Assessment of the macro-micro linkages between rural livelihoods, agricultural research innovation systems and agricultural policy changes in Malawi

By

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DEDICATION

This work is dedicated to my mother, Professor Eta Elizabeth Banda, and my sister, Dr. Angela Chipo Ulemu Chaponda, for their never-ending support and love. You have been the giants on whose shoulders I have stood to see a little further.

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DECLARATION

I declare that this thesis hereby submitted for the degree of PhD in Agricultural Economics at the University of Pretoria is entirely my work and has not been submitted anywhere else for the award of a degree or otherwise.

Parts of the thesis have been published and submitted for publications in journals.

Any errors in thinking and omission are entirely my own responsibility.

Signed: …………………………...

Name: Mariam A.T.J. Mapila

Date: November, 2011

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ABSTRACT

ASSESSMENT OF THE MACRO-MICRO LINKAGES BETWEEN RURAL LIVELIHOODS, AGRICULTURAL RESEARCH INNOVATION SYSTEMS AND AGRICULTURAL POLICY CHANGES IN MALAWI

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This thesis argues that the full impact of Agricultural Innovation Systems (AIS) driven research, that works to enhance not only agricultural production and productivity but also market linkages cannot be captured effectively using only micro-economic level studies; but rather requires the use of a combination of micro and macro-level analysis. This is because the innovation systems perspective entails the collaboration of different actors across the entire agricultural value chain. Therefore this study aimed to firstly quantify the degree to which AIS driven research impacts upon the livelihood outcomes of rural smallholder farmers. Second, the study aimed to determine the extent to which a combination of macro-economic and agricultural policy shocks impact upon household incomes in the maize-based farming system in Malawi; given macro-micro linkages as strengthened by AIS research.

The first objective was tackled by using quasi-experimentation with propensity score matching to establish a valid counterfactual and single differencing to measure impact. The second objective was achieved by using a combination of quantitative and qualitative statistical and econometric tools to delve into the dynamics of the maize market at different levels and to develop a model that is capable of capturing the maize market dynamics. A multi-equation partial equilibrium model of the national maize market was therefore developed and linked in a top-down unidirectional manner to the local maize economy via a price-linkage equation. A non-behavioural arithmetic micro-accounting approach was adopted to estimate household incomes that were linked to the local economy, through which macro-economic level maize price changes transmit.

The results of the study empirically demonstrate that AIS driven research impacts positively upon the livelihood outcomes of rural households. This is demonstrated with participating households exhibiting statistically significant higher production outcomes (upland crop production, maize harvests, value of assets, and value of livestock); household incomes as well as human capital outcomes in some cropping seasons. In addition participating households also had much higher statistically significant fertilizer use prior to the implementation of the fertilizer subsidy program in the country; and statistically significant higher fertilizer use patterns for the first two cropping seasons following the implementation of the subsidy program. Participating households had greater linkages with the market economy which allowed them to take greater advantage of market incentives but which also made them more vulnerable to policy shocks. This study therefore shows that the analysis of the impacts of the paradigm shift in agricultural research towards an innovation system orientation cannot be contained at the household level, as this would lead to the formulation of inadequate policies that do not take into account the effects of greater market linkages of the rural households.

Policy implications are that increasing production and productivity and linking farmers to markets may not in itself be enough for sustained livelihood improvement, as the resultant greater linkages to the market economy may be detrimental to household livelihood outcomes in the face of uncoordinated policies. In order for the paradigm shift in agricultural research towards an innovation systems perspective to be effective in sustaining an entrepreneurial culture in rural societies in Africa, there is need to foster the diversification out of agricultural enterprises for income, while supporting productivity improvements for food security. In addition any interventions should be implemented only after systematic analysis of the potential consequences of the resultant enhanced macro-micro linkages. This would help to ensure that there is no mismatch between policies and livelihood improvement strategies.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

ADMARC	Agricultural Development and Marketing Corporation
ADD	Agricultural Development Division
AIS	Agricultural Innovation Systems
AISP	Agricultural Input Support Programme
AKIS	Agricultural Knowledge and Information Systems
ANOVA	Analysis of Variance
BFAP	Bureau for Food and Agricultural Policy
CGE	Computable General Equilibrium
CIAT	International Centre for Tropical Agriculture
COMESA	Common Market for Eastern and Southern Africa
DAES	Department of Agricultural Extension Services
DARS	Department of Agricultural Research Services
EPA	Extension Planning Area
ERI	Enabling Rural Innovation
FO	Farmer Organization
FPR	Farmer Participatory Research
HSD	Honestly Significant Difference
IFPRI	International Food Policy Research Institute
LADD	Lilongwe Agricultural Development Division
MOA	Ministry of Agriculture
NARS	National Agricultural Research System
NFRA	National Food Reserve Agency
NGO	Non-Governmental Organization
NRM	Natural Resources Management
PM&E	Participatory Monitoring and Evaluation
PSM	Propensity Score Matching
RMSE	Root Mean Square Error
SPI	Starter Pack Initiative
TIP	Targeted Input Programme

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The complexity of rural livelihoods and poverty in the developing world has led to a shift in the agricultural research paradigm from the strengthening of top-down national agricultural research systems towards non-linear dynamic systems that are geared to enabling greater individual and community innovation, greater capacity by end users to obtain and to properly utilise knowledge and research outputs, as well as overall transformation (Spielman, 2005; World Bank, 2007a; CTA, 2010). The shift in the agricultural research paradigm has been a gradual process since the early 1980s, when it was recognised that the participation of the intended end users of agricultural technologies in the research process would lead to greater adoption and improved research output. These participatory agricultural research systems paved the way for research processes that went beyond the mere participation of end users in field research to the incorporation of indigenous technical knowledge. This allowed better adaptation of technologies and the identification of farmers' priorities for new knowledge; thus changing the nature of research agenda setting. The focus of these participatory agricultural research approaches was to increase the supply of new knowledge and to strengthen national research systems.

In more recent years, the agricultural research paradigm has undergone another major shift towards an Agricultural Innovation Systems (AIS) perspective. This perspective views the agricultural research process as a complex and dynamic system, in which the participation of end users is only one part of a complex set of other processes and interactions between different actors that are working together (directly or indirectly) to bring about innovation or improvements at different levels in the agricultural system/value chain. The shift towards AIS orientation was precipitated by the realisation that despite stronger national research systems, agricultural productivity remained low in many parts of the developing world. This was as a result not only of the lack of appropriate technologies and the lack of access to those technologies, infrastructure, inputs and credit; but also due to the lack of access to markets because of gaps in information and skills that prevented rural end users from effectively utilising, adopting and adapting technologies.

One case in point is Malawi, where the government has created an enabling environment for the work of agricultural research and development agencies that, through the use of agricultural innovation systems concepts, recognise the potential for improving rural livelihoods by enabling rural innovation amongst smallholder producers, hence reducing rural poverty. The reduction of rural poverty is critical for Malawi, as nearly 40% of the total population live below the poverty line. This is mainly due to the prevalence of smallholder agriculture; which is characterised by complete reliance on rain-fed farming, making it susceptible to shocks arising from unfavourable weather conditions and low landholding sizes with a typical household of about six people cultivating on average less than 0.5 hectares of land (World Bank, 2007b). Despite the difficulties of the agricultural sector in Malawi, it remains the backbone of the economy with contributions of nearly 35 % to total GDP. In addition, the agricultural sector accounts for approximately 80 % of all export earnings and employs over 85 % of the country's total population (World Bank, 2007a). The agricultural sector is dualist in nature, with smallholder and estate sub-sectors. The majority of the population (85 %) engaged in subsistence farming within the smallholder sub-sector and nearly 67 % of all rural incomes come from subsistence farming (Chinsinga, 2007). Smallholder agriculture is predominantly maize based. An increasing population, low land holdings, erratic rainfall, poor soil fertility management and natural resource degradation all contribute to intensify the fragmentation of land and low soil fertility, resulting into general poor agricultural productivity.

As such, investments in agricultural research to develop improved technologies and improved delivery mechanisms for better utilisation of natural resources for enhancing livelihoods have been a key concern within scientific and policy forums in Malawi. This is also the case in many other developing countries (Hall, *et al.* 2006). In Malawi, innovation systems concepts in agricultural research have been promoted, as evidence exists that any small improvements in the incomes of rural individuals, which can be brought about by the adoption and utilisation of improved agricultural technologies, have the potential to bring significant improvements in rural livelihoods (Delgado, *et al.* 1998; Mwabu & Thorbecke, 2001).

