical framework of agriculture household model are heavily drawn from Singh, Squire & Strauss (1986) especially the Part I (Singh, Squire & Strauss 1986) and Chapter 3 (Singh & Subramanian 1986) and 9 (Roe & Graham-Tomasi 1986).

Several models that have been studied in Singh, Squire & Strauss (1986) provide a picture of how farmers in rural market take their decision. Nevertheless, we can't find one extended model that relaxed many assumptions so that it suit the situation that we found in rural area in Malawi relating with the adoption of hybrid maize. Hence, in this study, we will try to take some conclusions from several different models that might fit the real condition.

In agriculture household model, farmers try to maximize their utility coming from the consumption of goods and leisure. The goods are usually agriculture goods, which farmer both produce and consume and the manufacture goods that farmer rely on the market to obtain. Farmers facing several constraints such as the production function, full income constraint, and time constraint. Hence, the first order condition, assumes that there is interior solutions, resulting that the marginal rate of substitutions will equal to the price ratio (Singh, Squire & Strauss 1986).

However, for farmers in Malawi, "*maize is life*" so then maize is very important to secure maize for own consumption as the result of market failure that made them doesn't willing to rely on the market (Alwang & Siegel 1999; Orr & Orr 2002).Therefore there is no clear distinction in consumption-production utility maximization, production and consumption are maximized simultaneously, not in a recursive way, this is called the non separable problem. As a result, there are also some farmers who do not sell their maize in the market. Market failures can also caused by the problem in the rural labor market; we can say that there is also imperfect market as there are also some barriers in hiring *ganyu* labor.

Hence, in our case, the *non-separable* model is needed, with the consequences, the prices become endogenous as it depend on preference of the farmers and the production technology that farmer use, hence the marginal rate of substitutions are not fixed and different from farmer to farmer. In addition, the decision on how much the quantity of food to be sold in the market and how much the quantity of input needed for the production depend on this endogenous price that also known as the *shadow price*.

Singh & Subramanian (1986) formulated the agricultural household model for farmers who grow more than one crop. In addition, this model allowed farmer to grow the same crop with different technology. This model fit in our case as we want to see how farmer decide whether they grow local maize, hybrid maize or any combination of them in their plots. Local maize is different from hybrid maize in term of the cost of production and the yield. Hybrid maize that has twofold higher yield than local maize has higher input cost as farmer need to buy the hybrid seed each cropping season, and they are required to use fertilizer to obtain optimal output from hybrid seed. We do assume that farmer has the same consumption preferences between the local and hybrid maize.

Nevertheless, the model by Singh & Subramanian (1986) assumed that farmers take the decision of production and consumption separately, even that they realized that this assumption was not applicable for farmers in one of the countries that was being studied: Nigeria. The difference between the extended model by Singh & Subramanian (1986) with the basic agriculture household model is that this model allow farmers to have different type of land and they can take decisions which crop that best to be grown in each type of the land or to leave the land fallow. The condition in rural Malawi can be seen as in this model. Farmers will have several plots that sometimes separated and dispersed by some kilometers. Hence, we can assume that each plot as one specific type of land. In addition, farmers grow multiple crops such as local maize, composite maize, hybrid maize, and other crops such as cassava, groundnuts, and sweet potato.

The model conclude that if the specific land constraint is binding, farmers will grow one specific crop in the one specific type of land if the shadow price of this specific type of land in term of the utility is equal to the marginal utility of income times the profit that come from growing the specific crop at this specific land. In our case, we can see that farmer will grow hybrid maize in one plot if the shadow price in term the utility from the specific plot is same with the marginal utility of income times the profit from growing hybrid maize in this plot.

Nevertheless, we recognize that growing hybrid maize is a risky activity to be taken by poor farmer in Malawi, as this activity required higher input costs whilst the output of production is uncertain as the cultivation is heavily rely on the rainfall that is exogenous. The fact that there is a lag between production decision is being taken and the output is yielded and trade off between consumption this year or next year make it is critical to use the dynamic model. Hence, we inspect the agriculture household model by Roe & Graham-Tomasi (1986).

In Roe & Graham-Tomasi (1986) model, farmers try to maximize utility of consumption and asset overtime subject to production function and the asset condition. The production function consists of output in next period as the left hand side and inputs which are labor and land on this period on the right hand side with random variable of next period. The asset condition required that asset of next period should be equal to farmers endowment plus profit minus consumption and plus asset and asset return on this period. They conclude that:

> *"The risk preferences for solving the problem of maximizing the expected utility of profit must be derived from the household's preferences for income risk and ultimately from their preferences concerning consumption variability." (Roe & Graham-Tomasi 1986 p.263)*

Based on the studies above, we expect that farmers will grow hybrid maize if the expected utility of profit that coming from growing hybrid maize at least in one plot is higher than the expected utility of profit of not growing hybrid maize whilst this expected utility is depend on the preferences toward income risk and the variability of the consumption.

In addition, in this study, we assume that farmers in our sample are fall into the first two groups of farmer as defined in Taylor & Adelman (2003) which are *"… (1) the net surplus producing family farm, typical of small owner-operated farms of medium productivity; (2) the subsistence and sub-subsistence household farm, typical of small-scale, low productivity agriculture, frequently operating under marginal conditions and incomplete markets; …" (p.34-35).* As discuss in the basic agricultural household model, these two groups of farmer will act differently as the response of the change in exogenous variables, and might have difference preferences toward risk.

With the subsidy fertilizer and hybrid seed is taking place, we could the program in general will reduce the price of inputs and increase the pay off from adopting the hybrid maize for each farmer. Hence, theoretically, subsidy policy will create favorable underlying condition for adoption. Nevertheless, we still expect that the risk aversion problem is still dominating as we find that many farmers do not hybrid maize and most of the farmers rely on rain-fed cultivation. In addition, compare with the other grains, maize is actually the crop that highly sensitive to the drought (McCann 2005).

Study by Dercon (1996) showed how the farmers' endowment in term of asset can be used to capture their risk mitigation and adaptation behavior. Dercon (1996) stressed that, in case there is no credit and insurance market, farmer will tend to insure themselves against the risk through risk management strategy or income smoothing activities. He mentioned that household can use their own asset as the buffer when the bad outcome emerges. Hence, farmer with higher asset, will end up adopt high return crop and high risk while the poor will adopt the low return and low yield crop. He applied his model on sweet potato adoption, which is the low risk and low return crop, in Tanzania, and he found that asset is negatively correlated to the extent of sweet potato adoption. Dercon (1996) pointed out that liquid asset that is important in shaping what farmers decide to carry out, and he used livestock as the proxy of household's assets.

Rosenzweig & Binswanger (1993) analyzed how the weather risk is related with the activities and the outcome carried out by farmers. They conclude that richer farmer will have more alternatives to be carried out even if those activities have higher degree of weather risk. On the other hand, poorer farmers are more vulnerable to weather risk resulting higher degree of risk aversion as they know that it is difficult to cope when the bad thing turn out (Dercon 1996). Rosenzweig & Binswanger (1993) used total wealth as the determinants of household portfolio of activities which comprise of several categories of asset such as landholding, livestock, farm equipment, liquid capital, and consumption asset.

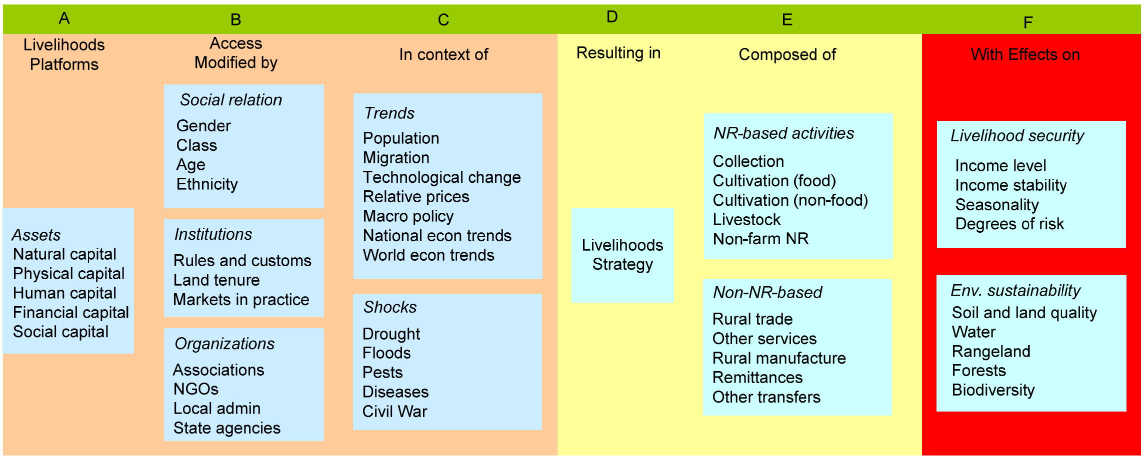
In line with the previous studies, we keep in mind that asset can be used as the buffer when the bad weather comes. Farmers who have better endowment will end up with adoption as they would be able to afford the risky investment. Nevertheless, instead using one of the assets such as livestock in Dercon (1996), we try to incorporate broader categories of assets as the determinants of adoption. We extend the Rosenzweig & Binswanger (1993) total wealth with social and human capital. For doing this, we adopt the sustainable livelihoods framework that has gain its popularity for focusing on what poor people have in relation to the livelihoods option that are open for them, and in our case, the growing of hybrid maize and fertilizer application. By applying the sustainable livelihood framework, we attempts to provide both economic and social explanation of the adoption and find which kind of asset that significantly influence the decision.

Cahn (2002) and Ellis (2000), contributors to the sustainable livelihoods framework literatures, mentioned that what the poor have will determine their livelihoods activities that more or less the same thing as examined in Dercon (1996) and Rosenzeig & Binswager (1993). What farmers have are grouped into 5 categories of assets. They are widely known as pentagon of assets consists of natural, physical, human, financial and social capitals. Influencing by mediating process, these assets can be "used" to choose livelihoods strategies of the household and produce the outcome. The mediating processes comprise social relation, institutions and organization, as well as trend and shock. Households would be able to choose to get involve in non resource base and/or resource base activities. The outcome of the livelihood strategies can be seen in the forms of livelihood security and environmental sustainability.[8]

[8] One can consult Ellis (2000) for a broader explanation of the contents of the livelihoods framework.

The figure 2.1 below shows the livelihoods framework as in Ellis (2000):

Figure 2.1 The Livelihoods Framework



Source: Ellis (2000) (adapted from Scoones (1998) and D. Carney (1998))

We try to examine one by one the pentagon assets in relation to the adoption of hybrid maize and fertilizer in rural household in Malawi. *Land size holding by household*, one form of natural capital, is one of the critical inputs for production process. As we mentioned above, our respondents are fell into two different categories that make size of land holding affect differently the decision to adopt hybrid maize. For subsistence farmers who need to fulfill their maize requirement, we expect that farmer who has land constraint tend to adopt hybrid maize to fulfill their requirement from their limited land.[9] Based on this consideration, we expect that land will negatively correlate with the adoption, smaller land size higher probability of adoption. Unfortunately, farmers who have smaller amount of land holding are also the poorest who the most unlikely to tackle either the risk or the cash constraint that restricts them from buying the necessary inputs. On the other hand, for farmers who are market oriented, higher land will contribute to higher output from hybrid maize and higher profit. The trade off between the risk and the subsistence requirement that should be fulfilled of smallholder farmer and maximizing profit of larger farmer make the influence of land size holding to adoption behavior undetermined.

[9] As mentioned by Ellis, Kutengule & Nyasulu (2003) that cited from Devereux (1997) and World Bank (2005), farmer with less than 0.5 ha of land with large member of household will not able to fulfill the requirement of maize, even with the hybrid maize.

The quality of land in term of its fertility is one other form of natural capital own by households. Many studies have reported that one factor that undermines the farm potential in Malawi is the reducing soil fertility. Hence, fertilizer is important factor to increase the fertility of the soil and give the better output (Orr & Mwale 2001; Tchale & Sauer 2007). With the expectation that farmer with good soil quality need smaller amount of fertilizer that can be translated to smaller inputs cost, we predict that the soil quality will positively correlated with the adoption.

Human capital such as *number of labor* and *education of head of household* will contribute positively to the adoption of hybrid maize. As hybrid maize is relatively difficult to be processed and stored, it requires more time and labors (McCann 2005). Hence, number of household labor which is the most important source of labor in agriculture activities is expected positively correlate with adoption.[10] Actually, as mentioned above, even though there is *ganyu* labor to work within the farm but there are still some barriers to hire in, so that we expect that farmer will try to utilize own labor first before hired in *ganyu*. Furthermore, number of labor within household is a proxy of household size for whom maize requirement should be fulfilled. Higher number of labor mean that there are more mouth to be feed and more maize to be produced and by adopting hybrid maize, the requirement is much likely to be filled especially if farmers have smaller land.

Head of households' educational background will influence the way of thinking and the attitudes of farmers. With relatively higher education they would be able to "count" the cost and benefit of growing hybrid maize and able to incorporate risk in their calculation. Hence, we expect to see positive relationship between the education of the head of household and the take up of the package. Chirwa (2005a) found significant positive correlation between education and the take up of fertilizer and the same sign for hybrid maize adoption but it not significant.

[10] The idea that own household labor is the most important source of labor is coming from White, Labarta & Leguía (2005).

Ownership of *physical capital* will contribute positively to the adoption of hybrid maize, as hybrid maize need more care and some agriculture tools will make the work more efficient and productive. Some farm equipments such as *panga* and *axe* are needed to make the work easier. In addition, for some farmers who expect to sell some surplus to the market, ownership of mode of transport such as *oxcart* and *bicycle* becomes important as this will reduce the cost of marketing and increase the profit.

As there is a lag between the investment of seed and fertilizer being made to the output, then, the financial asset that can easily be transformed to cash is extremely important. These *financial asset*s can be seen in the form of *livestock*, and *access to credit*. As mentioned in Dercon (1996), livestock is positively related to the adoption of high return and high risk crop as households who have higher livestock will have buffer when the harvest turn out to be bad. On the other hand, in case farmers have barely liquid assets, credit can be seen as an alternative of sources of cash that can be transferred to the input of productions. Sometimes, farmers would be able to access the input in form of credit. Hence, access to credit will give farmers an opportunity to invest in hybrid maize and fertilizer. Studies such as Simtowe & Zeller (2006) and Zeller, Diagne & Mataya (1998) show the importance of credit on adoption of better livelihood strategies in Malawi.