The AIS research paradigm has manifested itself in practice and also in policy, with agricultural research innovation systems approaches featuring highly in policy documents of many African countries[1] (Sanginga, *et al.* 2009). In practice, AIS driven research has manifested itself as a research paradigm in which there is emphasis on two key aspects. The first is developing technologies to enhance production and productivity; and the second is linking farmers to produce markets. These two interlinked activities are carried out whilst ensuring sustainability of the engagement of the end users by strengthening farmers' capacity for research and on-farm experimentation and their capacity to identify and access markets. This is done with the aim of demystifying the scientific research process and effectively shifting farmers from being recipients of knowledge and research outputs to becoming part of the knowledge generation process.

Apart from engaging end users, AIS driven research also engages the wider community and involves other actors who are important in the agricultural value chain, but who are traditionally not involved in research. This involves the engagement of non-traditional research actors such as agribusiness owners, input and output dealers and policy makers as part of the innovation platform (Van Rooyen & Tui, 2010). In the past, the focus of research was only on the first aspect, with the assumption that markets and institutions were in place. However, it was found that in many cases, farmers frequently rejected technologies because markets essentially failed them due to various reasons; including the thinness of markets in remote rural areas, high transactions costs associated with accessing lucrative markets and/or the prevalence of other pre-existing socio-economic barriers to entry (Kherallah & Kirsten, 2002; Johnson, 2005 cited by Kaaria, *et al.* 2008).

1.2 RESEARCH PROBLEM AND JUSTIFICATION

Despite the importance accorded to the AIS research paradigm in transforming rural livelihoods from a subsistence orientation to an agri-business perspective, the paradigm is not a panacea for the problems plaguing the agricultural sector in Africa. This is mainly because

[1] In recognition of the presence of innovation systems perspectives in national policies, there is emerging work by the World Bank and the International Food Policy Research Institute to provide innovation benchmarking for improving public policies for strengthening national agricultural research systems.

some of its main features[2] have been part of the debates in the agricultural research arena for the last 20 years (Hall, 2007) but have been reworked to suit the contemporary social, economic and political conditions as well as advancements in analytical tools and research capacities. Although adaptation of the agricultural research process to suit prevailing contexts is not erroneous, the danger is that the prevailing agricultural research paradigm may lose focus of its core aims with the centre being on what Hall (2007a) terms "debates … by agricultural scientists … about how agricultural knowledge should be used for development ... with the aim of directing policy towards one specific approach at the expense of others". This may in fact be the reason that there are currently very few empirical studies that analyse the impacts of AIS in an African context on rural people's ability to better utilise available natural resources – thereby enhancing their production, increasing their food security or diversifying their livelihoods. Hence, in order to steer agricultural research policy debate towards actual discussion of the effects on end users' livelihoods of the use of AIS in the research process, it is essential that empirical evidence be generated. This will ensure that the focus is not solely on the organisation of the agricultural research process but rather mainly on the impacts of the paradigm shift.

Given these concerns and the increasing prevalence of the innovation systems concept in agricultural research rhetoric, policy and practice in Africa, and in Malawi in particular, it is essential that robust quantitative studies be conducted that analyse empirically the impact of the use of innovation systems concepts in agricultural research on the livelihood outcomes of rural households. Studies, such as those conducted by Kaarai *et al*. (2008; 2009) are mainly case study analysis of the impacts of the use of AIS concepts in the research process. These studies lack the analytical rigour of methods employed in the study of AIS as employed in the developed world (Spielman, *et al.* 2009). It is for this reason that the World Bank (2007b) has called for "empirical validation" of the use of AIS concepts in research in Africa.

Furthermore, since AIS research and development goes beyond technology development to the fostering of market participation of rural end users, any contemporary relevant studies must go beyond micro-economic level analysis to examine the impacts of macro-economic policy shocks that transmit through the market economy on rural livelihoods. Studies that go

[2] Main features of innovation systems agricultural research, such as farmer participatory research, farmer empowerment, inclusion of indigenous technical knowledge and the interaction of multiple interdisciplinary stakeholders, have in one way or another also featured in past agricultural research paradigms and analytical tools, such as the Agricultural Knowledge and Information Systems and Participatory Rural Appraisal.

beyond the micro-economic level to assess the impacts of macro-economic policy shocks can be found in literature (Robilliard *et al*., 2001; Bourguignon *et al*., 2008; Ravallion & Loksin, 2008; Bussolo *et al.,* 2008). However the majority of such studies provide an assessment of the aggregate impacts of macro-economic policy shocks such as impacts on aggregate reduction in poverty. They do not provide insight into specific household level effects. Secondly, the few studies which can be found in literature which assess household level effects in Malawi such as studies by Dorward (2003; 2006) and Dorward *et al*. (2004) have used modelling techniques in which the household model is integrated with a rural economy model to simulate the effects of different policy shocks; but in which the macro-economy is exogenous to the rural economy model. Although the modelling techniques are robust, they do not reflect reality of the linkages between the rural households, the rural economy and the macro-economy in Malawi. As such there has been a call for the development of simple, unambiguous techniques that are capable of providing an analysis of household level effects of macro-economic policy changes which take into account existing relationships and linkages between the different levels of the economy in Malawi (Dorward *et al*., 2004).

This study will therefore contribute towards not only understanding the paradigm shift in AIS research and development but it will also lead to the generation of credible evidence which can be used as a basis for the formulation of effective agricultural research policies and programmes that are aligned with macro-economic policies.

1.3 HYPOTHESES AND OBJECTIVES

As stated earlier, studies that specifically assess the impacts of AIS driven research on livelihood outcomes have not applied robust quantitative analytical tools. Although these studies provide great insight into the potential of AIS research as a means of improving household incomes, there are two key areas that reduce their efficacy for policy analysis. First, these studies do not provide the extent to which income has been affected by participation in AIS research interventions as they do not quantify the changes in incomes. Thus, there is the need for empirical studies to quantify the impacts of AIS driven research at the household level.

Second, the majority of these studies only assess how livelihoods for participating households have been influenced by research driven by AIS concepts. This is also problematic because the observable changes in the livelihood outcomes for participating households could be the result of other observable and non-observable time variant factors that have the potential to also influence incomes and livelihoods of the participating households, as well as the community at large. Thus, by only assessing the before and after changes in the livelihoods of participating households, it is possible to either over or under estimate the effects of the use of AIS concepts in research. This problem is commonly known as the attribution problem in impact evaluation because the observed outcomes cannot be attributed to the programme intervention that is under analysis (Alston & Pardey, 2001). The most effective approach for overcoming the attribution problem is the use of randomisation, where a programme is assigned randomly to some smaller group from amongst a larger group of eligible households. The results are then compared between the households that were randomly selected and those that did not participate. Although ideal, randomisation is not possible for this study as the analysis is being carried out after the programme intervention has already been completed. In such cases, the attribution problem is overcome by comparing the outcomes of participating and non-participating households. However, to merely compare participants and non-participants also leads to biases, as it is possible that participants had been selected based on a specific criterion which differentiated them from non-participants. In order to overcome this second problem or selectivity bias, the analysis must use non-participants (the counterfactual) who have very similar observable socio-economic characteristics to the participating households prior to the intervention. The detailed establishment of a valid counterfactual for this study is provided in Chapter 4.

Given the lack of quantitative empirical studies and the considerations pertaining to sample selectivity bias and the attribution problem, this study set out to test the following as the first hypothesis:

The livelihood outcomes of rural households in communities with AIS driven research interventions are higher compared to similar outcomes for rural households in communities without such interventions.

Going beyond production and productivity to ensure that farmers' livelihoods are transformed from being subsistence oriented to being market oriented implies that rural producers; who traditionally have little or no backward and forward linkages; are linked to the greater market economy. This would entail that farmer's livelihoods would be more dependent on the market economy and as such more vulnerable to market forces. This is especially the case in Malawi in which the agricultural sector is composed of three parallel markets which are differentiated by prevailing prices and the price formation process. Figure 1.1 provides an illustration of the Malawi maize market with the inter-linkages existing in the different levels.

The first market is the rural household economy which consists of individual farm households. From Figure 1.1, it can be seen that the household economy is impacted upon by many factors; of which, the basis is that households try to sustainably use all available scarce natural resources to produce livelihood outcomes using different strategies. This is made more complex given that the household is located within a context in which global, macro-level and meso-level changes impact upon them directly and indirectly (Scoones, 1998). The second market is the rural market economy which is the nexus of all household economies in a particular rural locality. And lastly, there is the national market which comprises all rural market economies as well as other sectors such as the estates, semi-commercial and commercial agricultural markets. In the rest of this thesis the 'macro' component refers to the integrated national maize market in Malawi. Any reference to the 'micro' component refers to the household level and the meso-level to the rural economy level.