The *involvement of the farmers in farmer organization* will build farmers' *social capital* which will contribute positively to the decision to adopt hybrid maize as in farmer organization. In farmer organization, we expect that farmers obtain some more insight from extension officer and also from their friends' experience of using hybrid maize. Most studies stressed the important of the learning process on the adoption (see e.g. Hiebert (1974), Baerenklau (2005)) In addition, we expect that farmers who have access to *radio* will experience other learning process as well and obtain more valuable insight related with farming activity and information regarding policy that implemented by the government that can affect their adoption decision.

We expect that the absence one or several types of capital will reduce the propensity to adopt the package of hybrid maize and fertilizer. Nevertheless, there are some social factors that are related to the adoption. For example, *gender* shapes the decision to adopt "better" livelihoods strategy as well. Most of female headed households have difficulties to adopt "better" livelihoods strategy caused by relatively lower endowment of labor, land and financial capital compared with their male counterparts (Dolan 2005). Furthermore, we expect that the *age* of household head will negatively contribute to the decision as there might be the attitudinal differences toward changes and risk aversion across group of age. Adegbola & Gardebroek (2007) mentioned that the elder is more reluctant to changes while the younger more risk lover. In addition, Chirwa (2005a) found that age is negatively correlated with adoption decision as older people prefer the taste of local maize to hybrid maize.

Institutional context shape the decision to adopt the package as well. Ellis, Kutengule & Nyasulu (2003) mentioned that based on their qualitative research, the most important institutional contexts in rural Malawi are the system for accessing land, the chief and traditional authority, the religious institutions, donors and non governmental institutions (NGOs), state or district official, and inducement payment. Some these institutional contexts contribute positively to increase wellbeing while some others do not. Hence, *dummies of district* will be used to capture the heterogeneity of the institutional contexts. Additionally, these dummies of district are predicted will be able to capture heterogeneity of trends and the specific condition of the agro-ecological zone.

Vulnerability condition of household will shape the decision as well. We predict that farmers who have at least one of the members were ill will have less probability to adopt hybrid maize. First, households will have less labor to work on the farm and need time from other member to take care of the sick that resulting reduce in farm work. Second, the ill household most probably will need cash to provide the treatment for the ill, so there is trade off either buying medicine or fertilizer.

Last, other livelihoods strategies that have been carried out previously by farmers will influence the decision. We try to incorporate two main activities other than own farm work which are *ganyu and* business. Whiteside (1999) defined *ganyu* as follow:

> *'any off-own-farm work done by rural people on a casual basis; usually covering a period of days or weeks, remuneration may be in cash or in kind (such as food), and is often, but not exclusively, calculated as piecework. Ganyu may be done for relatives, neighbours, smallholders further afield, for estates or even in other countries. The work is often, but is not exclusively relatively unskilled and agriculturally based. Men, women and children can all do ganyu.' (Whiteside 1999 p.1)*

Ganyu is the second "best" activity besides agriculture, even some researchers claimed that farmers who do *ganyu* tend to neglect own farm activity. In addition, it is usually the poorest of the poor who do *ganyu* to get immediate cash or in kind food. Whiteside (1999) stated that the payment for *ganyu* labor is very low that would not make farmer able to invest in their own land. Based on this consideration, we expect that the doing *ganyu* will negatively correlate with the uptake of the package.

We expect that other activity i.e. *business* will provide ambiguous impact on adoption as this activity can be seen as both as competing and supporting factor. For households who facing labor constraint will tend not to adopt hybrid maize if they have other source of income. On the contrary, for farmer who do not facing labor constraint, other sources of income will critically important to contribute some farm investment or serve as buffer if the bad state emerge. This would encourage farmer to grow hybrid. On the other hand, have access to other income might relax the cash constraint that reduce the urgency to self sufficient in maize.

In addition, we take other important source of agricultural income which is tobacco that is the most important cash crop. Using the same reasons as the one explain in business, we think that tobacco will give ambiguously effect on the uptake of hybrid maize and fertilizer.

BOX 1. HYPOTHESES- Determinants of Adoption

Based on the theoretical and empirical reviews above, several hypotheses have been formulated as the determinants of adoption hybrid maize and fertilizer. The hypotheses are:

1. Access to asset base will generally increase the propensity to adopt hybrid maize and fertilizer. The term "asset base" refers to the pentagon of asset as described in sustainable livelihood framework. Indicators that will be used in each type of asset are:
   - *Natural capital: land size (?), and land fertility*
   - *Human capital: labor, education*
   - *Physical capital (productive asset):panga, axe, oxcart, bicycle*
   - *Financial capital (liquid asset):other income (?), livestock, access to credit*
   - *Social capital: membership in farmer organization, radio*
2. Vulnerability context will impede the adoption of the package. We argue that farmers who have at least one ill member are less likely to adopt.
3. Social context will have an impact on the adoption decision. We argue that there are some special characteristics of the households that barrier the adoption, such as *female headed household* and *age of head of household.*
4. Access to other livelihoods strategies provides ambiguous influence to the propensity of adoption. Farmers who have other livelihood strategies such as have *small business*, and *grow tobacco* will reduce the propensity to adopt if they are facing labor constraints. In addition, we expect that *ganyu* activity will negatively relate with adoption.
5. Specific context and agro-climatic condition will affect the decision. *Dummies of districts* will be used to capture the different in area specific characteristics.

2.2 THE IMPACTS OF ADOPTION

In this subchapter, we try to provide some changes that most probably take place as farmer adopt hybrid maize. We try to calculate the impact of adoption on several outcomes: the size and proportion of land allocated for hybrid maize, the yield per hectare of maize land, the households' production and the food availabile for each member within household. As will be described in chapter 3, propensity score matching in combination with difference-in-difference method will be applied to calculate the impact. These methods will provide the unbiased estimators of the impact compare with previous studies that simply regress adoption decision as one of the explanatory variable with the impact as the dependent variable.

2.2.1 Change in Maize Land and Productivity[11]

Ellis (1993) mentioned that adoption new improved varieties, i.e. hybrid maize in our case, can be seen as *land saving technical change*, change in technique that allow farmer to maintain the same production from smaller land allocation. Graphically, *land saving technical change* can be seen through shift down the isoquant as in graph 1(a). Both isoquant, Q0 and Q0′ show the combination input of land and labor[12] that yield the same amount of output. The difference is that in the isoquant Q0, it is local maize is planted, while in the isoquant Q0′,the hybrid maize is adopted. With the same number of labor work for each activity (L*), it can be seen that if hybrid maize is implemented, less land is required (compare H0* to H0).

On the other hand, if one wants to look at the production function, adoption of technology such as hybrid maize will rotate up the production function. Production function Q show the output if farmer apply local maize and Q* if farmer grow hybrid maize. Increasing production will happen if same amount of land is allocated, i.e. with the same combination of land and labor farmer will be blessed with increasing yield from Q0 to Q1. In each combination of land and labor, the output of production using hybrid maize is higher than the one using local maize.

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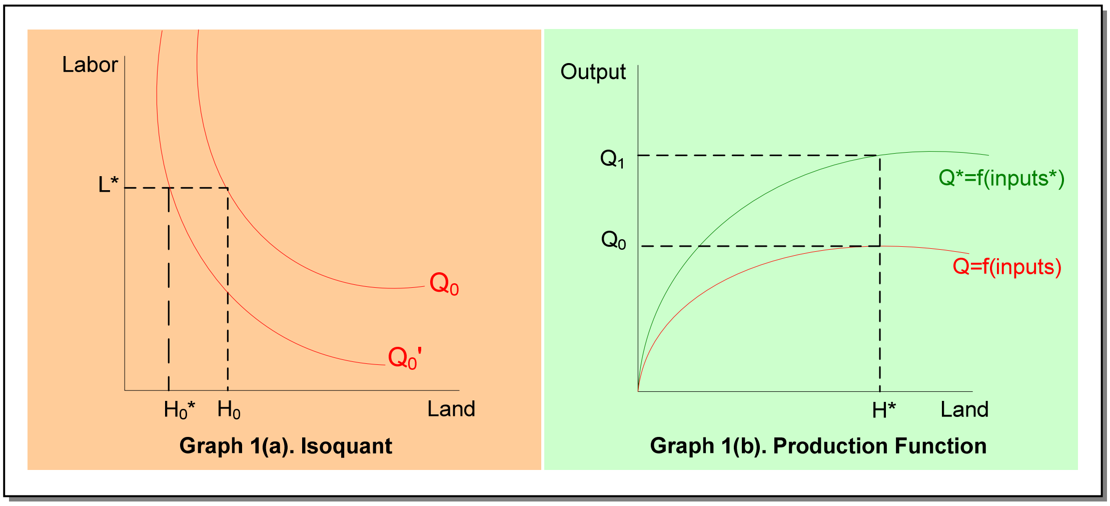
[11] This subchapter is drawn heavily from Ellis (1993) Chapter 11.

[12] Unfortunately, as we only can see the graph in two dimensions, capital can not be drawn, but it is assumed fixed.

Figure 2.2 Technological Change



Considering that most of the Malawian is subsistence farmer Smale (1995) mentioned that adoption hybrid maize will reduce the proportion of land allocated for maize production and can be transformed to grow other more nutritional food crops or cash crop which is more or less explained in Graph 1(a). In addition, Angelsen (1999) when modeling the deforestation under subsistence situation mentioned that increase productivity will lead to reduce deforestation as the need of land size for fulfilling subsistence requirement is reduced. Nevertheless, farmers haven't reached the subsistence yet as we observed that farmer experience hungry season in Malawi.

Based on these considerations, we think that what mentioned by Smale (1995) and Angelsen (1999) that farmer will reduce the land allocated for maize as productivity increase has not appeared for subsistence farmersa in Malawi. Instead, we expect to observe that farmer will maintain their size and proportion of land allocated for maize even when they adopt land saving technology, as presented in Graph 1(b). Based on the considerations above, we argue that adoption hybrid maize will not reduce land allocated for maize production. Relating with this hypothesis, we argue that farmer who adopt hybrid maize will discard the land that previously allocated for other maize varieties. We will try to test the change both in term of the size and the proportion of the land allocated for maize.

As we expect that farmer will not change the size and proportion of land that allocated for maize, adoption of hybrid maize is expected to increase the output per hectare of the farm. As can be seen from the Graph 1 (b), adoption of hybrid maize will increase the output from Q_0 to Q_1. We try to calculate this gap as a gain in yield as farmers adopt the package by controlling for some bias that might arises when we do the causal effect of the adoption.

2.2.2 Change in Households' Food Security

Food security has become the one of the central issues in development issues since decades. It is a multifaceted concept with hundreds of definition (FAO 2003). The definitions of food security become more complex from time to time. For example, compare the definition in Siamwalla & Valdés (1980) that stated:

> *"Food security may be defined as the ability of food-deficit countries, or regions or households within these countries, to meet target levels of consumption on a yearly basis,"* (Siamwalla & Valdés 1980 p.258).

With the one that is the official definition as stated in The State of Food Insecurity 2001:

> *"Food security [is] a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life"* (FAO 2003 p.47)

When the condition above is not satisfied, country, region or household can be stated in the food insecurity. Since 1970s, food insecurity started to be a big problem in Africa and transformed more people this continent become more undernourished (Dyerlee & Eicher 1997). In such situation, the role of agriculture to increase the food production becomes very important, not only to increase the food security but to minimize the conflict that may emerge as the result of hunger as stated in Dyerlee & Eicher (1997):

> *"Increased food production has a vital role to play in enhancing food security, peace and democracy in Africa in the twenty first-century."(Dyerlee & Eicher 1997 p. 3).*

In Malawi *per se*, food insecurity has long been a problem. In 1960-1970s, Malawi actually had food security at the national level. Nevertheless, there were many hungry people at household level (Harrigan 2008). Using the terminology of Devereux, the food insecurity in household level is "*the inability to acquire - through production, purchase plus transfers - sufficient food for a healthy, active life*" (Devereux 1997 p. 27). The situation in the late 1990s become worse, Malawi lost her national food security from own production and need to import food even in the favorable rainy season (World Bank 2003).

Ellis, Kutengule & Nyasulu (2003) study in rural Dedza district showed that in 2001, less than 5% of the household able to fulfill their maize requirement from their own garden while 72% of the household only have maize enough for three months period. The result from 2001, 2002 and 2003 TIP evaluation surveys as reported in Harrigan (2008) showed that in those three years period, only 3-6% of the household who would be able to produce their own maize, while there were 10-22% of the farmers who experience deficit more than 9 months.

Harrigan (2008) provide analytical framework of alternatives policy options that can be done by government to increase food security within country, either by self sufficient or by import. In addition, she provided the advantages and disadvantages of each policy option. She reported that import and food aid is actually costly for Malawi as this country has no access to the sea, and actually provides the subsidy for growing maize domestically is the cheapest way to build the food stock available for the country.[13] Additionally, she stressed the importance of achieving not only food security at the national level but also at individual household level.

As mentioned in Harrigan (2008), subsidized fertilizer is the best way to boost the production of maize in household level and to make sure that the poor has food available in their home. Nevertheless, as mentioned in Ellis, Kutengule & Nyasulu (2003), as farmer has less than 0.5 ha of land, growing hybrid maize is not a good enough as it still can not fulfill the maize requirement in the household especially if the household has many members.

[13] She mentioned Levy (1995) who provides the calculation of comparing cost of each policy option.

In this study, we want to assess how the fertilizer subsidy program in 2006 increase the ability of farmer to adopt hybrid maize and fertilizer and then is transformed to the ability of the adopters to increase food available per capita within household. We want to assess whether hybrid maize adoption together with fertilizer application will actually able to increase the food availability[14] within adopter household while take into account their land size holding and members of the household.

For the food security indicators here, we use the simplest one which is how many kg of maize per person farmers should have in home so that they can meet the requirement of maize per person. However, we do realize that measurement of food security is much complicated that need to assess whether the maize is really consume by the farmers and contribute to the nutrient intake such as the one did by Kumar (1994).

BOX 2. HYPOTHESES –Impacts of Adoption

Several impacts of the adoption of hybrid maize will be assessed and several hypotheses have been formulated in relation to each impact.

1. *The impact of adoption hybrid maize on land allocated for maize.*
   As farmer still need more maize to be produced, we argue that adoption hybrid maize will not change the proportion of land allocated for maize.
2. *The impact of adoption of hybrid maize on maize yield per hectare.*
   Adoption of hybrid maize will provide significant increase in maize yield per hectare.
3. *The impact of adoption of hybrid maize on food security in term of food availability.*
   Adoption of hybrid maize will increase food security within household significantly.

[14] By taking the maize availability in the household level, we talk about the first component and second component of food security which are food availability and food access. In addition, as farmers themselves who harvesting the maize, the maize would be available in their in their home and they would have access to this maize. Nevertheless, we do recognize that sometimes this is not the case as farmer need immediate cash so then they end up to run out the harvest soon and then still experience lack of food.

CHAPTER 3

DATA AND METHODOLOGY

3.1 DATA

Figure 3 Map of Malawi

Source: Benson et al (2002) with author's modification

This study is based on primary data that have been collected from rural households in 6 districts in Malawi comprise 4 districts that are located in the Southern region, the poorest region in Malawi, and 2 districts that are located in Central Region. The survey was performed in 2006 and 2007 to develop longitudinal data set. The first data set which had been collected in June-July 2006, consist of 450 respondents while the second one which had been collected in June-July 2007 comprise 433 respondents.

There were some attrition and replacement within the two periods of survey and there were some missing data on plot level in both periods that significantly reduce the number of observations. Eventually, we have longitudinal data sets of two years that comprise 351 households. [15]

The fact that this study aims to calculate the impact of the adoption of hybrid maize makes it necessary to limit the observations only to households who did not grow hybrid maize in the first year.[16] In addition, some missing data at the household level data and some measurement error make only 154 households that will be included in the analysis. The composition of observations based on districts is as follow; 13, 48, 19, and 25 households from Thyolo, Zomba, Chiradzulu, and Machinga District respectively, which are located in Southern Region of the country, while 27 and 22 households live in Kasungu and Lilongwe District, located in Central Region.[17]

In addition to the quantitative data that had been collected using questioners, we had collected qualitative data through some Focus Group Discussions (FGD) with some respondents from 11 villages.[18] In each of FGD, we have 20-40 respondents, both men and women, young and old. We have at least one village as the representative of each district. Nevertheless, we do realize that these 11 villages will not show the overall situation in each district. However, this FGD will give some insight for what's going on in the village.

[15] As we did the survey around June-July in these two years, the farmers just harvested their plots and have not planted yet. Hence, we collected cropping activities data from the previous year in addition to harvesting and household level data for particular year. In 2006, we asked what did farmers grow in 2005, how much their harvested in 2006, and what are the characteristics of the household in the 2006. While, in 2007, we asked what farmers grew in 2006, how much their harvest in 2007 and what are the characteristics of the household in the 2007.

[16] This refers to households that reported in 2006 survey that they did not grow hybrid maize on 2005/2006 cropping season. Including households that grew hybrid maize in 2005/2006 in the evaluation tend to underestimate the impact of hybrid maize and does not fit with the impact evaluation condition that say no treatment gain before the treatment. Hence, we only consider the "new" hybrid maize adopters as the treatment group which were household who reported in 2007 survey that they grew hybrid maize in 2006/2007 while reported in 2006 survey that they did not grow hybrid maize on 2005/2006 cropping season.

[17] The numbers of the observations in each district do not reflect the population in each district. The districts that were surveyed were based on selective purpose. Nevertheless, at the end, we found out that the district is not a powerful explanatory variable as we only have few samples within each district.

[18] Because of limitation of the space, the questioners are not included in this thesis. One who interested in the questioners can contact the author through email kartika_sj@yahoo.com.

Table 3.1 below present the basic indicators about maize and hybrid maize grower and land allocated for the maize production. Data that we have collected show that more than 90% of rural household in Malawi grow maize. This number is still consistent even when we reduce the sample size, except for sub-dataset of 2006 that showed only 75% of the farmers grew maize in 2005. This most probably came out as we drop out the hybrid growers in 2005 and it changed the distribution of maize growers in the sample. This figure shows farmers try to self sufficient in maize production and may reflect that farmers afraid to rely on the market (Alwang & Siegel 1999; Orr & Orr 2002).

Table 3.1 Land Allocation and Maize Growers Indicators

INDICATORS	2005/2006	2006/2007
Maize growers, % (from whole sample, n_{2006}=450, n_{2007}=433)	96.75	96.77
Maize growers, % (from longitudinal sample, n=351)	94.3	94.87
Maize growers, % (from data that is analyzed, n=154)	74.67	92.83
Hybrid maize growers, % (n_{2006}=450, n_{2007}=433)	49.56	46.08
Hybrid maize growers, % (n=351)	45.01	46.72
Hybrid maize growers, % (n=351, 2006=100%)	100	56.7
Hybrid maize growers, % (n=154)	0	33.12
Average share of land allocated to maize, % (n=351)	71.6	65.31
Average share of land allocated to hybrid maize, % (n=351)	29.82	24.62
Average share of land allocated to maize, % (n=154)	72	65.18
Average share of land allocated to hybrid maize, % (n=154)	0	16.61

From two periods of surveys, we found that 45-50% of the farmers grow hybrid maize, this number capture whether the farmer grow only hybrid maize, or any combination with other type of maize. Nevertheless, we found that hybrid maize adoption is not continuous; meaning that farmer can adopt hybrid maize this year and discard it next year. We found that of the farmers who grew hybrid maize in the 2005/2006 cropping season, only 56.7% grew it in the second period.[19]

[19] In such situation, our two years subsequent survey have one advantage for being able to isolate the outcome of hybrid maize adoption within one year period. If, for example, we have the survey that repeated after 5 years, our research question become irrelevant as farmer will adopt and discard within the 5 years period.

As one of the main objectives of this study is to assess the direct impact of adoption of hybrid maize and fertilizer on the several outcomes, we will put more emphasize on households who grew hybrid maize and apply fertilizer on it, the "*adopters*", which comprise 42 households or 27% of 154 households.[20] We want to compare their outcome with the adoption and the counterfactual situation in case they have not adopted hybrid maize.[21] Using the evaluation terminology, this adopters can be called as the "*treatment group*", while the "control" group or non-adopters consist of 112 households who did adopt the package.

Both in longitudinal sample of 351 household and sample analyzed in this study of 154 households, we found 72% of the land holding by rural household is dedicated for maize production in 2005/2006 cropping season and slightly reduce to 65% in 2006/2007 cropping season. Our survey also confirms that the proportion of land allocated for maize is around 70% (Smale 1995; Zeller, Diagne & Mataya 1998). From this proportion of land, around a third is allocated for hybrid maize.

3.2 DESCRIPTIVE STATISTICS

3.2.1 Characteristics of Adopters

This subchapter presents the descriptive statistics that show the characteristics of the household within the sample. The data being presented below is obtained from the 2006 survey. We present the descriptive statistics based on categories of asset as mentioned in chapter 2 and we compare the condition of adopter and non-adopter.

Table 3.2 Natural Capital Endowments within Households

	non adopter		adopter		total	
	mean	st.dev	mean	st.dev	mean	st.dev
Total land holding (hectare)	1.05	1.05	0.96	0.57	1.03	0.94
Good soil fertility condition*	0.1	0.31	0.09	0.29	0.1	0.3
Average soil fertility condition*	0.45	0.5	0.52	0.5	0.47	0.5

* dummy variables

[20] There are 9 households who adopt hybrid maize but did not apply fertilizer. We categorize them as non adopter as in our study we want to see the impact of household who adopt the package. In addition, include this 9 household to the adopters group will undermine the impact of adoption the package.
[21] Sub-section 3.3 will present how to obtain the counterfactual situation.

As can be seen in table 3.2 above, the average land size holding of our sample is slightly higher than 1 ha. This amount of land is confirm the condition that farmer in Malawi has very small land holding. Breaking down the sample to the adopter and non-adopter group, we found that the non-adopters group has slightly bigger land than the adopter group. The former tend to has 1.05 ha in average while the latter has 0.96 ha. This seems to support the idea that land constraint farmer tend to adopt hybrid maize, nevertheless *t-test* show that the difference is not significant.

Our surveys also reflect the soil quality in Malawi that has been reported become worse and worse and become one of the causes of low yield of maize production (Orr & Mwale 2001). We found that almost half of our respondents report that they have bad soil quality, while only 10 % report that they have good soil quality. The soil quality condition is more or less the same for the adopter and non adopter. This condition contributes to the importance of fertilizer to boost the agricultural production in Malawi, as the soil itself does not contain enough nutrients.

In term of human capital as presented in table 3.3 below, each household has in average less than 3 labors.[22] In average, adopter farmer has higher average number of labor within household with 2.7 labors compare to 2.3 labors within non-adopter farmers. In term of household member, we found that in average, households have 5.3 members which were higher than the figure reported in Malawi Integrated Household Survey 2 with the national average member per household was 4.5 persons. Comparing the adopter and non adopter, the former has 5.57 persons in the family in average while the latter have 5.20 persons. As we can see, the two variables: labor and household size is relatively high correlated[23] and we found that adopter household has slightly higher number of labor and household size tend to support the hypothesis that more member in the household will drive farmers to grow hybrid maize and apply fertilizer on it.

[22]The definition of labor here is member of the household who are older than 15 years old and younger than 65 years old. This definition tend to understate the actual number of labor as in practice in Malawi, we can find very young children working in the plot.

[23] The correlation between the two variables is 0.6.

Table 3.3 Human Capital Endowments within Households

	non adopter		adopter		total	
	mean	st.dev	mean	st.dev	mean	st.dev
Number of labor (persons)	2.32	1.16	2.73	1.49	2.43	1.27
Household size (persons)	5.20	2.45	5.57	1.88	5.30	2.31
Head of household has primary school*	0.58	0.27	0.59	0.49	0.58	0.49
Head of household has secondary school*	0.08	0.27	0.14	0.35	0.09	0.29

* dummy variables

For the education characteristics,[24] 58% of head of household had primary education and this figure is more or less the same for both groups. Slightly less than 10% of head of respondent has higher education than primary school which is captured in the secondary education group. Nevertheless, there are significant difference between the adopter and non adopter in term of secondary education: 14% compare to 8%. Overall, there are 32% of head of respondents with no education. This number is similar to the one in Malawi IHS 2004-2005 Report that reported 28% of head of household has no education, 54% has primary education, and 18% has secondary and higher education. Nevertheless, we found that percentage of head of household who has secondary education is much less in our sample than in IHS.

Table 3.4 Physical Capital Endowments within Households

	non adopter		adopter		total	
	mean	st.dev	mean	st.dev	mean	st.dev
Households have *panga**	0.5	0.50	0.64	0.48	0.53	0.50
Households have axe*	0.49	0.50	0.45	0.50	0.48	050
Households have bicycle*	0.41	0.49	0.47	0.50	0.42	0.49
Households have oxcart*	0.03	0.18	0	0	0.02	0.16
Households have radio*	0.51	0.50	0.52	0.50	0.51	0.50
Total physical asset (MK)	3050	4700	4125	5500	3350	4950

* dummy variables

[24] Based on education variable, we divided households into three categories. First, households with no education, if the head of household has no school experience at all. Second, household with primary education if head the household has 1-8 years experience at school. Third, household with secondary education if head the household has more than 8 years experience at school.

We try to list the farm equipments own by households in table 3.4 above. We found that half of the households do not own basic farm equipments such as *panga* and *axe*. This most probably contribute to the low productivity as well. We found that around 40% of the household own bicycle and only two percent who have oxcart. None of the oxcart is come from the adopter. We found also that half of the household has radio.

In average, household has MK 3350 of physical asset that include furniture, bicycle, radio, agriculture equipment and others. We found that adopter household in average has a third more physical asset than the non-adopter. In addition, we found also there are some non-adopters who have barely asset.

Table 3.5 Financial and Social Capital Endowments within Households

	non adopter		adopter		total	
	mean	st.dev	mean	st.dev	mean	st.dev
Livestock asset (MK)	23225	92050	7560	10550	18950	78900
Household received credit*	0.13	0.34	0.40	0.49	0.21	0.40
Household is member of farmer organization*	0.08	0.27	0.33	0.47	0.15	0.36

* dummy variables

In term of livestock asset, we find that in average the monetary value of livestock holding by the rural households is 18950 MK. This livestock asset comprises the monetary value of cattle, chicken, goat, pig, rabbit, duck, and turkey own by the household. Apparently, there is anomaly in the livestock asset holding among the adopter and non adopter compare to the one in our expectation based on Dercon (1996) that farmer who has higher asset will tend to adopt more risky activities.[25]

In term of access to credit, around 21% of the household receive credit from NGOs or donor institution. Nevertheless, breaking the number to the adopter vs. non-adopter group, we find that the former has more access to credit as 40% of the household in this group received credit compare to 13% of the household of the non-adopter group who received credit. This fact supports our hypothesis that credit will give the opportunity for the farmer to adopt hybrid maize.

[25] We found that this anomaly due to the fact that there are some households that have extremely high livestock asset, nevertheless they involved in business and tobacco production, this may be the explanation of the anomaly situation.

Table 3.6 Institutional and Vulnerability Context of the Households

	non adopter		adopter		total	
	mean	st.dev	mean	st.dev	mean	st.dev
Female headed household*	0.35	0.48	0.14	0.35	0.30	0.45
Age of head of household (years)	47	15	43	15	45	15
Household has at least one member was ill*	0.04	0.21	0.04	0.21	0.04	0.21

* dummy variables

Our data shows that 30% of the households have female as the head of household. This number is slightly higher than the one reported in Malawi IHS 2004-2005 report that stated 23% of the household has female as the head. Between adopter and non adopter group there are huge difference of percentage of household that has female headed household, with 14% and 35% of female head household constitute the former and the latter respectively. We found the tendency that female headed household tend not to grow hybrid maize.