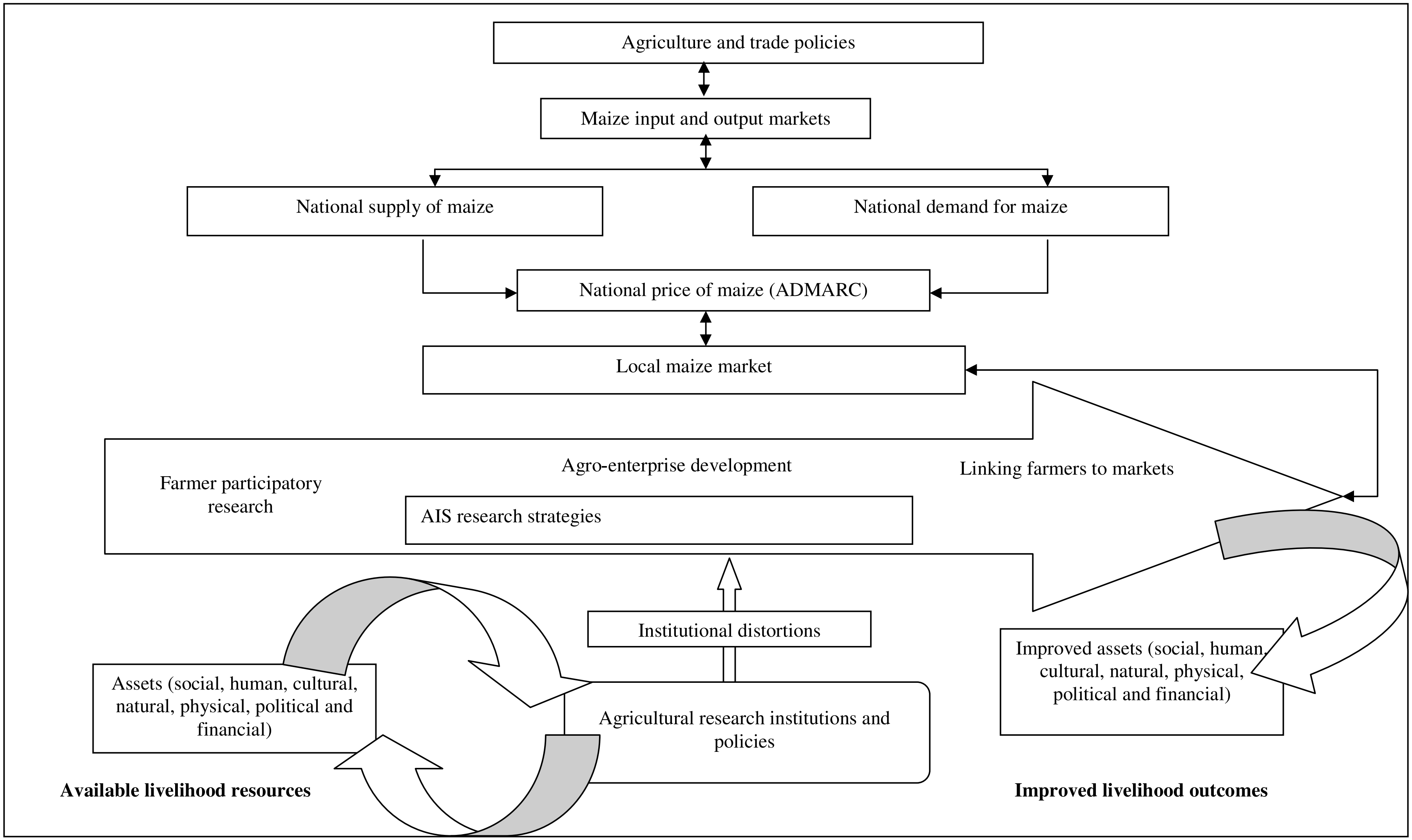

Figure 1-1: Conceptual framework for the study

The rural economy is linked to the national economy in that any changes in national policies brought about by changes in the national political environment or the global policy environment results in sector wide changes and this includes changes in the agriculture sector. Although the agricultural sector in the country has been greatly liberalized, maize is still largely under government price controls and this entails that changes in prices at the national level lead to changes in national input and outputs markets (see Figure 1.1). These changes impact upon the national supply and demand of maize which in turn further leads to changes in national prices. Changes in national prices that are the result of direct government controls or changes in the dynamics of national demand and supply affect the local economy as the national price is the basis upon which local economy market prices are set.

At the household level, smallholder producers who are linked to both local input and output markets through research interventions that are driven by AIS concepts would hence be affected by price changes occurring at the macro-level because of the linkage between local economy maize prices and national level prices (Figure 1.1). Thus the livelihood outcomes of smallholder rural producers, who are working with research interventions that are driven by AIS concepts, will be impacted upon indirectly by changes at the macro-economy through the price transmission mechanism of the maize market. Furthermore the effects of greater market linkages creates complexities for rural households because they are both producers and consumers hence their livelihood outcomes are affected by both demand side and supply side factors (Chirwa, 2010). This entails that an increase in the market price of the staple food crop maize would mean an increase in income for households that are producers of the crop but for consumers the increased price would mean a decrease in incomes as food would be more costly. For households that play the dual role of both consumer and producer, the impact of such a market price change entails that they can be affected from either the supply side or demand side. In addition, Quisumbing (1996) has demonstrated that price increases of predominantly staple food crops often lead to farming households using the crop as a cash crop at the expense of home consumption. Hence the way in which market forces impact households that play the dual role of consumer and producer depends to a large extent on the nature of their livelihood portfolios (Chirwa, 2010) as well the control of resources and decision making at the household level.

The implications of these inter-linkages and rural household complexities are that research interventions that are driven by AIS cannot work in isolation from either agricultural sector policies or other macro-economic policies. Hence in order to generate credible evidence of the impacts of the use of AIS research and development, it is essential to go beyond quantification of household level impacts.

Therefore given these considerations this study tested the following as a second hypothesis:

The degree to which rural livelihood outcomes are affected by policy shocks; which transmit through maize market prices; will to a large extent depend upon the socio-economic characteristics of the household; participation in AIS driven l research interventions as well as the nature of macro-economic and agricultural sector policy coordination.

In summary, the objectives of this study are as follows:

1. To quantify the impacts of AIS driven research interventions on rural livelihood outcomes.
2. To determine the effects of the resultant greater linkages to the macro-economy and to demonstrate the impacts of uncoordinated policy making and implementation on rural livelihood outcomes for participating households.
3. To better understand maize price formation and the inter-linkages between maize markets at the national, local and farm/household level.
4. To formulate relevant policy recommendations for informing food and agricultural policy development and for agricultural research programme formulation and implementation.

1.4 STUDY OUTLINE

The rest of the thesis has been structured as follows. Chapter 2 provides a comprehensive review of the literature pertaining to rural livelihoods and innovation systems. Chapter 3 outlines the theoretical foundations on which macro-micro modelling is founded and on which this study is based. Chapter 4 presents the empirical results of the impact of agricultural research innovation systems interventions on rural livelihoods, thus providing a proof for the first hypothesis. Chapter 5 gives insight into the dynamics of the maize commodity market in order to show the mechanism through which policy effects are translated to households from the macro-economy to the micro-economy, and to better understand price formation in the country. Chapter 6 presents a simulation analysis of a combination of macro-economic and agricultural policy shocks in order to demonstrate the potential dangers of the lack of coordination between microeconomic, sectoral and macro-economic policies on rural livelihood outcomes. Chapters 5 and 6 serve to provide the proof of the second hypothesis of this study. The thesis concludes with Chapter 7, which provides a summary of all the findings from the study, the conclusions, policy recommendations and future areas of research.

CHAPTER 2

RURAL LIVELIHOODS AND AGRICULTURAL INNOVATION SYSTEMS

2.1 INTRODUCTION

This chapter presents a comprehensive and critical appraisal of the literature pertaining to the concepts of rural livelihoods and agricultural innovation systems. The first part of the chapter aims to provide a greater understanding of the concept of rural livelihoods. The second part provides an insight into the concept of agricultural innovation systems followed by a section that provides examples of the use of innovation systems in agricultural research and development in Africa. Lastly the chapter concludes with a review of the literature that critiques the use of innovation systems in agricultural research and development.

2.2 UNDERSTANDING RURAL LIVELIHOODS

A livelihood is a means by which a household obtains a living for their survival. It differs from mere income in that a livelihood comprises all available resources. These resources include the natural, physical, human, financial and social assets; the activities that the household or individual engages in; and the accessibility to those resources and activities as facilitated by the existing institutions and social relations that jointly determine the livelihood outcomes (Ellis, 2000). In rural African communities, livelihoods are based on a complex system in which agriculture and natural resources are the centre for survival. As such, the diversification and sustainable utilisation of the natural resource base is essential for the long-term viability of rural livelihoods (Bryceson, 2000; Ellis, 2000).