Average head of households' age is 45 years old. This average is much older than the one reported in Malawi IHS 2004-2005 Report that stated there were 30% of the household head belongs to 25-34 age group and 27% belongs 35-49 age group. While, comparing the age of head of household, we found that the adopter group tend to be younger than the non adopter. This fact seems to support the hypothesis that the younger are more open to changes.

Only 4.5 percent of the households have reported that one of members of the household was sick in 2006 while this number is same for the adopter and non adopter.

Table 3.7 Households' Other Livelihoods Strategies

	non adopter		adopter		total	
	mean	st.dev	mean	st.dev	mean	st.dev
Household has other income source*	0.85	0.36	0.73	0.44	0.81	0.38
Household has at least one business*	0.27	0.45	0.21	0.42	0.26	0.44
Household has at least one member doing ganyu*	0.27	0.45	0.36	0.48	0.30	0.45
Household grow tobacco*	0.11	0.32	0.21	0.41	0.14	0.35

* dummy variables

From our sample, 82% of the households have non-agriculture income. This non-agriculture income comprise households whose at least one of the member has any other source of income such as: from *formal employment*, *ganyu*, *business* and *remittances* from relative who work in the urban area or abroad. We found that the percentage of household who has other income is less than the percentage if they become adopter. The reasonable explanation of this is that for farmer who has other source of income, the urgency to self sufficient in maize becomes lesser as they will have cash to buy in the market. Hence, it reduces the propensity to adopt hybrid maize and fertilizer to increase the maize production. The same condition similarly emerges in the percentage of household with business.

Ganyu, casual labor, shows different picture from the one that we have in mind as we think that the adopter will need more labor so instead doing *ganyu*, they would prefer to work at their own farm. In fact, we found that percentage of households with *ganyu* is much higher in the adopter household.

As mentioned in chapter 1, tobacco is important crop for generating export revenue and some incentives has been given also for tobacco growers. Hence, we take into account this particular cash crop as one of important source of other agriculture income. We found that in our sample, 14% households grow tobacco, and 22% grow both tobacco and hybrid maize.

3.2.2 The Cost of Adoption

In this subchapter, we present some particular characteristics of the adopters,[26] especially the descriptive statistics of fertilizer and seed adoption and cost that occurs because of adoption the package.

In average, the adopters apply 7.52 kg of hybrid seed with the cost MK 482 on in average, 0.5 ha of land allocated for hybrid maize. 57% of farmers buy the seed that they have planted, 33% farmers received the seed from relative or the landlord for whom they do *ganyu*[27] 5% of them use their own seed,[28] and 5% use coupons[29] to buy the seed.

[26] Adopters refer to 42 households who grew hybrid maize and apply fertilizer on it.
[27] Nevertheless, the case that *ganyu* labor will receive seed from landlord is not so common.
[28] Most probably, this two household who reported that they use their own seed did the recycle of hybrid seed.

Table 3.8 Sources of Inputs of the Adopters

The Source	Seed freq.	Seed %	Fertilizer freq.	Fertilizer %
Own	2	4.76	0	0
Bought	24	57.14	9	23.68
Received	14	33.33	2	5.26
Coupons	2	4.76	27	71.05
Total	42	100	38	100

In addition, adopters apply almost 57 kg of fertilizer on hybrid maize plots and the cost for this fertilizer is MK 1339. Most of the household get access to the coupons to obtain fertilizer, 24% of the household bought the fertilizer at market price and 5% received from relatives. This fact show that the importance of fertilizer subsidy on the adoption of the package.

We found that from the whole sample of 154 households, 72% of respondents apply fertilizer and 31% of them apply fertilizer subsidy. From the household who get access to the fertilizer subsidy, 88% of them apply this fertilizer on hybrid maize. This show that farmer who has better access to fertilizer subsidy will end up adopt hybrid maize as the one that we predict.

Nevertheless, we recognize that there are problem about who get the coupons. From FGDs, we perceive that there are some problem of distributions of coupons and some "*black market*" of the coupons resulting that the non-targeted households, which is the one that relatively richer, have access to the coupons. However, at this stage, it is beyond the scope of this study to discuss the miss-targeting of the coupons.

The intention of this study is to see how is the impact of application of fertilizer, whether it is obtained by subsidized or not on hybrid maize. The subchapter 3.3 will present the methodology how we can assess the impact of adoption of hybrid maize and fertilizer subsidy.

[29] As universal subsidized of fertilizer has been demolished, Government of Malawi provides support through extended targeted input program where each targeted household will get coupons that give them access to buy 50 kg of fertilizer at price of MK 950 instead of MK 3000-4000 at the market price.

3.2.3 The Food Availability

In this subsection, we present condition of the maize harvest per capita. If, household do not sell the production of maize to the market, then we can say that this maize harvest per capita as food available for each member of the household. We found that in average, in 2006 harvest, farmers have 153 kg of maize available for consumption for each member of the household, while in the harvest 2007, we there is increase almost 17% of the food availability to 179 kg. Compare with the requirements of maize per year as many as 180 kg per capita, we found that within the two year, in average, farmers experienced hungry season for 1.3-2 months in 2006, while in average, farmers achieve self sufficiency in 2007.

Table 3.9 Food Situation within Households

	non adopter		adopter		total	
Food Situation	mean	st.dev	mean	st.dev	mean	st.dev
Food Availability per Capita 2006 (kg)	159	310	141	168	154	278
Food Availability per Capita 2007 (kg)	149	181	258	291	180	221

Look specifically on at the non-package adopter, in 2006 harvest, each member has 159 kg while in harvest 2007, the figure is slightly smaller with 149 kg. Nevertheless, *t-test* result show that there is no significant different between the two figures.

3.3 METHODOLOGY

To answer the research questions of this study, impact evaluation or counterfactual analysis will be applied. In study of development, impact evaluation mostly used to asses the impact of the programs by the government and the projects applied by donor community by comparing the outcome of the intervention between the treatment group and non-treatment group (Ravallion 2005). Even though in this study, no project is applied and it is farmer himself who decided to be the adopter or non-adopter of hybrid maize and fertilizer, it is still possible to apply impact evaluation of adopting hybrid maize and fertilizer. This subchapter present how impact evaluation is performed and how our case can fit as impact evaluation case.

3.3.1 The Formulation of Impact Evaluation Problem[30]

As mentioned above, the aim of impact evaluation is to assess the gain that received by treatment group for being treated. To calculate the impact, outcome indicators are needed. Applying to our case, the *treatment* is *adopting hybrid maize and fertilizer*, and the *outcome indicators* are the *size and proportion of land allocated for maize, the maize yield per hectare of maize land, the maize production within household and the food availability per capita*. Because we have both the "as if" treatment and the outcomes, we can apply the impact evaluation.

As hybrid maize has been adopted for some decades, the impact can not be properly calculated if we consider all adopters as we do not know their hybrid maize growing history. Consequently, we will only calculate the impact for "new" adopters. [31]

The outcome indicator can be written as *Yi* for household *i* in the sample size *n*. Household who take up the package will have dummy variable $D_i = 1$, while household who do not take up the package will have $D_i = 0$. The outcome if farmers grow hybrid maize is Y_i^T and if not, Y_i^C. Superscript T and C show "treated" and "counterfactual" respectively. Then, household's gain from growing hybrid maize is $G_i = Y_i^T - Y_i^C$.

Overall, we are interested in the impact of adoption of hybrid maize on the outcome indicator of the adopters or in econometrics term: the average treatment effect on treated (ATT).[32]

$$ATT = E(Y_i^T - Y_i^C \mid D_i = 1) = E(Y_i^T \mid D_i = 1) - E(Y_i^C \mid D_i = 1) \tag{1}$$

[30] This subchapter is synthesis from Ravallion (2005), Aassve et al. (2007), and Caliendo & Kopeinig (2008).

[31] As we will discover later, the adoption of hybrid maize is not continuous, so as we have two periods of longitudinal data, we will only consider farmers who in the first period didn't grow hybrid maize in the sample and then assess the impact of the adoption of hybrid maize of farmers who adopt hybrid maize in the second period.

[32] In their paper, Ravallion (2005) and Aassve et.al (2007) used ATET as abbreviation. Nevertheless, many literatures use ATT as abbreviation and the statistical software that we will use report "ATT", hence, ATT will be used here.

Problem arise as we can not observe the outcome indicator of the adopters if they didn't adopt, $E(Y_i^C \mid D_i = 1)$. We can easily take $E(Y_i^C \mid D_i = 0)$ the outcome indicator of non adopter as the counterfactual if there is no systematic different between the adopters and non adopters. Nevertheless, it is seems unreasonable as based on our literature review, we expect that household with more asset accumulations will end up as adopter, so taking $E(Y_i^C \mid D_i = 0)$ as counterfactual situation will lead to bias estimators.

To overcome the problem, conditional independence assumption (CIA) is imposed. The CIA tells us that conditional on X, which consists of farmers' characteristics, the counterfactual situation do not depend on adoption decision, in the econometrics term:

$$Y^C \perp D \mid X \qquad (2)$$

In the form of expectation, this CIA can be seen as $E(Y_i^C \mid X_i, D_i = 0) = E(Y_i^C \mid X_i, D_i = 1)$. Applying to our case, this assumption shows that from farmers who have the same characteristics, such as same educational background, we will find the counterfactual outcome is similar for both groups. Nevertheless, if X consists of many characteristics such as asset, education etc., there are many matches should be done and this create dimensional problem.

To overcome the problem, Rosenbaum and Rubin (1983) proposed matching based on propensity score $P(D = 1 \mid X) = P(X)$.[33] In our case, propensity score will show how much the probability of farmer will adopt hybrid maize based on their household characteristics.

By applying propensity score matching (PSM), the sources of bias from the different observable characteristics are eliminated. Elaborate the propensity score matching to our average treatment effect, now, the formula of ATT becomes:

$$ATT = E(Y_i^T - Y_i^C \mid D_i = 1, P(X)) = E(Y_i^T \mid D_i = 1, P(X)) - E(\hat{Y}_i^C \mid D_i = 0, P(X)) \qquad (3)$$

The subsection below will present the practical thing to perform PSM.

[33]This is based on the consideration that if the expected outcome is independent from treatment conditional on the characteristics, then the outcome will independent from treatment as well conditioning on a balancing score $b(X)$. Propensity score is one of example of balancing score.

3.3.2 Performing Propensity Score Matching (PSM)[34]

As we have binary response: treatment and non-treatment, we can perform any binary response model such as logit or probit model to calculate the propensity score. In our case, we will apply the logit model and take the log of odds ratio for the matching purpose instead of the propensity score. The reason for doing this is that we do choice-based sampling when we limit the sample to only the farmers who do not grow hybrid in the first year to make the condition as if the treatment (adoption decision) only will come in the second year. The matching based on the log odds ratio will overcome the problem of non-random sampling (Todd 1999).

Despite the fact that our main purpose of applying logit model is to find the matching for the adopters by balancing the covariates, we will discuss the result of logit model to predict the probability of the farmers to take up the package as well. This is possible as when choosing the variables that should be included in the logit model for matching purpose; we performed it with the economic theory as the foundation as explained in previous chapter. This is important to make sure that the variables that are included in the estimation are only variables that have effect both on the treatment and the outcome.

In addition, variables that are being included should not be influenced by the treatment or the anticipation to join the treatment. Our model includes explanatory variables that were collected from the 2006 survey, while the adoption decision is taken from the 2007 survey. Hence, our explanatory variables will pass this requirement. The table 3.1 below presents the list of explanatory variables that will be included in calculation of log odds ratio mainly for matching purpose and secondarily for finding the variables that significantly influence the farmer decision to adopt hybrid maize and fertilizer.

[34] Most of this section is drawn from Caliendo and Kopeinig (2008) that provide practical guidance for the implementation of PSM. One who wants to understand the econometrics theory lying behind the method can consult Wooldridge (2000), Dehejia & Wahba (2002) and many more.

Table 3.10 List of Variables and the Expected Signs

Variables		*Explanation and Type of Variable*	*Expected Sign*
Dependent: Adopter vs. non-adopter of hybrid maize and fertilizer (Obtained from 2007 survey)			
dmaize1	Dummy	1=Adopter Household 0=Non Adopter	
Independent Variable (Obtained from 2006 survey)			
NATURAL CAPITAL			
landtotha	Continuous	land holding per household (hectare)	+/-
soil fertility quality:	Dummy	Reference: infertile soil	
soilfergood		1=average 0=otherwise	+
soilferaverage		1=good 0=otherwise	+
HUMAN CAPITAL			
labor	Continuous	labor per household (person)	+
age	Dummy	1=age>40&<60 years old 0=otherwise	-
		1=age>60 years old 0=otherwise	-
education:	Dummy	Reference: no education	
primary		1= primary 0=otherwise	+
secondary		1= secondary 0=otherwise	+
PHYSICAL CAPITAL			
bicycle	Dummy	1=own bicycle 0=otherwise	+
radio	Dummy	1=own radio 0=otherwise	+
FINANCIAL CAPITAL			
totasset06	Continuous	monetary value of non-liquid asset (MK)	+
livestockasset	Continuous	monetary value of livestock asset (MK)	+
get_credit	Dummy	1=household get credit 0=otherwise	+
SOCIAL CAPITAL			
fo	Dummy	1=household join farmer organization 0=otherwise	+
INSTITUTIONAL AND VULNERABILITY CONTEX			
head_sex	Dummy	1=female headed household 0= otherwise	-
ill	Dummy	1=has one or more family sick 0=otherwise	-
OTHER LIVELIHOODS STRATEGIES			
dother_inc	Dummy	1=have other source of income 0=otherwise	+/-
business	Dummy	1=have small business 0=otherwise	+/-
ganyu	Dummy	1=do ganyu 0=otherwise	-
tobbaco	Dummy	1=growing tobacco 0=otherwise	+/-
LOCATION			
districts	Dummy	Reference: Lilongwe	+/-
		1= Thyolo 0=otherwise	
		1= Zomba 0=otherwise	
		1= Chiradzulu 0=otherwise	
		1= Machinga 0=otherwise	
		1= Kasungu 0=otherwise	

3.3.2.1 The Logit Model to Predict the Probability of Adoption

As discussed previously, farmers will exploit hybrid maize and fertilizer if the expected utility resulting from the output of hybrid maize is higher than expected utility resulting from the output of non-hybrid maize. Furthermore, the expected utility either from growing hybrid maize $E(U_H)$ will depends on the characteristics of the farmers (X), $E(U_H)=f(X)$. X is vector of characteristics of farmer consist of their pentagon of asset, their institutional context, and the trend of the area where they are living as has been presented in the table 2 above. In the econometric model, we can estimates the expected utility of hybrid maize:

$$(E(U_H))^* = x\beta + \varepsilon \qquad (4)$$

where β shows vector of parameters to be estimated, having a dimension of $Kx1$, while the dimension of X is $1xK$, ε is a continuously distributed variable which independent of X and have symmetric distribution about zero.

Nevertheless, expected level of utility of each farmer is a latent variable that can not be measured. The thing that can be observed is that farmer will grow hybrid maize (adopt=1) if his expected utility from hybrid maize $E(U_H)$ is higher than expected utility from non-hybrid maize $E(U_{NH})$, otherwise, farmer will not grow hybrid maize (adopt=0).

$$Adopt = 1_{((E(U_H)^* > E(U_{NH}))} = \begin{cases} 1 \ \ if \ \ (E(U_H)^*) > E(U_{NH}) \\ 0 \ \ otherwise \end{cases}$$

Then, we can formulate the logit model which is:

$$\Pr(Adopt = 1 \mid X) = \frac{e^{x\beta}}{1+e^{x\beta}}, \qquad (5)$$

Transform (5) to the log odd ratio:

$$L_i = \ln\left(\frac{p}{1-p}\right) = x\beta + e \qquad (6)$$

We will perform this model using the statistical software which is STATA. After obtaining the parameters of variables that are included into the model, we should be able to verify the signs, whether it satisfy the hypothesis we made earlier. Hence, the model should have the best predicting power for the probability to take up the package.

3.3.2.2 The Logit Model to Find the Matching

As mentioned previously, the main objective to perform the logit model is to obtain the value of the log odd ratio in order to perform the matching process which is the process of finding the farmers who are non-adopters of hybrid maize but have similar log odd ratio with the farmers belongs to the adopters group to provide counterfactual situation for the adopter in case they do not adopt. This step should be performed because taking the non adopters as counterfactual will lead to bias as there are possibilities of observable bias, resulting from different observable characteristics of farmers that determine the decision of adoption. By performing the matching process, the bias that comes from the observable characteristics will be reduced.

In the process of finding match for the adopters, there are several matching algorithms that can be chosen. There is no consensus which algorithm is better, as each algorithm will have advantages and disadvantages. The matching algorithms are namely *nearest neighbor matching, caliper and radius matching, stratification and radius matching, stratification and interval matching, kernel and local linear matching.*

In this study, three of the algorithm will be applied and compared which are *nearest neighbor matching with replacement*, *kernel matching* and the *stratification matching*.[35] The reasoning behind choosing these three algorithms is that the two first mentioned the most common used in the literatures while the second one the simplest one and as when calculating the log of odd ratio we do stratification for checking the balancing properties,[36] then it is easy to perform the latter. For the nearest matching, replacement is necessary as we have small dataset, so it makes us able to find more matching compare to the condition of non-replacement when the control group that has been used one couldn't be used for matching another treatment group (Dehejia & Wahba 2002). Each algorithm has its own advantage and disadvantages. Nevertheless, they should produce more or less the same result, especially if the data is sufficiently large in term of observation (Becker & Ichino 2002).

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[35] Dehejia and Wahba (2002) provided brief introduction to propensity score matching method and several algorithms that can be applied. One can consult econometrics handbook for deeper explanation.

[36] Balancing properties require that there is no difference between the mean of each explanatory variable in each block of propensity score that can be analyzed using *ttest* (Dehejia and Wahba 2002).

After performing the matching process, the gain from adoption (G) for each adopter can be calculated by taking the difference of outcome of the adopters, in the case of adopting and prediction of the outcome when they were not. $G_i = Y_i^T - \hat{Y}_i^C$. The average impact of adoption can be seen as the equation (3) above.

In *nearest neighbor matching with replacement*, there are different ways to find the match for each treated unit. First, by taking the control unit that has the closest propensity score to the treated unit, and second, by matching the treated with average of *n* closest control group. Then ATT is estimated by taking the average of the effect from each treated unit that has the control unit.

In the *stratification matching*, the region of common support, which is the region capturing the overlap of propensity score between the treated and control unit, is divided into several blocks and then the difference average outcome between treated group and control group is calculated form each block and then to ATT is obtained from the overall average.

In the *kernel matching* which is a non-parametric matching estimators, it is the weighted average of all observations in the control group that will be use to construct the counterfactual outcome (Caliendo & Kopeinig 2008).

Nevertheless, this model still contains some bias as we only take out the bias coming from the observable heterogeneity (Mendola 2005).[37] In fact, in the reality, we have the bias coming from unobserved heterogeneity, for example farmer skill, farmer's effort on the field, etc. We can not observe this heterogeneity, but it is possible that farmers who have higher skill or farmers who are more diligent will end up being the adopter and eventually, these special characteristics will contribute to higher outcomes. If this bias is not corrected, we will obtain overestimate estimators of the impacts of adoption of the package of hybrid maize and fertilizer.

Hence, by assuming that farmer's skill and efforts are time invariant, we would be able to apply the difference-in-difference (DID) method to eliminate this bias.

[37] She mentioned some references: Heckman and Navarro (2004), Smith and Todd (2003), Heckman et al (1997), and Heckman et al (1998)

3.3.3 Difference-In-Difference Method[38]

The first requirement to apply difference-in-difference (DID) method is availability of longitudinal data. Many studies confirm that even though the researchers aware that there is time invariant unobserved heterogeneity, they do not able to correct the bias because of unavailability of the longitudinal data. This study attempts to overcome this shortcoming by utilizing the longitudinal data of two years that have been collected from 6 districts in Malawi.

The idea of the DID is to take into account the difference of the outcome before and after the adoption in order to eliminate the time-invariant source of bias. The outcome of each adopter in specific year can be seen as follow:

$$(Y_{it}^{T} \mid D_i = 1) = Y_{it}^{C} + G_{it} + \varepsilon_{it} \tag{7}$$

where i shows each adopter household and t shows the period, in this study as only two periods of data, then t=0,1. Y_{it}^{C} shows the counterfactual condition in case that the household did not adopt, and G_{it} show the gain from adoption and ε_{it} are zero mean error terms that not correlated with the adoption decision that also capture measurement error.

The counterfactual outcome from non-adopters group that has been matched is represented by $\hat{Y}_{i1}^{C}$. Taking the expectation over all participants, the average treatment effect (ATT) of differences-in-differences estimator for the outcome is:

$$E((Y_{i1}^{T} - \hat{Y}_{i1}^{C}) - (Y_{i0}^{T} - \hat{Y}_{i0}^{C}) \mid D_i = 1, P(X)) = E(G_{i1} - G_{i0} \mid D_i = 1, P(X)) \tag{8}$$

The error terms for both period is disappear as by assumption, the expected of error is zero.

In the first year, when no farmer in our sample grow hybrid maize, there is no gain of the treatment, so we have $G_{i0} = 0$. Then, the DID estimator shows the average treatment effect on treated.

[38] This subchapter is mostly drawn from section 4 Chen & Ravallion (2003) with some part is taken from Caliendo & Kopeinig (2008).

To make it easier to calculate, we rearrange the difference-in-difference estimator as in equation (8) become equation (9) below.

$$E((Y_{i1}^{T} - Y_{i0}^{T}) - (\hat{Y}_{i1}^{C} - \hat{Y}_{i0}^{C}) \mid D_i = 1, P(X)) = E(G_{i1} \mid D_i = 1, P(X)) \quad (9)$$

We will calculate the average treatment effect on treated for several outcomes: the size and the proportion of land allocated for maize, the yield per hectare of maize land, maize production in household and food availability per capita.

There are several statistical programs that can be used for estimating both the propensity score matching and the average treatment effect. In this study, we used STATA as the statistical software and apply the program provided by Becker & Ichino (2002) that directly tells us whether the propensity score is balancing or not. Several commands under the package from Becker & Ichino (2002) are *pscore, attnd, attnw, attr, atts* and *attk.* Commands that are being used in this study are *pscore* (for calculating the propensity score; log odd ratio in our case) and *attnd, attk* and *atts (for calculating ATT using nearest, kernel and stratification matching method respectively).*

In addition, we always imposed common support option, *comsup*, to make sure that the matching is coming from the region of common support and apply *bootstrap* when calculating bootsrapping standard error of ATT to take into account several sources of variance: the variance from the process of calculation of propensity score, variance because common support is imposed, variance coming from matching without replacement and the order when the treated find the matching and applied 100 replications. We use the default setting for other things.

CHAPTER 4
RESULT AND DISCUSSIONS

4.1 FACTORS AFFECTING ADOPTION DECISION

As mentioned in chapter 3, we use logit model to estimates parameters that related with the adoption of hybrid maize and fertilizer. The logit model can be formulated as:

$$\Pr(Adopt = 1 \mid X) = \frac{e^{x\beta}}{1 + e^{x\beta}};$$

where X is vector of farmers' characteristics[39] and β s show the parameters that we want to estimates. Taking the linear prediction out of the model will give us the log of odd ratio as mentioned in the equation (6) in chapter 3.

We tried several model specifications of the logit model, most of them were done in order to obtain the model that fulfill the balancing property. This is difficult in our case as we have only 154 observations. The implication of this limitation is that we should drop some explanatory variables that insignificant to maintain the degree of freedom high.

Three models that are presented in the table below are the representative the models that have been estimated. *Model 1* is the general model that consists of all explanatory variables, including the dummy of districts and sub-categories of the sources of other income. In *model 2*, we drop the dummy of districts and replace the sub-categories of sources of income become one dummy variable only. In *model 3*, we drop more insignificant variables such as soil fertility conditions and dummy of age.

Furthermore, we tried to choose the best model out of these three. There are some criteria in order to obtain the best model; first, as we need the model for matching purpose, then the model should fulfill the balancing property. By applying the command *pscore* in STATA, one will directly know whether the propensity score is balance or not. The tests of balancing property show that there is one variable in *model 2* that do not fulfill the balancing property requirement. Hence we only consider the two other models for the next test. The second criterion is that the model passes some other tests, such as *specification error*, *goodness of fit*, *multicollinearity*, and *influential variable*.

[39] The explanations of what characteristics of farmer are included in the model can be seen in the appendix, in addition to the data source of the variable and how variables are generated.

Table 4.1 The Output of Logit Models

	MODEL1	MODEL2	MODEL3
Dep Var: Adopt Hybrid&Fertilizer vs. not			
Total land own by HH (in hectare)	-0.370	-0.217	-0.365
	(0.381)	(0.340)	(0.310)
HH has maize plot with good soil fertility	0.974	1.150	
	(0.848)	(0.791)	
HH has maize plot with average soil fertility	0.827	0.722	
	(0.535)	(0.490)	
number of person 15-65 in HH	0.305	0.298	0.269
	(0.204)	(0.186)	(0.168)
head of HH has primary education	-0.242	-0.328	0.004
	(0.628)	(0.578)	(0.505)
head of HH has secondary education	0.384	0.533	0.734
	(0.842)	(0.796)	(0.747)
household has radio	-0.788	-0.662	-0.522
	(0.570)	(0.506)	(0.464)
livestock own by household (000 MK) 2006	-0.014	-0.012	
	(0.015)	(0.016)	
HH received credit	1.719**	1.703***	1.490**
	(0.555)	(0.513)	(0.477)
HH joined farmer organization	2.288***	1.867***	1.687**
	(0.628)	(0.559)	(0.528)
sex of head of HH	-0.914	-1.062	-1.345*
	(0.665)	(0.651)	(0.606)
age of head of HH >40&<60	-0.674	-0.710	
	(0.589)	(0.537)	
age of head of HH >60	-0.998	-1.195	
	(0.749)	(0.687)	
HH has ill member	0.456	0.235	0.396
	(1.116)	(1.076)	(1.086)
HH has business	0.064		
	(0.636)		
HH has member who do ganyu	0.538		
	(0.538)		
HH grew tobbaco	0.651		
	(0.703)		
HH live in thyolo	0.612		
	(0.949)		
HH live in zomba	0.057		
	(0.864)		
HH live in chiradzulu	-1.205		
	(1.050)		
HH live in machinga	-0.120		
	(0.885)		
HH live in kasungu	0.617		
	(0.813)		
HH has other source of income		-0.655	-0.623
		(0.549)	(0.526)
Constant	-1.854	-0.935	-1.036
	(1.080)	(0.936)	(0.797)
STATISTICS			
ll	-65.098	-67.842	-71.483
N	154	154	154
aic	176.195	167.683	164.966
bic	246.045	216.275	198.373

* p<0.05, ** p<0.01, *** p<0.001
Figure in parentheses show standard error

The models that are presented above have passed these specification tests. However, *model3* has better goodness of fit based on the comparison of BIC (Bayesian Information Criterion). Hence, based on *Model 3*, our logit estimators become:

$$L_i = \ln\left(\frac{p}{1-p}\right) = -1.036 - 0.365 totlandha + 0.269 labor + 0.004 primary$$
$$+ 0.734 secondary - 0.522 radio + 1.490 get\_credit + 1.687 fo$$
$$-1.345 head\_sex + 0.396 ill - 0.623 dother\_inc$$

From the models above, we found that received credit and join farmer organization will significantly increase the probability of hybrid maize and fertilizer adoption. The significance of these two variables is consistent across the models. Nevertheless, as it is difficult to interpret the coefficients of logit model, marginal effects after logit estimation have been computed and presented bellow[40]:

Table 4.2 The Output of Marginal Effects after Model3

Marginal effects after logit

y = Pr(dmaize1fert) (predict)
= .2168529

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.	]	X
landtotha	-.0620577	.04148	-1.50	0.135	-.143358	.019242	1.03206
labor	.0456629	.02934	1.56	0.120	-.011834	.103159	2.43506
primary*	.0007379	.09034	0.01	0.993	-.176334	.17781	.584416
second~y*	.1444365	.17117	0.84	0.399	-.191053	.479926	.097403
radio*	-.088886	.07457	-1.19	0.233	-.235047	.057275	.512987
get_cr~t*	.3051403	.11327	2.69	0.007	.083134	.527146	.207792
fo*	.3606698	.12924	2.79	0.005	.107374	.613966	.149351
head_sex*	-.1954189	.07622	-2.56	0.010	-.3448	-.046037	.298701
ill*	.0739404	.15325	0.48	0.629	-.226419	.3743	.045455
dother~c*	-.1172934	.10572	-1.11	0.267	-.324505	.089918	.818182

(*) dy/dx is for discrete change of dummy variable from 0 to 1

From our model, we found that the size of land holding (*landtotha*) is negatively correlated with the probability of adoption of hybrid maize and fertilizer. Despite the fact that the parameters is insignificant, this finding seems to support the proposition that subsistence farmers are who facing land constraint will tend to adopt hybrid maize so they would be able to produce optimal amount of maize out from their limited land.