The complexity of a livelihood system is described by Niehof (2004) as being one that is composed of separate components which must be in place in order for the household to obtain a living from the available assets. The first component of any livelihood system is inputs, which are the different types of resources. In the case of agricultural-based communities, these would comprise of natural resources, such as water, forests and land. These inputs are transformed into livelihood outcome using different strategies and efforts that the household exerts in order to obtain the livelihood outcome. The transformation of inputs into livelihood outcome takes place within a context in which the livelihood system interacts with other systems and existing institutions. This context includes all aspects that make the livelihood system vulnerable and it includes the greater policy, political and environmental context.

The inputs are combined differently through various strategies and this makes up the livelihood portfolio. The different activities in a household's livelihood portfolio are often complimentary and, although actual written farm business plans do not exist in many rural settings, the household plans extensively in order to determine the type of activities that make up the livelihood portfolios. This process of planning is crucial and determines not only the livelihood outcomes but also the control and utilisation of available resources, which in turn determines the intra-household vulnerability of different household members. The combination of activities in the livelihood portfolio is done in such a way as to reduce the vulnerability of the livelihood outcomes to shocks arising from the environment. In many rural households in which the basic needs of food, shelter and clothing have not been met, the driving force or purpose for generating a livelihood is to meet these basic human needs. A livelihood system is deemed sustainable when it is able to improve the assets of the household and to maintain its ability to provide for the household not only in the present but also for the future, while at the same time not undermining the natural resource base (Farrington, *et al.* 1999).

Complex livelihood systems have been in place since time immemorial in different societies all over the world. They differ depending on spatial, geo-political, cultural and social conditions (Ellis, 2000). In Malawi, rural livelihoods are characterised by a narrow range of risky and low productive activities (Dorward & Kydd, 2004) that are made more vulnerable by poor infrastructure, low education and literacy levels, and poor health (Peters, 2006). Another distinct feature of livelihoods in Malawi is that the majority of farmers within the maize-based farming system are faced with seasonal food shortages which they overcome through the utilisation of residue moisture in the short dry winter season (Mloza-Banda & Banda, 2003). Like many other rain-fed farming systems in Africa, livelihoods in Malawi are characterised by low access to agricultural services such as inputs, markets, extension and low resource endowments (Dixon & Gulliver, 2001).

In post-colonial Malawi, the single-party government closely controlled rural household economies through the regulation of the pricing and marketing of agricultural inputs and produce, as well as the regulation of the type of cash crops grown. These controls led to both positive and negative livelihood outcomes. On the negative side, they limited the opportunities faced by rural producers and discouraged private-sector involvement in the agricultural marketing of inputs and produce. On the positive side, the government ensured the availability and affordability of the staple food crop maize for urban consumers while guaranteeing an output market for rural producers (Chirwa, 2010).

2.3 THE CONCEPT OF AGRICULTURAL INNOVATION SYSTEMS

An innovation system is a network of actors and organisations that are linked by a common theme with the aim of developing new agricultural technologies, methods and forms of organisation for use by the end users of agricultural technology to tackle identified problems (World Bank, 2007b). An innovation system is governed by the prevailing institutions and policies that affect performance of the actors involved and the regulation of the technologies developed (World Bank, 2007b). Agricultural innovation systems are therefore research platforms whose main focus is solving challenges pertaining to agriculture. They consist of interdisciplinary research teams of agricultural scientists from both private and public sectors working with the end users of agricultural technologies as well as other relevant stakeholders such as agribusiness owners, policy makers and extension agents. The innovation systems concept embraces not only the scientists who are traditionally involved in agricultural research but also the end users of technologies and the interactions that take place between all the actors in the research process (World Bank, 2007b; IAC, 2004:141).

A representation of an agricultural innovation platform is given in Figure 2.1. The agricultural innovation platform represents an interface where different actors, including interdisciplinary teams of scientists, end users, extension agents, agribusinesses, and other stakeholders, interact in order to identify agreed-upon problems for which innovations need to be developed. The interaction in the innovation platform is non-linear in nature with the different actors networking freely with a component for institutional and human capacity development being key (Jones, 2008). Once problems are identified, actors work together to develop and adapt technologies to the local environment. This leads to improved production and ultimately, enhanced livelihood outcomes.

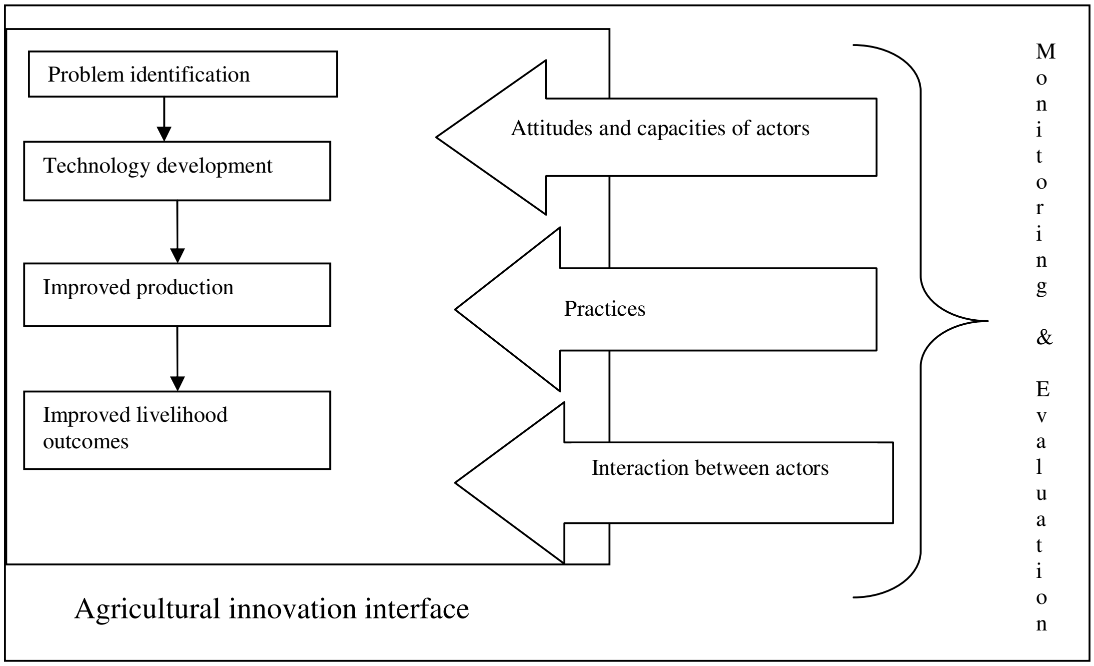

Figure 2-1: Representation of an agricultural innovation platform
(Source: own compilation)

Throughout this process, there is constant feedback using mechanisms that are put in place at the onset of the innovation platform. In addition, changes in the attitudes, knowledge, skills, practices, and interactions taking place between actors are monitored. The results of evaluations of these aspects are used to develop strategies for improving the capacity of actors to enable them to improve their innovation.

There are many forms of innovation, which can also exist in different sectors. Rural innovation in the sphere of agriculture is based on the concept that research programmes should work towards identifying the needs of producers and determine how they utilise knowledge either at the farm or enterprise level (GFAR, 2001). This entails a shift in the research paradigm from the transfer of knowledge that is generated by research, to research on how knowledge itself is utilised and translated into outcomes by the end users. Furthermore, innovation in the agricultural sphere is conceived as an increase in productivity or competitiveness for a given product; with the improvement in productivity or competitiveness arising from a change in either the production technology or marketing strategy. Innovation is desired to either introduce a new agricultural product on the market or to ensure that producers may become more competitive with an existing product, thus gaining access to more lucrative markets (GFAR, 2001). Hence, rural innovation essentially puts agro-industries as the basis for socio-economic development in rural areas.

Furthermore, the concept of rural agricultural innovation is rooted in the philosophy that thinking should shift from a farm or production systems perspectives, in which the ultimate goal is to produce sufficient food for subsistence, to an agribusiness perspective, in which the goal of agricultural production is to create rural agro-enterprises (Njuki, *et al.* 2008; Kaaria, *et al.* 2008, GFAR, 2001) that create employment and income. This would fulfil subsistence food requirements and achieve food security and the creation of thriving rural economies.

The concept of agricultural innovation is not new. Rather, it is a continuum of experiences and approaches from past agricultural research paradigms. According to Hall (2002), origins of the concept of innovation systems can be traced back to the notion of national systems of innovation. In the 1990s, the Agricultural Knowledge and Information Systems (AKIS) concept dominated practice and conceptualisation of agricultural research (World Bank, 2007a). AKIS focused on the linkages between research, education, extension and the identification of farmers' priorities for new technologies. AKIS recognised that apart from research, there are other ways of generating and gaining access to information. This included scientists building research agendas upon indigenous or rural technical knowledge which encompassed the knowledge, beliefs and customs that people innately possess (Farrington & Martin, 1988).

The incorporation of rural and indigenous technical knowledge in the agricultural research processes was the result of experiences and assessments of agricultural research of the 1980s, at a time when participation of farmers took precedence. Farmer Participatory Research (FPR) was implemented mainly through the National Agricultural Research System (NARS). FPR dominated agricultural development and research and involved farmers to a great extent in technology development (Okali, *et al.* 1994). FPR can be seen as the base on which current agricultural innovation systems are founded as the FPR concept aimed at not only generating and disseminating technologies but also at changing the orientation of research and development structures in order to build grassroots research capabilities (Okali, *et al.* 1994). The NARS, which used FPR as a means of linking with farmers, involved the strengthening of research supply through the provision of infrastructure, capacity development, and management and policy support at national levels (World Bank, 2007a).

The commonality between the NARS and AKIS was that both focused on research supply which strengthened research systems. However, the increased supply of new knowledge in itself was an insufficient condition for creating greater capacity for innovation in the agricultural sector (Rajalahti, *et al.* 2005). Additionally, the NARS approach assumed a linear relationship in the transfer of knowledge from the researcher via extension to the farmer under the assumptions that the institutions through which this process was taking place were stable (Spielman, 2005:9). AKIS remedied some of the shortcomings of the NARS approach, as it incorporated the processes of knowledge flows. However, AKIS failed to take into account the diversity of research actors (Spielman, 2005:10).

As such, the paradigm shift in agricultural research practice and conceptualisation from the NARS and AKIS to the prevailing agricultural innovation systems concept was the result of these limitations and the realisation that, without the actual intellectual involvement of the end users of agricultural technologies, attempts to develop new technologies and to increase their dissemination and adoption would be futile. In the African context, this research approach has largely focused on enabling mainly subsistent and semi-subsistent households to innovate for the market; thus shifting their livelihoods from a subsistence orientation to one of market orientation.

In general innovation systems are transitory in the sense that the actors that come together under an innovation platform will move on after the objectives they set out to achieve have been met (Daane, 2010). In addition they are context specific and as such although the key principles remain the same, the practical manifestation will differ depending on the actors involved and their capacities, the objectives of the innovation platform as well as the social, economic and environmental context within which the innovations systems is established. Because of this, it is therefore important to understand the specific innovation system that is under study. This study used the Enabling Rural Innovation (ERI) initiative as a case study. ERI was an agricultural research innovation system that was developed by the International Centre for Tropical Agriculture (CIAT). It was piloted in three districts in the Central Region of Malawi; one of which is the Lilongwe District in which this study was conducted. ERI was an innovative research framework for linking smallholder farmers to markets and its focus was on strengthening the capacity of resource-poor smallholders to access market opportunities. Sanginga & Chitsike (2005) and Ferris *et al.*, (2006) provide in depth guidelines on the use of ERI as a framework for implementing research and development programs. They also provide insight of the roles of different players within the innovation interface from Figure 2.1.

The main aim of the ERI initiative was to create an entrepreneurial culture in rural communities of Africa (Kaaria, *et al.* 2008; 2009).

The ERI approach was driven by innovation systems concepts as described above (e.g networks of different actors) and it was governed by the resource to consumption framework, which, according to Kaaria *et al.* (2009), has the following principles:

1. Technology development and research agenda setting is based on the needs and interests of the beneficiaries as well as available resources and market opportunities.
2. Technology development is guided by a comprehensive beneficiary diagnosis that aims to identify the variations in intra-household allocation and control of resources with the aim of understanding the constraints and opportunities to technology adoption and reinvestments in natural resources.
3. Gendered differences in roles and perceptions and differences of roles between stakeholders are explicitly integrated into the technology development process to ensure equity in accessing the technology as well as in the distribution of benefits.
4. The approach builds a community's skills in identifying and analysing market opportunities and, in so doing, enabling community's to match existing market opportunities with the available community assets.

In addition, the ERI approach had six key components that governed its field implementation (Kaaria, *et al.* 2009) as follows:

1. *Agro-enterprise development and participatory market research.* The focus is on building skills and knowledge of community members, farmer organisations and local service providers to allow them to engage effectively with markets.
2. *Farmer participatory research and natural resources management.* Involves the decentralisation of research agenda setting to the communities through the creation of farmer research committees who articulate the demands of the community and who ensure adapting of technologies to suit local conditions.

3. *Social and human capital*. Group development is nurtured in order to ensure effective performance of local farmer organisations, thus strengthening the social and human capital in the communities.
4. *Gender equity and empowerment of women.* This is an integral part of the ERI process and involves the use of proactive strategies and gender sensitive facilitation skills to ensure that the capacity of both men and women is enhanced.
5. *Community-based participatory monitoring and evaluation systems.* These are put in place to enhance group functioning, participation as well as to improve local decision making. This involves the development of measurable indicators by the communities; which can be used to measure change.
6. *Effective development and management of partnership*. The ERI approach aims to build effective local partnerships between relevant stakeholders who have a working relationship with communities and those who have the potential for scaling up the use of the ERI approach.

Using the ERI guiding principles, CIAT established one of three pilot innovation platforms in Malawi in the Ukwe Extension Planning Area (EPA) in Lilongwe District. This consisted of a multi-disciplinary team of CIAT social scientists; extension agents from the Department of Agricultural Extension Services as well as local extension staff based in the community; researchers from the Department of Agricultural Research Services; and other agricultural social scientists from the Ministry of Agriculture based in Lilongwe Agricultural Development Division. The innovation platform worked together to select an appropriate community within the EPA for piloting the ERI initiative based on a criteria that included all year-round road accessibility; availability of a motivated local-level extension agent; willingness of other development partners working in the community to take an active role in the initiative; and the existence of interest in the community for further agricultural research and development (Sangole, *et al.* 2003).

Once the community was selected, the innovation platform, together with the community, conducted a participatory diagnosis of the community challenges and opportunities. This process was the initial way of engaging the communities in order to sensitise them to the ERI initiative and also to develop a shared vision for the future of the community (CIAT, 2007). The outcome of the participatory diagnosis was the development of a collective plan of action for overcoming identified problems using available community resources and assets.

After the participatory diagnosis, the Ukwe innovation platform implemented the community action plan by starting with the formation of farmer research and market groups within the community. The leaders from these groups represented the community in the innovation platform. This was followed by a participatory market analysis of existing market opportunities which culminated in the selection of an agro-enterprise based on existing social and wealth differences as well as gender preferences within the community. The selected farmer market group was trained in market research. In the study area, piggery was chosen as the agro-enterprise to be developed as a cash enterprise and maize as the food security enterprise. Finally, the innovation platform through the farmer research groups planned and implemented simple research experiments around various other agro-enterprises. This was done in order to build capacity of the community to conduct research experiments to enable them to better understand their farming enterprises and, in so doing, to demystify the process of agricultural research experimentation and hence build their ability to innovate. Apart from the ERI initiative, the study community also had on-going government extension programs.

2.3.1 Innovation systems practice in African agriculture

Apart from the ERI initiative which was piloted in several countries including Malawi by the International Center for Tropical Agriculture (CIAT) and which is used as the case study in this research; there are many other agricultural research and development initiatives on the continent that are driven by innovation system concepts. These innovation system interventions are context specific and are initiated to meet specific goals but they are all guided by innovation systems principles. Table 2.1 provides examples of some of the initiatives, agricultural research and development programs in Africa that are driven by innovation systems concepts. Table 2.1 is not exhaustible as there are numerous initiatives in agricultural rural innovation in Africa (Hall, 2007:10). The various programs and initiatives in Table 2.1 show that there is a wide diversity of the application of innovation systems in Africa. Despite this diversity, the goals of the programs show that innovation systems concepts are mainly applied in the African context in order to promote and enhance the commercialization of traditionally low productive subsistence agriculture.

2.3.2 Studies of agricultural innovation systems in Africa

From Table 2.1, it is possible to see that the use of innovation systems concepts in agricultural research and development; and policy has become widespread in Africa. Despite this, empirical studies that show quantitative improvements in household welfare arising from the use of innovation systems concepts in agricultural research and development are rarely found. However there are a few studies that exist. Kaaria *et al.* (2008) assessed the use of the Enabling Rural Innovation (ERI) initiative, an innovative agricultural research approach for linking smallholder farmers to markets and for improving livelihood outcomes, using case studies from Uganda and Malawi. The study employed multiple regression modelling to assess the determinants of income amongst rural households in two pilot sites. The results indicated that greater linkages of farmers to markets improved household incomes. The improved incomes led to farmers accumulating more household assets and increasing their investments in their farm enterprise.