[40] Only model 3 is presented here, as this is the best model out of the three based on the BIC.

Some variables have the signs as have been predicted such as number of labor (*labor*) and education of head of household (*primary, secondary*), however they are not statistically significant.[41] Number of labor in the household (*labor*) positively correlated with the adoption of hybrid maize and fertilizer. Household whose head has education (*primary, secondary*) more likely to adopt hybrid maize and fertilizer compare to household whose head has no education at all. In addition, comparing the marginal effect, primary education actually contributes almost nothing to the probability of taking up the package, while secondary education much higher to increase in the probability to adopt. Unfortunately, our model can not show that this is statistically significant.

Furthermore, our model shows that households that have other sources of income are less likely to adopt hybrid maize and fertilizer. This finding tends to support the second explanations as mentioned in chapter 2. Farmers who have at least one of member of household who gathering any income for the household will have more cash in hand so they would be able to buy food from market and reduce the urgency of self sufficiency.

The parameters of variable *radio*, which is the ownership of radio, turn out having the opposite sign with the one that we have predicted. The other variable that turns out to have different sign with the one we predicted is *ill*, which show that household has ill member. However, none of these coefficients are statistically significant.

We found that there are three variables that statistically significant and have the expected signs as we predict before. The three variables are household received credit (*get_credit*), involvement in farmer organization (*fo*) and female headed household (*head_sex*). The first two positively correlated with the probability to be the adopter while the latter is negatively correlated with the adoption decision.

Moreover, the marginal effect computation shows us that, household who received credit will end up with 0.30 higher probability to adopt hybrid maize and fertilizer, farmers who joined farmer organization will have probability 0.35 higher than farmer who did not get involve in farmer organization. On the contrary, household whose head is female is less likely to adopt hybrid maize and fertilizer. With female as the head of household, the probability to adopt the package is reduced by 0.19.

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[41] In this study, we use the common 5% of level of significant, unless we mention different level.

Our study shows that farmer organization is very powerful in contributing to the adoption of hybrid maize and fertilizer; this is opposite to the one find by Chirwa (2005b). This might be contributed by the fact that in the farmers organization, farmer get some insight on how to be success when the grow hybrid maize, how much the best combination of the fertilizer, seed and the land Benson (1999). In addition to the technical knowledge that was mentioned previously, based on the FGD, farmers organization able to functioning as the source of learning from each other through both formal and informal discussion. Farmer would be able to learn from previous good and bad experiences of their friends.

We found that having access to credit is contribute substantively to the decision to adopt hybrid maize and fertilizer. As we do realize, most of farmers in our study area are so poor, and they do not have some capital to buy seed and fertilizer. They rely on credit for doing this. In addition, we found from FGD that actually credit is much related with the farmer organization, as there are some farmer organizations that delivering credits for farmers both in cash or in kind of inputs.[42] Smale, Heisey & Leathers (1995) use the membership in credit club as one of explanatory variable of growing hybrid maize, they found that membership in the credit club will positively correlated with the land size that are allocated for hybrid maize, while Zeller, Diagne & Mataya (1998) found that predicted credit membership will increase the share of land for hybrid maize.

[42] Nevertheless, we check to our data, only 7 out of 154 households that join farmer organization and credit at the same time and the correlation between two variables is 0.0997, which support us to put them in the separate variables and found both of them are very powerful to explain adoption behavior.

We found that female headed household significantly reduces the propensity to adopt hybrid maize and fertilizer, by 0.2. Some previous study shows that actually, being female headed household is not directly reduce the propensity of being an adopter. However, being female headed household hinder the involvement in farmer organization and credit club that negatively influence the adoption (Gilbert, Sakala & Benson 2002).[43] Our data show that, only 15% of female headed household who received credit compare to 23% of their male counterpar. In relation to involvement in farmer organization, 16% of male headed farmer join farmer organization which is 6% higher than female headed household involvement. In addition, being female headed household most probably can be translated to less attention from extension officer (Gilbert, Sakala & Benson 2002). In addition, as mentioned previously, being female headed associate with lower endowment compare with the male counterpart.

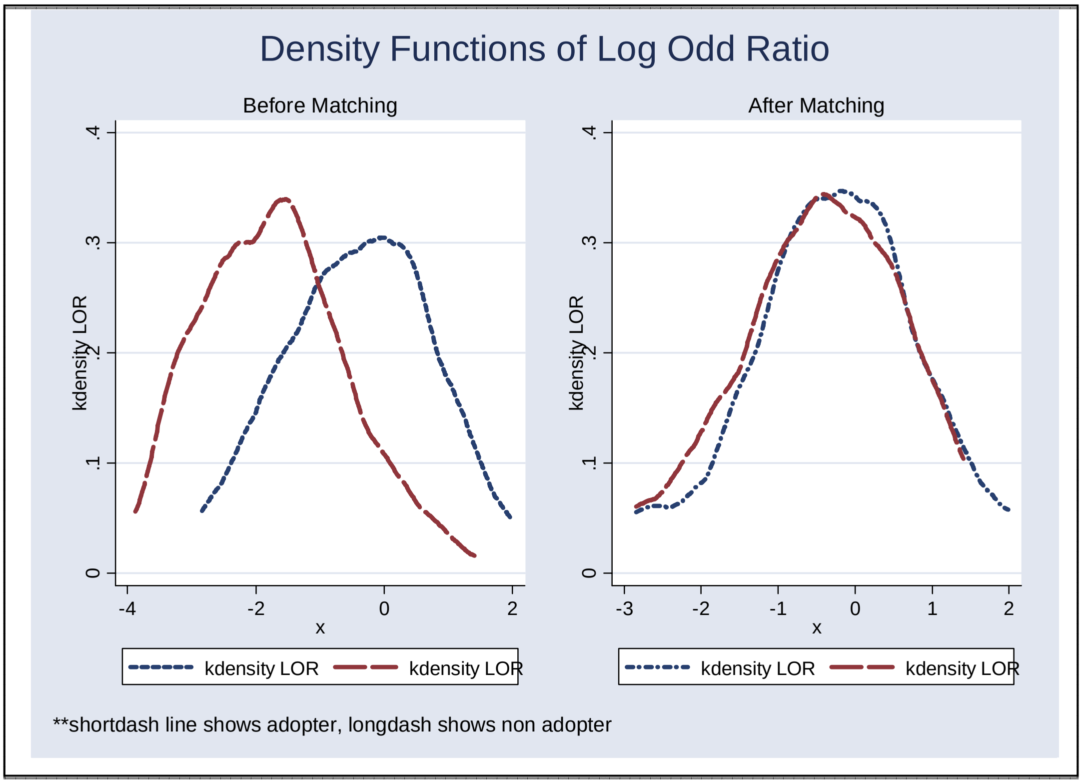
4.2. IMPACT OF ADOPTION OF HYBRID MAIZE AND FERTILIZER

In this subchapter we try to calculate how much the gain of the adoption process for the adopter to show the importance of hybrid maize adoption. As mentioned previously, we used model 3 in order to find the match for the treatment group to calculate the impact of taking up the package of fertilizer and hybrid seeds. Figure 4.1 below shows the density functions of the log odd ratio of each observation that were obtained from the linear prediction of the model 3 based on personal characteristics of each respondent.

In the figure 4.1(a), we present the density of log odd ratio for the two groups: adopter and non adopter while in the figure 4.1(b), the density functions of the same groups is after matching is presented. As can be seen from figure 4.1(a), we have relatively wide region of common support that make it easier to find the "match". All observations under the common support region will be used in the kernel and stratification matching to calculate the average treatment effect whilst in the nearest matching method only adopters and the match will be included in the calculation. In nearest neighbor matching method, we found exact matches for the some observations on treated group and we found that there are more control units in with lower log odd ratio and more treated units at higher log odd ratio. This shows actually that there are some biases as well in our calculation, which arise from the small sample size that we have. Nothing can be done to correct this kind of bias except increase the sample size.

[43] They cited the work by Due and Gladwin (1991).

Figure 4.1 The Density Functions of Log Odd Ratio



4.2.1 Impacts on Land Allocated for Maize

We calculate the impact of adoption on both the size and the proportion of land allocated for maize. In addition, we calculate the impact of adoption hybrid maize on proportion of land that allocated for other maize, which are composite maize and local maize.

Unlike the one that predicted by the subsistence theory that farmer who adopt hybrid maize will reduce the land allocated for maize, we find that the size of land allocated for maize is increase 0.15 – 0.395 hectare among the adopters. However, this increase is not significant.

Table 4.3 Impacts of Adoption on Land Allocated for Maize

Dependent Variable		Matching Estimates Kernel Method	Nearest-Neighbor Method	Stratification Method
Land Allocated for Maize (hectare)		0.154	0.395	0.070
		(0.182)	(0.297)	(0.145)
		(0.396)	(0.184)	(0.630)
Proportion of land allocated for maize		0.057	-0.019	0.100
		(0.109)	(0.127)	(0.090)
		(0.492)	(0.880)	(0.266)
Proportion of land allocated for non hybrid maize		-0.332**	-0.400***	-0.315**
		(0.103)	(0.112)	(0.099)
		(0.001)	(0.000)	(0.001)
Number of Observations	Treated	42	42	42
	Control	93	25	93

* p<0.05, ** p<0.01, *** p<0.001
standard error and t-statistics are in parentheses

In term of proportion of land allocated for maize, our three algorithms of matching method give different result. Kernel and stratification method show that the proportion of land allocated for maize is increase as farmers adopt hybrid maize and fertilizer. On the contrary, the nearest matching method shows that the adopters tend to allocate smaller proportion of land for maize production. Despite the fact that there are two opposite signs were resulted, the change is not significant.

The results above support our hypothesis that despite adopted hybrid maize and fertilizer, farmer will not reduce the land that allocated for maize. The result is consistent both in term of land size or the proportion. As discuss in the theoretical part, the reason for this is farmers have not reached the subsistence requirement yet. In addition, farmers are facing land constraint that they can not expand the land for maize production. Hence, when they adopt hybrid maize and fertilizer, they will apply them from the land that previously was dedicated for maize also. We calculate the change in proportion of land that allocated for other maize varieties and we find that adoption of the package will significantly reduce the proportion by 0.31-0.4.

4.2.2 Impact on Yield per Hectare

As widely mentioned in previous literature, hybrid maize in combination with fertilizer will give much better yield compare with the non-hybrid maize. In this subsection, we present the result of impact evaluation of hybrid maize and fertilizer adoption on the yield per hectare. We find that the yield per hectare land allocated for maize will increase by 928-1131 kg depend on the algorithm that being used when we calculated the matching.

Table 4.4 Impacts of Adoption on Yield per Hectare

Dependent Variable		Matching Estimates Kernel Method	Nearest-Neighbor Method	Stratification Method
Yield per hectare (kg)		1130.849***	927.609**	1089.096***
		(325.405)	(360.117)	(238.820)
		(0.001)	(0.010)	(0.000)
Number of Observations	Treated	42	42	42
	Control	93	25	93

* p<0.05, ** p<0.01, *** p<0.001
standard error and t-statistics are in parentheses

We find that farmer who grows hybrid maize and apply fertilizer on it enjoy around 1 ton/ha higher than when they do not adopt. This increase is very significant. If we compare Overall in Malawi, the productivity per hectare has change from 1590 kg/ha in 2005/2006 cropping season and 1909 kg/ha in 2006/2007 cropping season, which show that there is increasing 319 kg/ha that contributed by some farmer using hybrid maize, fertilizer and good weather (FEWS NET 2007b). Nevertheless, this number captures all farmers. This study find that the increase of hybrid maize and fertilizer adopter is much higher than the overall increase, showing that farmer actually can highly benefit from the adoption of hybrid maize and fertilizer. Nevertheless, the figure that is reported here is also contributed by the good rainfall in the 2006/2007 cropping season that actually exogenous in our model.

We do realize that without controlling on this exogenous factor, what we presented here is meaningless. The positive impact of the adoption behavior will not as high as reported here in case the bad weather coming. Consequently, it is urgent to make the weather condition which previously exogenous become endogenous by providing more irrigation system so farmer will not only depend on the rainfall, so the gain from the fertilizer and hybrid seed can be retain in each cropping season. In addition, by using irrigation, farmer will be able to have more than one cropping season each year.

4.2.3 Impact on Actual Harvest per Household

In this subsection, we present the result of the impact evaluation on the total maize in kilogram (kg) that actually harvested by farmers that will provide better understanding on how much the contribution of adoption hybrid maize and fertilizer on food availability within household. The result from average treatment effect using difference-in-difference method in combination with propensity score matching to control the bias show that farmers will gain 274-354 kg if they adopt hybrid maize and fertilizer in 2006/2007 cropping season. The result is statistically significant when we use the kernel and stratification as the matching method. In addition, when using the nearest matching method, the result is significant if we use a bit more than 10% of level of significant.