Other studies by Kaganzi *et al*. (2009) demonstrate that using an iterative market-led learning process based on innovation systems concepts and applied under the ERI initiative led to small-scale farmers in south-western Uganda being linked to high value markets. Using the innovative approach of developing agro-enterprises under the ERI framework, smallholder farmers were able to enter the market and sustainably meet rigorous quality requirements for the market. Barham & Chitemi (2009) evaluated an innovative agricultural development approach called the Agricultural Marketing Systems Programme, which uses innovation systems concepts to strengthen the marketing abilities of producer groups in Tanzania. Using differencing techniques, the study shows that the innovative intervention led to statistically significant improvements in the marketing performance of farmer groups. However, groups that were better off in terms of natural resource endowments were more likely to be successful in being effectively linked to the market, as compared to worse off farmer groups.

Table 2.1: Selected examples of innovation systems driven initiatives in Africa

Name of AIS initiative	Country	Main goal	Lead institute	Actors involved
Enabling Rural Innovation (ERI)	Malawi, Uganda, Zimbabwe, Mozambique, Rwanda, Burundi, DR Congo	To improve the livelihoods of households through the creation of rural agro-enterprises	International Centre for Tropical Agriculture (CIAT)	Various actors in each country and in specific research sites. These included local farmer groups, government (rural sector support project), private and government research services (International Service for National Agricultural Research, DARS), private sector, NGO's (CARITAS, Plan, Africare, Africa2000Network, academia)
Partnership for Agricultural Development (PIAD) or the National Innovation Coalition	Sierra Leone, Malawi, Rwanda, Zambia, Nigeria, Tanzania	A national innovation coalition that works to advocate policy makers	Research Into Use (RIU)	Various representatives from various government departments, NGO's in various innovation platforms that have been established in each country (over 30 innovation platforms exist in the six countries)
Floriculture Agricultural Science Technology and innovation systems	Kenya	Aims to maintain competitiveness of the cut flower industry in Kenya		Flower farmers, research and training institutions, credit and finance institutes, government agencies, input suppliers, industry associations, bureau of standards
Sustainable intensification of maize-legume cropping systems for food security in Eastern and Southern Africa (SIMLESA)	Malawi, Zimbabwe, Mozambique, Ethiopia, Kenya, Tanzania, Uganda, South Africa	An agricultural research initiative that aims to use innovation platforms to test and promote new agricultural practices	International Maize and Wheat Improvement Center (CYMMT)	National Agricultural Research Services; Australian Centre for International Agricultural research; Murdoch University; Queensland Department of Employment, Economic Development and Innovation; Ministries of Agriculture and Food Security; International Crops Research Institute for the Semi-Arid Tropics; South Africa Agricultural Research Council; Association for the Strengthening Agricultural Research in Eastern and Southern Africa
Promoting Local Innovation (PROLINNOVA)	Burkina Faso, Ethiopia, Ghana, Kenya, Mali, Mozambique, Niger, Nigeria, Senegal, South Africa, Sudan, Tanzania, Uganda	An NGO initiated program that aims to build a global network to promote local innovations in agriculture	Various NGO's	Donors include the Netherlands Government and the Rockefeller foundation. Working partners and donors include World Bank Indigenous Knowledge (IK) program; Action Aid International; CGIAR; Technical Centre for Agriculture (CTA); Duras project, Global Forum on Agricultural Research; International Fund for Agricultural Development; Misereor; Swiss Centre for Agricultural Extension
Fodder Innovation Project (FIP)	Nigeria	Aims to strengthen the technical capacity of fodder practices thus increasing livestock fodder to improve the livelihoods of peoples that are dependent on livestock	International Livestock Research Institute(ILRI)	The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT); The International Institute of Tropical Agriculture (IITA); United National University –Maastricht Economic and Social Research Institute on innovation and Technology (UNU-MERIT)
Sub-Saharan Africa Challenge Program (SSA-CP)	Zimbabwe, Malawi, Mozambique, Rwanda, Burundi, Uganda, the Sahel, Sudan, Northern Guinea	An innovation systems driven agricultural research framework that encourages the engagement of various actors in the value chain in order to promote innovation in an agricultural system	Forum for Agricultural Research in Africa (FARA)	Various partners in each country/pilot learning site and region including farmer originations, national agricultural research institutes and International Agricultural Research Centres, Universities

Magreta *et al*. (2010) used participatory gross margin analysis to demonstrate how linking farmers to markets using innovation systems concepts in agricultural research improved farmer's livelihoods through increased gross margins in the rice-based farming systems in Southern Malawi. Increased incomes from rice marketing led to improvements in household food security, asset accumulation and housing.

Although studies that aim to assess the use of innovation systems in agricultural research and development are few and mainly qualitative in nature; as a collective they demonstrate that innovation systems concepts foster the creation of linkages between rural households and the market economy. These linkages entail the strengthening of market involvement of rural households and greater exposure of the household to macro-economic shocks.

2.3.3 Skepticism surrounding Agricultural Innovation Systems

As innovation systems concepts have become widespread in African agricultural research and development, there has also been the emergence of challenges and criticisms. This section presents the three broad challenges and criticisms of the use of innovation systems concepts in agricultural research and development in the African context.

Firstly, the use of innovation systems concepts in African agriculture is confounded by significant operational challenges brought about by the lack of practical guidelines for translating the key principles of innovation systems into practical use for the varied contexts of African agricultural systems (Ergano *et al*., 2010). This is because the use of innovation systems in African agriculture is at an early stage. At the same time, innovation systems evolve in response to the context in which they are being applied. Hence this entails that practical guidelines covering the diversity of African agriculture are unlikely to be developed. The operational challenges of the use of innovation systems concepts in African agriculture is more, therefore, a reflection of the lack of capacity on the part of practionners to fully comprehend, use and translate innovation systems concepts in the African agricultural context.

Second, there is lack of sufficient resources to support rural innovation. This arises from the 'smallness of the market for smallholder innovation' which makes it difficult to attract private investment (Jones, 2006). This has further been confounded by a reduction in agricultural research funding from both international and national sources due to disappointment with the impacts of agricultural research in the past (Jones, 2006; Igbatayo, 2010). Apart from the reduction in funding for agricultural research and development, Hall (2007a) further argues that both private and public investment have not fully responded to the paradigm shift in agricultural research and development towards an innovation systems orientation. This he attributes to the inability of innovation system advocates to create a functional, consistent and influential platform for lobbying public policy makers and private investors. Instead what one observes in practice is pockets of different and competing innovation systems interventions that are implemented at relatively small scale (e.g. at farmer group level) which sometimes fail to be scaled up and out.

Thirdly, the inability of agricultural innovation systems in Africa to attract funding can be linked to the lack of empirical evidence that provides conclusive policy recommendations and which shows the usefulness of innovation systems in African agriculture (Spielman, 2006). This lack of evidence is the result of the difficulties associated with measuring the complexities of agricultural innovation interactions and performance (Spielman & Kelemewonk, 2009). These complexities result into the use of non-diversified descriptive methods to assess the outcomes of the application of agricultural innovation systems in the developing country context (Spielman, 2006). The problem with this is that evidence generated from such assessments is not relevant for policy makers as it does not provide concrete policy recommendations to allow for the development and implementation of strategies nor does it facilitate the allocation of resources for promoting the use of innovation concepts in agriculture by policy makers (Spielman, 2006; World Bank, 2007b; Spielman & Kelemewonk, 2009). Hence in order for innovation systems thinking to become relevant to policymaking and to contribute towards poverty reduction, there is need to generate robust empirical evidence.

Despite the criticisms and challenges to the use of innovation systems in African agriculture, the focus by the global agricultural research and development arena and policy makers worldwide is on innovation and innovation systems (Hall, 2007); as a key in unlocking African agriculture and in creating self-sustaining agricultural systems. However in order for innovation systems to be effective in this regard, there is need to harness the diversity of innovation systems experiences and conceptualization to create a diverse but unified platform of what Hall (2007a) terms collective innovation or innovation diversity. One component to working towards this collective innovation; is understanding the impacts of the use of innovation systems in different contexts on the continent. As this would enable the creation of context specific evidence on which effective unified platforms for lobbying policy makers would be created. This study is one step towards that.

2.4 CHAPTER SUMMARY

In conclusion, this chapter has demonstrated that the importance accorded to innovation systems in agricultural research has only begun to be tangibly demonstrated by empirical evidence. The available empirical evidence consists mainly of household-level evaluations of changes in livelihood outcomes arising from the use of innovation systems in African agricultural research and development initiatives. Studies that go beyond the household level to assess the consequences of greater innovation and the resultant market linkages are not found in literature. Herein lies the uniqueness of this study, which; in addition to quantifying the household level effects; aims to quantitatively assess the impact of macro-economic and agricultural sector policy shocks and policy sequencing on rural smallholders, given the work of agricultural research interventions that are driven by innovation systems concepts. In so doing, the study will contribute to the on-going debate about the role of innovation systems in promoting agricultural and rural development in Africa.

CHAPTER 3

ANALYTICAL FRAMEWORK

3.1 INTRODUCTION

This study employs a macro-micro approach to meet its set objectives. This chapter presents the technical details and the theoretical foundations on which macro-micro modelling/analysis is based. This is achieved by firstly providing detailed theoretical foundations for the micro-component of the macro-micro model developed for this study, followed by a general overview of the macro-component. An in-depth description of the latter is provided in Chapter 5. The last section addresses how linkages are established and how consistency is achieved between the macro and micro components.

In any macro-micro study, it is important to contextualise the terms "micro" and "macro", as they can have different meanings in different contexts. Macro, in this study, does not refer to macro-economic policies; but refers to the integrated national maize market in Malawi; which is a country level "market" with many components that make up the Malawi maize sector. The micro component is the household level which consists of individual rural farming households engaged in the production and marketing of maize. The rural household economy modelled in Chapter 5 can be regarded as the meso-level found between the national maize market and rural farm household.

3.2 THE MICRO-COMPONENT

A full structural estimation of household behaviour that takes into account different aspects of a household's complete activities, such as consumption, production, labour supply and other social economic activities, is not econometrically possible (Cogneau & Robillard, 2004) – although theoretically possible. Instead, common practice is to focus on modelling the aspects of the household's behaviour that is relevant for the study. This study is mainly concerned with assessing the impact of macro-economic policy changes and agricultural prices policies on household incomes. Therefore, at the micro level, the focus is on estimating incomes for different rural household groups.

In rural Malawi, household income is not synonymous with cash wage income, but is rather a computed value that consists of wage income, income earned from self-employment and the imputed value of crops and livestock kept for home consumption. In this study, aggregate income constituted ten different income sources (Chapter 4). In such cases, household income estimates comprise a system of equations that consists of the earnings equation for household members who are of working age and who therefore contribute economically to the household; self-employment equations that estimate the potential income that can be earned from self-employment; and occupational choice equations that describe the allocation of time by individuals within the household who are of working age between wage employment, self-employment and non-farm/non-labour time.

The methodology for estimating rural household income is given below. This is adapted from the work of Bourguignon *et al*. (2001) and Robilliard *et al*. (2001), which was further adapted by Alantas and Bourguignon (2004):

Let y_{it} denote household income for household i at time t. It is assumed that income (y_{it}) depends through a function $Y(\;)$ and there are four main arguments governing the relationship:

i) The observed and unobserved socio-economic characteristics of different household members denoted x and ε, respectively.

ii) The set of remuneration prices at which these characteristics are given in the labour market (β).

iii) A set of parameters that define the participation and occupational choices of different household members (λ).

Given this, household income can be expressed as follows:

$$y_{it} = Y\left(x_{it}, \varepsilon_{it}, \beta_t, \lambda_t\right) \qquad (3.1)$$

The following four equations provide a decomposition of Equation 3.1:

$$Logw_{mi}^{t} = X_{mi}^{t}\beta^{t} + u_{mi}^{t} \;\;;\;\; i = 1,\ldots k_m \qquad (3.2)$$

$$L_{mi}^{t} = Ind\left[X_{mi}^{t}\lambda_{1X}^{t} + Z_{mi}^{t}\lambda_{iZ}^{t} + v_{mi}^{t}\right];\; i = 1,\ldots k_m \qquad (3.3)$$

$$L_{mi}^{At} = Ind\left[X_{mi}^{t}\lambda_{2X}^{t} + Z_{mi}^{t}\lambda_{2Z}^{t} + v_{mi}^{Ai}\right];\ i = 1,...k_{m} \quad (3.4)$$

$$L_{mi}^{NAt} = Ind\left[X_{mi}^{t}\lambda_{3X}^{t+} + Z_{mi}^{t}\lambda_{3Z}^{t} + v_{mi}^{NAt}\right];\ i = 1,...k_{m} \quad (3.5)$$

Equation 3.2 is a typical Mincer earnings equation and it gives the log of the wage earnings[3] for individual household members (i) for a specific household (m) expressed as a function of a set of personal characteristics (X). u_{mi}^{t} is the residual term and it describes the effects of unobserved determinants of wage earnings. Earnings are modelled as a function of personal characteristics of only those household members who are able to earn an income. This enables the capturing of the heterogeneity of earnings within different income groups which may arise due to differences in socio-economic characteristics (Ahmed & Donoghue, 2010).

Equations 3.3, 3.4 and 3.5 represent the occupational choices available to each household member who contributes towards household income. In this study, there are ten different sources of income that were regrouped into these three occupational choices. Firstly, salaried employment included both on and off-farm income falling under Equation 3.3 (L_{mi}^{t}) represents the labour supplied by a household member i as a wage earner outside the household. Second, the real and imputed income from all upland crops except maize, livestock income, income from wetlands and the real and imputed value of maize falling into Equation 3.4 (L_{mi}^{At}). This represents all labour supplied by a member of the household i on the farm that the household owns and cultivates. Third, non-agro based commercial enterprises and agro-based commercial enterprises of the household falls under Equation 3.5 (L_{mi}^{NAt}), which represents the labour supplied by a household member i on the family's non-farm/non-labour income-generating activities. The v_{mi}'s are the residual terms and they represent the unobserved factors that determine household members occupational choices.

The co-efficient estimates for the occupational choices of different households members (λ) are represented by the X_{mi}'s and Z_{mi}'s and, as can be observed from the three occupational choice equations, these are common for all individuals within a household. However, these

[3] The Mincer earnings equation is commonly a log-linear function because it is an empirical operationalisation of the human capital model. The human capital model stipulates that individuals invest in human capital up to a point where investment costs just equal the present value of schooling gains. This implies that during the post school phase, levels of investment in human capital decline monotonically until it reaches zero at retirement. Since potential earnings are proportional to human capital stock, it implies that potential earnings also increase at a decreasing rate over a life cycle. The log-liner earnings wage function is therefore the empirical application of the linear declining post-school investment theory. See Lemieux (2006) and Polackek (2007) for details.

may differ across demographic groups' i.e. between male and female household members or between older and younger household members. The vector Z captures the household characteristics that include mainly the productive assets such as land; while X is a vector of the standard human capital variables such as years of schooling and access to trainings.

A review of the literature shows that many studies include in the vector for household characteristics, different variables such as area of residence, demographic composition of the household, resource endowments, the incomes of other household members, and human capital as well as consumers preferences (Robillard, *et al.* 2001; Kuepie, *et al.* 2007; Ahmed & Donoghue, 2010). However, other estimations of labour income include additional variables that have the potential to lead to household heterogeneity such as market access (Lay, 2006), labour market experience, occupation of the household head and other income source variables (Ferreira, *et al.* 2003). De Hoyos (2005) goes further to create subsets of the Z vector that take into account gendered differences of the male and female household members. Thus, in addition to the standard variables, he includes in the subset for female household members the number of children in the household and the sex of the household head.

This study goes beyond any of these studies in that the vector for household characteristics, differentiated households further by capturing their participation in the ERI initiative. This is achieved by creating subsets for participating and non-participating households that contain identical household characteristic variables, with the only difference being participation in the ERI initiative (the case study innovative agricultural research intervention for this research). The inclusion of participation in the ERI initiative in Z captures heterogeneity of households that may be created by changes at the household level arising from participating. Since the ERI initiative is rather recent, it is unlikely that other studies in literature have incorporated such a parameter in the estimation of occupational choices. The subsets in Z are presented by the notation e and Equations 3.3 to 3.5 can be rewritten as follows:

$$L_{mi}^{t} = Ind\left[X_{mi}^{t}\lambda_{1X}^{t} + Z_{mie}^{t}\lambda_{iZ}^{t} + v_{mi}^{t} \right]; i = 1,...k_m ; \quad e = \begin{cases} 1 ERI-participation \\ 0 ERI-nonparticpation \end{cases} \tag{3.6}$$

$$L_{mi}^{At} = Ind\left[X_{mie}^{t}\lambda_{2X}^{t} + Z_{mie}^{t}\lambda_{2Z}^{t} + v_{mi}^{Ai} \right]; i = 1,...k_m ; \quad e = \begin{cases} 1 ERI-participation \\ 0 ERI-nonparticpation \end{cases} \tag{3.7}$$

$$L_{mi}^{NAt} = Ind\left[X_{mie}^{t}\lambda_{3X}^{t+} + Z_{mie}^{t}\lambda_{3Z}^{t} + v_{mi}^{NAt} \right]; i = 1,...k_m ; \quad e = \begin{cases} 1 ERI-participation \\ 0 ERI-nonparticpation \end{cases} \tag{3.8}$$

The labour supply parameter λ has three subsets (λ_1 for wage labour; λ_2 for self-employment; and λ_3 for non-farm/non-labour income) that differ depending on the household member under consideration.