Table 4.5 Impacts of Adoption on Actual Harvest

		Matching Estimates		
Dependent Variable		**Kernel Method**	**Nearest-Neighbor Method**	**Stratification Method**
Households' Actual Harvest (kg)		354.283*	273.333	311.621*
		(140.226)	(166.118)	(128.721)
		(0.012)	(0.100)	(0.015)
Number of Observations	Treated	42	42	42
	Control	93	25	93

* p<0.05, ** p<0.01, *** p<0.001
standard error and t-statistics are in parentheses

We try to transform this gain in the monetary value. As we noted in previous chapter, adopter spend in average MK 1821 to be applied in their hybrid maize plot. This total cost comprises the cost of seed MK 482 and the cost of fertilizer MK 1339. We calculate the monetary value of the gain by multiplying the gain with the market price. FEWS NET (2007a) reported that the prices of maize are ranging over the local markets from MK 10.56 to MK 25.00 per kilogram of maize. Hence, in this calculation, we try to use the ADMARC price which is MK 17/kg for calculating the net income as this price can be seen as the average price.[44] By growing hybrid maize and applying fertilizer on it, farmer will have increasing income between MK 4646 - MK 6022. Then the increasing net income for the adopters is MK 2825- MK 4201.

[44] This price is actually just an indication price. We recognize that farmer who sell their maize, especially on the farm gate, will receive less than this price, and sometimes, farmers who need to buy maize in the market pay more than this price.

We found that most of the adopters use one bag of fertilizer subsidized on their hybrid maize plot, and they pay around MK 950 for that. In case there is no subsidy, farmer should pay MK 3000. So, in case that fertilizer and seed is not subsidized, then the monetary value of the adoption becomes MK 1143-MK 2519 as there is increase in price of fertilizer as much as MK 2050 and should also subtracted by the market price of the seed which is based on interview with the relatively educated farmer, for 0.5 ha of land, it is needed 10 kg of hybrid seed and the cost of this seed without subsidy is ranging from MK 1800-2600. In addition, we haven't calculated as well the cost of transport or in other form, lower price at farm gate. We do assume here that farmer apply fertilizer and seed proportionally to the land size allocated for hybrid maize and yield is proportional to the input so then calculation of net income from the mean will reflect the real condition. Hence, based on this calculation, we can show that for average farmer it will not profitable for the farmer to produce hybrid maize in without subsidy.

In the case with subsidy, we note that the increase is actually insufficient, especially if farmer also hire *ganyu* labor and buy other variable inputs that are out of calculation of the cost. We try to calculate this change in net income in term of change in income per capita. Based on EIU (2007), by dividing GDP at market prices on number of population, we obtain the GDP per capita MK 22626. Hence, the change in net income of MK 2825- MK 4201 per household, assume one household has 5 member (=MK565-840 per capita), is equivalent to 2.5-3.7% of increase in income per capita. This low level of changing in net income is contributed by small land size holding by each household. In case household has one hectare land, we notice that the gain in yield is 1200 kg/ha. Hence, with the price of MK 17 per kg, farmer will be able to get gross income MK 20400. For the typical household with 5 members, it contributes 18% of average income per year.

4.2.4 Impact on Food Security Condition and Food Availability per Capita

This subchapter presents the food security condition for each member of the household. Figure 4.2 below shows the condition of the household in term of food availability per capita in the two years period. The horizontal line shows the subsistence requirement per capita of 180 kg per year (Harrigan 2008).[45] *Food availability per capita* in this study is calculated from the total harvest per household subtracted by the cost of input for particular year in term of kilograms of maize and then divided by number of adult equivalent within household. The reason for subtracting is that some farmer obtained loan when to buy the input. Hence, when harvest comes they need to payback the loan. On the other hand, for some farmer who bought input with cash, this subtraction can be used for buying input for the next period. For calculating number of persons in the household in term of adult equivalent, we define labor as adult that has value 1, while children and elderly has the value 0.5, this appropriate with the one recommend by FAO as mentioned by Harrigan (2008).

Defining that households who are located above the subsistence line as *food secure household*, while those who are located below the line is categorized as *food deficit household*, we find that there is an improvement in number of farmers who able to secure the food in the household from 2006 to 2007.[46] We find that more household in 2007 stay above the line. This finding is consistent with the aggregate condition in Malawi where there is high surplus in 2007 maize harvest compare to one of 2006, which was widely recognized as the result of subsidized fertilizer program and the good rainfall.

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[45] Harigan (2008) mentioned that this 180 kg is based on the FAO recommendation, while for children the requirement is 90 kg.

[46] When drawing the graphs and calculating percentage of household who are food secure and food insecure, we limit our sample only to farmers who grow maize in the both periods. We do so as we couldn't recognize whether farmers do not grow maize because they are fully integrated to the market and have other source of income or because they are to poor to grow and they are actually the most food insecure. Nevertheless, either we do this correction or not, the percentages are similar.

Figure 4.2 Food Availability Condition within Households

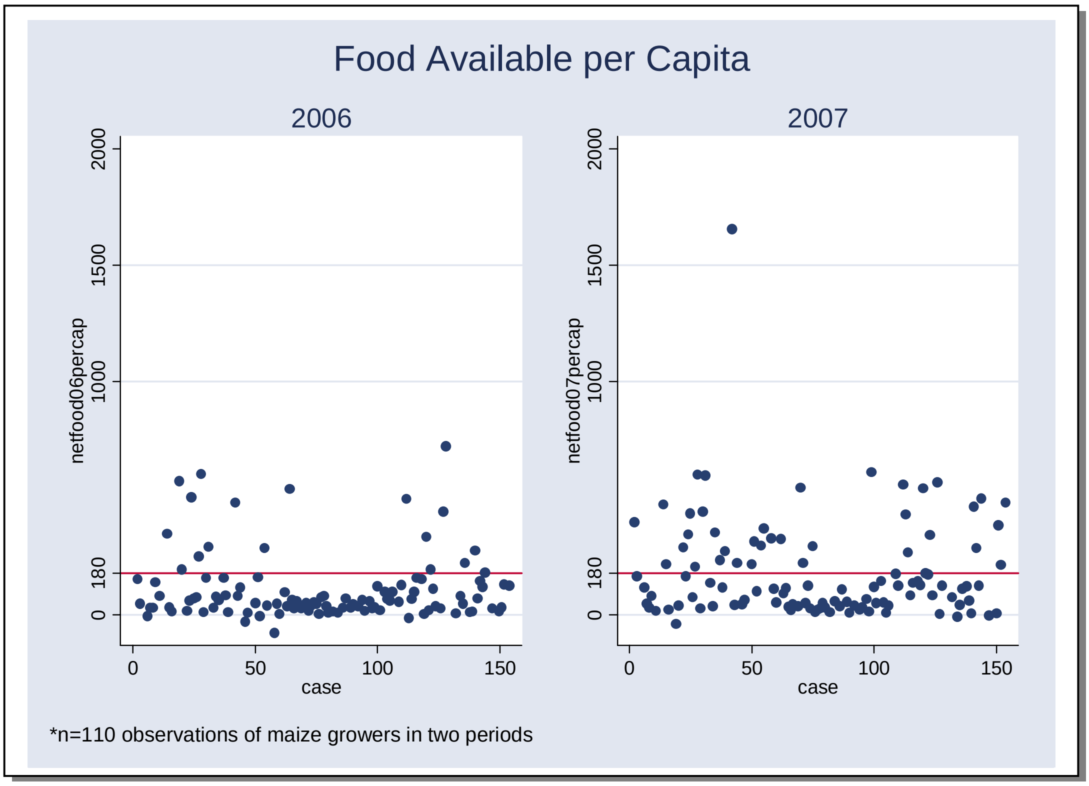


Table 4.6 below shows the change in household food security condition within two years. From the sample of 110 households of maize growers within the two years, we found that 59% of the households are *chronically* food insecure, 32% are *stochastically* food insecure and only 9% are food secure. In addition, we found that percentage of food insecure households is reduced from 84% in 2006 to 66% in 2007.

Table 4.6 Food Security Condition of Maize Growers

	household food condition in 2007		
household food condition in 2006	**food secure**	**deficit**	**total**
food secure	10	8	18
food secure, %	*9.09%*	*7.27%*	*16.36%*
deficit	27	65	92
deficit, %	*24.55%*	*59.09%*	*83.64%*
Total	37	73	110
	33.64%	*66.36%*	

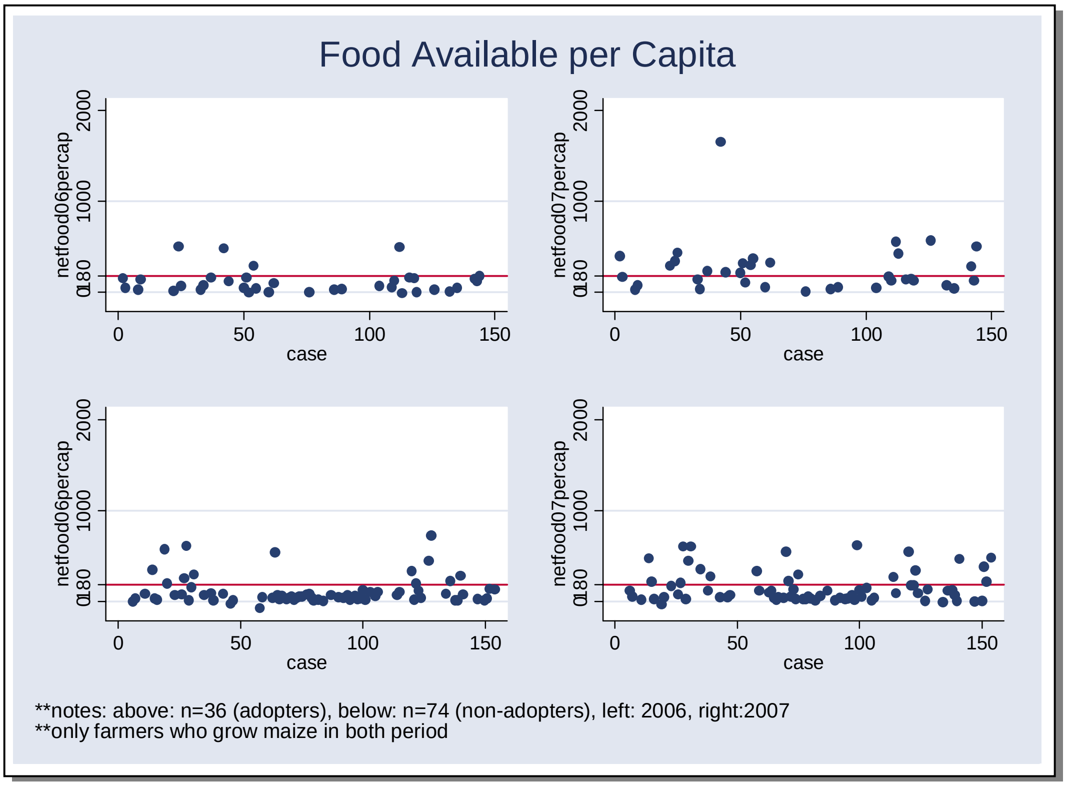
In the table 4.7 and figure 4.3 below, we present the comparison between household food situation between the adopters group and non-adopter groups within the two years period. We found that there is general pattern of improvement between the two groups. Deficit household is reduced from 82% to 73% within the non-adopters group compare with from 86% to 53% within the adopters group. We note that the change of this percentage is much bigger in the adopter groups compare with non adopters, the change in the former is 33% compare with 9% of the latter. In addition, we found other interesting finding that for the adopters group we find none of the household who are previously food secure become food insecure, compare with 11% of household who are move to below subsistence line in non-adopter groups. This finding shows that hybrid maize adoption able to prevent food secure farmers slip into non-secure.

Table 4.7 Comparison Food Security Condition of Maize Growers by Adoption

	food condition in 2007					
	non adopters			adopters		
food condition in 2006	food secure	deficit	total	food secure	deficit	total
food secure	5	8	13	5	0	5
food secure, %	*6.76%*	*10.81%*	*17.57%*	*13.89%*	*0.00%*	*13.89%*
deficit	15	46	61	12	19	31
deficit, %	*20.27%*	*62.16%*	*82.43%*	*33.33%*	*52.78%*	*86.11%*
Total	20	54	74	17	19	36
	27.03%	*72.97%*		*47.22%*	*52.78%*	

Figure 4.3 below show the visualization of the change in household food security condition.

Figure 4.3 Food Availability Condition Based on Adoption



As can be seen from previous subsection, for average farmers, there is a petite incentive for growing hybrid maize and applying fertilizer in term of the cash. Nevertheless, as maize is the staple food, moreover, "*maize is life*" as mentioned in Smale (1995), and most of farmers are still experience hungry season, it is reasonable to think that farmer will highly value the increase in the food available within household, especially per capita compare with the cash that might be generated if the food is sold. That's why in this section, we try to calculate the impact of adoption of the package on the food availability per capita within household.

By applying difference-in-difference method after doing propensity score matching, we obtained the estimators of the impact of adoption of hybrid maize and fertilizer on food available per capita as described in the Table 4.8 below.

Table 4.8 Impacts of Adoption on Food Available per Capita

Dependent Variable		**Matching Estimates** Kernel Method	Nearest-Neighbor Method	Stratification Method
Food available for each member of household (kg)		101.903*	101.561*	92.280*
		(42.071)	(48.395)	(39.105)
		(0.015)	(0.036)	(0.018)
Number of Observations	Treated	42	42	42
	Control	93	25	93

* p<0.05, ** p<0.01, *** p<0.001
standard error and t-statistics are in parentheses

We calculate the gain in term of per capita increase in the net food availability per capita within household, then, we compare the condition between the adopters and their match which provide the counterfactual situation of the adopters. As we mentioned previously, what we mean by the net food availability is we reduce the cost of input in term of kilograms of maize from the actual harvest. We found that the adopters will have 92-102 kg of maize available for the consumption for each member of the household as the impact of adoption. When calculating this impact, we take into account the change in household size as they might be new member in the household or some member who left house.[47]

Comparing the gain from adoption with the subsistence requirement per capita per year, we find that this gain can fill the hunger for 6-7 months period. Hence, if farmer previously experience around 7 months of hungry season, adoption fertilizer and hybrid maize would be able to drive out the hungry season. On the contrary, for some farmers who previously experience hunger for less than 7 months, they would be able to have some surplus that can be sold to generate cash that can be allocated for other purpose that contribute to increasing welfare of the farmers.

[47] The new member of the household can consist of new born baby, kinship or sometimes also niece, nephew or grandchild whose parents died of HIV/AIDS as reported in many studies, while some member left the household because of marriage, education purpose or looking for a new job. This change in household size significantly affects the food available per capita within household. We found that in case the size of household is holding constant, the increase in the food available per capita is 123-133kg, which is almost a third higher than when the change in the household is taken into account.

In addition, we try to test whether there are specific characteristics of the household that contribute to the difference in the gain within the adopters. We try to examine the difference across whether farmers facing land constraint or not and different group of educational background and gender of the household head. These three variables are interesting because of their specific characteristics. For the land constraint, it is interesting to see whether households that facing land constraint, which we define as household who has less than 0.5 ha of land have different outcome of adoption. For the educational background, despite the fact this variable is not significant in influencing the uptake of the package, we expect that this variable is still important that might result the difference in the impact of the adoption. For the gender of the household head, we find that female headed household is negatively correlated with the adoption. Nevertheless we are interested to see the impact of the adoption done by female headed household, to see whether female headed household perform as good as their male counterpart in term of providing food for each of member of the household.

Table 4.9 Impacts of Adoption on Food Availability Based on Land Constraint

	Matching Estimates		
Categorize	**Kernel Method**	**Nearest-Neighbor Method**	**Stratification Method**
Households facing land constraint (<0.5 ha)	35.563	-39.137	58.729
	(78.201)	(81.489)	(66.835)
	(0.649)	(0.631)	(0.380)
Households are no facing land constraint (≥0.5 ha)	105.189*	117.988*	91.085
	(48.631)	(52.643)	(52.075)
	(0.031)	(0.025)	(0.080)

* p<0.05, ** p<0.01, *** p<0.001
standard error and t-statistics are in parentheses

The impact of adoption based on the size of land holding by household is reported as in table 4.9 above. We found that there is no significant impact of adoption of hybrid maize and fertilizer on food available per capita for the group of farmer who has less than 0.5 ha of land. While for the group of farmers who has at least 0.5 ha of land, there is positive impact of adoption as many as 91-118 kg. This finding is similar with the one mentioned in Ellis, Kutengule & Nyasulu (2003) and the one mentioned in Devereux (1997) for farmers who categorized as *very small smallholder* that would not be able to produce maize for self sufficient and need transfer from government. This study also show that for farmer categorized in at least *medium category*, the adoption is work out to provide food for each of member of the household for 6-7 months.

Table 4.10 Impacts of Adoption on Food Availability Based on Educational Background

	Matching Estimates		
Categorize	**Kernel Method**	**Nearest-Neighbor Method**	**Stratification Method**
Households head has no education	-22.980	-21.514	-0.993
	(79.171)	(91.817)	(76.701)
	(0.772)	(0.815)	(0.990)
Households head has primary education	38.181	15.005	47.459
	(34.624)	(56.226)	(38.922)
	(0.270)	(0.790)	(0.223)
Households head has secondary education	481.925*	472.678**	281.521*
	(212.633)	(172.974)	(126.730)
	(0.023)	(0.006)	(0.026)

* p<0.05, ** p<0.01, *** p<0.001
standard error and t-statistics are in parentheses

Table 4.10 above shows the impact of adoption of hybrid maize and fertilizer on the food available per capita within household based on education background of head of household. We found that there is increasing trend of impact based on education. If head of household has no education, the impact of adoption on food availability is negative. This is possible as in fact we calculate the net food available, meaning we do correction of the cost of input in term of kilograms of maize. This shows us that farmer who has no education may be has difficulties to apply fertilizer and hybrid maize in the best way. So, they end up getting nothing when the harvest come and should pay for the input. Household whose head has primary education has slightly higher impact of adoption. Nevertheless, we found that the impact of adoption either head of household has no education or primary education is not significant. One can say that the uptake of fertilizer and hybrid maize will has no impact on food availability if farmer has relatively lower education.

On the other hand, we found that farmers who have secondary education have high and significant impact on food available for each member of the household. There are several explanations out of this; first farmers who have secondary education would be able to follow the instruction in the package of fertilizer and hybrid seed. Second, there might be that farmers who has better education has better endowments such as land and cash so then they can access more inputs and get optimal outcomes. Third, it is likely that farmer who has relatively higher education tend to have smaller household size that increases the food availability per capita for this group. Hence, this study shows the importance of secondary education for increasing food security. Nevertheless, there is a study this impact specifically.

Table 4.11 Impacts of Adoption on Food Availability Based on Household Head's Gender

	Matching Estimates		
Categorize	**Kernel Method**	**Nearest-Neighbor Method**	**Stratification Method**
Female Headed Household	17.721	128.818	196.468
	(156.239)	(310.251)	(178.320)
	(0.910)	(0.678)	(0.271)
Male Headed Household	106.599*	98.513	95.833*
	(49.700)	(53.382)	(42.749)
	(0.032)	(0.065)	(0.025)

* p<0.05, ** p<0.01, *** p<0.001
standard error and t-statistics are in parentheses

Table 4.11 above compares the impact of uptake the package on food availability between female headed household and male headed household. We found that the impact of adoption hybrid maize is not significant in the female headed household. We found from the analysis of determinant of adoption that being female headed household is a constraint to adopt the package, and here, we found that for the adopters from female headed household, uptake the hybrid maize and fertilizer will have no significant impact on food availability. On the contrary, we found that in male headed household, there is positive and significant gain from adoption as much as 96-107 kg of maize per member of the household. This most probably are contributed by the same reasons as have been mentioned as the advantage of male farmers such as better access to farmer organization, credit and have higher endowment.

CHAPTER 5
CONCLUSION

In Malawi, food insecurity has long been a problem. Agriculture related policies to boost the production of food, particularly maize, have been implemented since the independence. As a landlocked country, self sufficient in maize is the cheapest way to ensure that national food security is achieved. The depressing situation of food insecurity has changed recently. In addition to favorable weather in 2006/2007 cropping season, fertilizer subsidy by the Government of Malawi has been recognized for not only being able to increase the production to the highest record but also to provide surplus that can be exported and donated to the food deficit neighbor countries.

Despite the fact that fertilizer subsidy program has successfully bring about food security at macro level, the impact at the household level has not cleared yet. This study attempts to provide counterfactual analysis of household food security in the groups of farmers who adopt both hybrid maize and fertilizer, the one that actually carried out the activity as it is expected when the subsidy is given out. By utilizing two years longitudinal data, we would be able to apply difference-in-difference method in combination with propensity score matching to have unbiased estimator.

To provide the complete picture, before calculating the impact, we first analyzed factors affecting hybrid maize and fertilizer adoption in 2006/2007 cropping season. We found that farmers' involvement in the farmer organization and access to credit increase the probability to adopt hybrid maize and fertilizer, while female headed household reduce the probability to adopt.

From the impact analysis on the land allocated for maize, we found that adoption of hybrid maize and fertilizer would not change the size and proportion of land allocated for maize and that adoption of hybrid maize will significantly reduce the land allocated for other type of maize.

The counterfactual analysis on the yield per hectare shows that there is increase around 1 metric tonne per hectare if farmer grow hybrid maize. Nevertheless, as most farmers have less than 1 hectare of land, they would not be able to enjoy this higher yield. The actual increase in term of kg of maize is only 273-355 kg that shows that it is not profitable for the farmer to produce hybrid maize if the input is not being subsidized.

Despite there is petite incentive for growing hybrid maize and applying fertilizer in term of the cash, doing this might be important from the point of view of household food security as *"maize is life"* in Malawi. Using net food available per capita as the indicator of food security, and categorizing household who has net food available per capita less than 180 kg as food deficit household, we found that growing hybrid maize tend to reduce the percentage of food insecure household much higher than the non-hybrid maize does. In addition, growing hybrid maize prevent household that food secure in the first period to slip into food deficit in the second period.

From counterfactual analysis of the uptake the package on net food available per capita within household, we found that adoption able to make farmer secure food for 6-7 months more than if they grow non-hybrid maize.

Eventually, we examined whether some specific characteristics of the household such as the land size, the education background and the gender of head of household affect the impact of adoption. We found that adoption of hybrid maize will have no significant impact if farmers have less than 0.5 ha and headed by a female. On the contrary, farmer with secondary education will contribute to higher impact of the adoption compare with farmer who has either no education or has primary education.

We conclude this study by saying that even hybrid maize and fertilizer is able to reduce the hunger for 6-7 months periods, but it do not able to yield significant improvement for the most vulnerable groups: land constraint farmers, female headed household and non educated farmer.

This study able to provide the counterfactual analysis from the adoption of hybrid maize and fertilizer, using longitudinal data from primary survey as an advantage, which some of study failed to provide. Nevertheless, this counterfactual analysis can not be generalized as there is important exogenous factor that affect the outcome which is rainfall. As this study is carried out in the good rainfall condition, we would expect that the magnitude of the impact will reduce if the weather turns out to be unfavorable. On the contrary, we expect that the finding that adoption of hybrid maize will not bring about improvement for the most vulnerable group will be the same in case the bad rainfall coming. Nevertheless, situation may change into positive direction if the rainfall condition better than the one in 2006/2007 cropping season.

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APPENDIX: THE DEFINITIONS OF VARIABLES

FOR THE LOGIT MODEL

DEPENDENT VARIABLE

Adopter vs. non-adopter hybrid maize and fertilizer *(dmaize1f)*

This variable is coming from the 2007 survey. We use harvest as the control variable, if farmer harvest hybrid maize, then we take them as adopter, in addition, we check also whether they applied fertilizer for their hybrid maize. If they adopted both, then they are defined as adopter which has value "1", while the others non-adopter "0".

INDEPENDENT VARIABLES-*are drawn from 2006 data set, unless it is mentioned the other*

Total land own by HH *(landtotha)*

The sums of all plots (in hectare) own by household both the area that is cultivated and fallow.

HH has maize plot with good soil fertility *(soilfergood)*

Dummy variable of soil fertility condition, if household reported that they have a good soil quality, soilfergood=1, otherwise=0.

HH has maize plot with average soil fertility *(soilferaverage)*

Dummy variable of soil fertility condition, if household reported that they have a average soil quality, soilferaverage=1, otherwise=0

Number of person 15-65 in HH *(labor)*

Labor is defined as a total of member the household whose age is more than 15 years old and less than 65 years old.

Head of HH has primary education *(primary)*

Dummy variable of education, has value=1 if head of household has experience 1-8 years in the school.

Head of HH has secondary education *(secondary)*

Dummy variable of education, has value=1 if head of household has experience more than 8 years in the school.

Household has radio *(radio)*

Dummy variable of ownership of radio, has value=1 if household own radio

Livestock own by household (000 MK) 2006 *(livestockasset)*

Monetary value of the livestock asset own by household. It is valued as average market price of the livestock. The livestock consist of cattle, chicken, goat, rabbit, turkey, duck, and pig.

HH received credit *(get_credit)*

Dummy variable, has value=1 if household receive credit both from formal or informal lenders.

HH joined farmer organization *(fo)*

Dummy variable, has value=1 if household join any farmer organization. This variable had not been asked in the 2006 survey. Nevertheless, we asked open ended question for the period of household join the farmer organization in the 2007 survey. We recognize the farmer has join organization and has the *fo* value=1 if household has join more than 1 year.

Sex of head of HH *(head_sex)*

Dummy variable of the sex of household head, has value=1 if household is headed by female.

Age of head of HH >40&<60 *(age)*

Dummy variable of age, has value=1 if head of household is older than 40 years old but younger than 60 years old.

Age of head of HH >60 *(age1)*

Dummy variable of age, has value=1 if head of household is older than 60 years old.

HH has other source of income *(dother_inc)*

Dummy variable of other source of income, has value=1 if household has other source of income, which might consist of ganyu, business, wage employment, and remittances.

HH has business *(business)*
Dummy variable of businnes, has value=1 if at least one of household member doing business.
HH has member who do ganyu *(ganyu)*
Dummy variable of ganyu, has value=1 if at least one of household member doing ganyu.
HH grew tobacco *(tobbaco)*
Dummy variable of growing tobbaco, has value=1 if at household grow tobacco.
HH has ill member *(ill)*
Dummy variable, has value=1 if household has at least one of the member were ill. This variable had not been asked in the 2006 survey. Nevertheless, we five year recall periods when we as about the questions about the shock that hit the household. We recognize household as ill member if they reported that there is sick member in 2006.
HH live in Thyolo *(Thyolo)*
Dummy variable of district, has value=1 if at household live in Thyolo.
HH live in Zomba *(Zomba)*
Dummy variable of district, has value=1 if at household live in Zomba.
HH live in Chiradzulu *(Chiradzulu)*
Dummy variable of district, has value=1 if at household live in Chiradzulu.
HH live in Machinga *(Machinga)*
Dummy variable of district, has value=1 if at household live in Machinga.
HH live in Kasungu *(Kasungu)*
Dummy variable of district, has value=1 if at household live in Kasungu.

FOR THE COUNTERFACTUAL ANALYSIS
For the impact evaluation, data from both surveys is used on these variables:
Maize Land (ha)
Total land allocated by household for maize cultivation (in hectare).
Proportion Land Maize
This shows proportion of land allocated by household for maize production.
Proportion Land Non-Hybrid
This shows proportion of land allocated by household for maize production subtracted by the proportion of hybrid maize.
Yield per hectare
This shows the yield that farmer would be able to get if they grow any kind of maize in one hectare of land.
Total harvest (kg)
This shows the actual total harvest that household obtains from the specific amount of land that they have.
Food available per capita
This variable is coming from the total harvest per household divided by total number of adult equivalent within household. For non-labor member, it is assign the value 0.5 for adult equivalent, this consistent with the FAO recommendation as mentioned in Harrigan (2008) that children is assigned half requirement of adult.
Food deficit household
It is defined that household that has the food available per capita less than 180 kg is categorized as food deficit (deficit=1), while household who has higher than 180 kg is defined as food secure (deficit=0).
When calculating the impact, we take the difference between the two years period of each variable for each household and then looking for difference between adopter and the match.