Occupational choices are all modelled as a discrete logit model in which the household member has only two choices to either supply labour or not to supply labour. Labour is modelled as a discrete variable because the actual number of working hours per household member in each occupation is not captured (Robilliard, *et al.* 2001; Alantas & Bourguignon, 2004). This modelling technique is represented in the three occupational choice models by the notation *Ind*.

The aggregate household income is then obtained using an accounting identity that sums the wage income, earnings from self-employment (value of own production) and non-labour income as well as an exogenous variable for incomes earned from remittances and other cash transfers.

Aggregate rural household income can therefore be presented as follows:

$$y_m^t = \sum_{i=1}^{k_m} L_{mi}^t w_{mi}^t + \prod\nolimits_A^t \left[Z_m^{Tt}, \sum_{j=1}^{k_m} L_{mi}^{At}, s_A^t, \beta_A^t \right] + \prod\nolimits_{NA}^t \left[Z_m^{Tt}, \sum_{j=1}^{k_m} L_{mi}^{NAt}, s_{NA}^t, \beta_{NA}^t \right] + y_{0m}^t \qquad (3.9)$$

Where:

$\prod_A^t$ Profit function for self-employment income (value of own production)

$\prod_{NA}^t$ Profit function for non-farm/non-labour income

y_{0m}^t Exogenous variable representing transfers of income (remittances)

s_A^t and s_{NA}^t are the residuals of the profit functions which can represent either the unobserved factors determining profits or measurement errors

Equation 3.9 shows that aggregate household income is a non-linear function of wage income, profits generated from self-employment, profits generated from non-farm/non-labour income, various occupational choices for different household members and an exogenous parameter from transfers (y_{0m}^t), and the observed household characteristics of different household members that are of income-earning age.

In this study, both the wage income and profits were observed and captured at the household level, and not on an individual household member basis. This therefore is equivalent to modelling household income for a household with only one member, i.e. the household head. As such, the household income model was reduced to an arithmetic function that involved the summation of the different sources of household income. The arithmetic estimation of income reduced the household income generation model to a simple micro-accounting model. This is feasible for this study as the shock to be implemented does not alter the occupational choices of household members. Micro-accounting is fully consistent with micro-economic behaviour but the estimated models can only be used for short-term and/or medium-term analysis, due to the lack of behavioural responses that make them unsuitable for long-term analysis (Bourguignon, *et al.* 2008).

3.3 THE MACRO-COMPONENT

In literature, the most commonly-used tool for macro-economic modelling in macro-micro analysis is the Computable General Equilibrium (CGE) model. This is evidenced by numerous macro-micro studies assessing macro-economic policy shocks on household incomes and income distributions (Thurlow & Van Seventer, 2002; Robilliard, *et al.* 2001; Bourguignon, *et al.* 2008; Ferreira, *et al.* 2003; Ahmed & Donoghue, 2010; Diao, 2010). However, any other type of macro-economic modelling techniques (e.g Vector Auto Regression (VAR) models, Dynamic Stochastic General Equilibrium (DSGE) models, Partial Equilibrium Models (PEM), Structural cointergration VAR models (SVAR)); can be used (Bourguignon, *et al.* 2010).

For this study, a partial equilibrium framework was chosen as a tool for modelling the national (macro-level) maize market in Malawi, as it is capable of reasonably approximating the general effects of agricultural policy changes where weak links between commodities and their supplier or output sectors exist (Perali, 2003). In addition the approach allows for dynamism in the analysis as one can simulate the impact of policies over time. Due to the complexities of constructing and solving dynamic CGE model; partial equilibrium approaches are more appropriate for Malawi as the latter provides a less generalised, more disaggregated and more realistic picture of the general effects of macro-economic policy changes. Partial equilibrium models can be either single-market or multi-market models that represent a system without linkages with the rest of the economy (Britz & Heckelei, 2008; Van Tongeren, *et al.* 2001). The effects of and/or effects on the rest of the economy and/or on other sectors can be included in a top-down approach (Van Tongeren, *et al.* 2001).

3.3.1 General structure of model and economic theory

A typical partial equilibrium framework consists of four blocks that are the supply, demand, trade and price blocks. Domestic supply in partial equilibrium models is the summation of domestic production and beginning stocks. According to economic theory, production or supply of an agricultural commodity is dependent upon farmers' willingness to produce the commodity based on expected prices (Ferris, 1998). Expected prices influence agricultural supply because of the biological nature of agricultural production, which leads to time lags between when decisions are made and when output is attained. In the Malawi case, the absence of a futures market and limited forward contracting, which both allow farmers to establish price at the time when production decisions are made (Ferris, 1998), entail that price expectations are formed on the basis of past prices. In rural areas of Malawi where markets are thin and where there is poor access to markets due to high transaction costs and poor transport logistics, producers receive prices that are lower than prices prevailing in the national maize market or in other more lucrative urban markets. The dependency on past prices entails that maize prices received by rural households are consistently lower.

Apart from expected own prices, economic theory further stipulates that the production of an agricultural commodity is influenced by the prices of competing and/or complementary commodities, the price of inputs or technology and climatic changes. In Malawi, the majority of smallholder maize producers are subsistence farmers who do not substitute maize for other crops regardless of the market prices. In addition, the maize-based farming system in Malawi is mainly a mixed farming system in which maize is intercropped with various grain legumes that are planted in much smaller amounts. These two characteristics of the maize-based farming system in the country entail that the inclusion of prices for competing or complementary commodities in the modelling of maize supply is computationally difficult. Changes in climatic conditions, especially those pertaining to variations in water availability such as rainfall and droughts, play a major role in maize production in the country; as agricultural production is highly dependent on rain-fed farming with little or no irrigation, thus making it highly susceptible to climatic variability. Dynamism in production is captured in the partial equilibrium model, as production is calculated as an identity that is dependent upon the area of maize planted multiplied by crop yields; thus incorporating the biological lags associated with agricultural production and climatic variability.

The domestic demand block is composed of domestic human consumption, seed and industrial use, and ending stocks. Economic theory stipulates that consumption of a commodity is affected by many factors with the price of the commodity, the price of substitutes, changing tastes over time and the income of the consumer being key (Ferris, 1998). In rural Malawi the majority of smallholder producers consume their own production with supplementation from the market to meet any shortfall in subsistence needs. This implies that maize consumption may not be very responsive to market prices. In addition, food baskets of rural households in the country are non-diversified, with maize being the main food crop with little or no substitutes.

Over time, empirical evidence shows that societies tend to move away from the consumption of grains such as maize. For Malawi, with a rising population and where the majority of the people are food insecure, any improvements in welfare over time leads to an increase in maize consumption, as consumers use any additional income to meet their subsistence food requirements. This is mainly the case for the rural population who form the majority of the country's population. As such, the effect of the trend variable on maize consumption in Malawi may not be in line with the existing empirical evidence. As mentioned earlier, incomes are also known to affect the demand for a commodity. In Malawi, smallholder farmers are both producers and consumers of maize. This implies that household incomes may not impact upon consumption as stipulated by economic theory. This is because an increase in the income of rural households may be the result of a rise in the amount of a crop that the household markets which may be done at the expense of home consumption. Hence in the case of Malawi, the duality of smallholder farmers as both producers and consumers of maize imply that maize consumption is confounded both by supply-side and demand-side dynamics.

The trade block consists of imports and exports with imports being estimated as a function of net exports and the summation of imports and net exports providing exports. This treatment of the trade block makes trade explicit but exogenous to the model. In addition, imports are also determined by a government's trade policy and parity prices which take into account the costs associated with importing a good from one country to another as well as exchange rates. In Malawi, maize trade is controlled by government, with public policies dictating the amounts of maize to be exported or imported. The trade block is closely linked to the price block as domestic prices are influenced by a country's trade policies (Meyer, 2006) as well as other government policies and the domestic demand and supply dynamics. In Malawi, maize prices are mainly determined by government policy, as prices have been under some form of control since Malawi gained independence. Despite this, regional and international maize prices have some influence on the domestic maize price as maize is often imported to meet domestic food shortages. This implies that regional and international prices have an effect on domestic pricing.

3.3.2 Equilibrium in an imperfect market

As stated earlier partial equilibrium analysis is the determination of equilibrium in a single market. According to economic theory, market equilibrium is achieved by the stabilizing effect of a competitively set price. In Malawi however, the government sets floor and selling prices for maize. Maize price interventions are not new to Malawi as the government has always controlled the marketing and trade of maize. Various policy options with direct price interventions have been part of the Malawi maize market since independence (Chirwa, 2009). After independence maize pricing was based on a pan-territorial and pan-seasonal parity price regime which was shifted to a price band in 1996. This price band which was implemented through ADMARC remained in place until 2000 (Chirwa, 2005). In the 2007/08 season, another maize price band was put in place in an attempt to curb maize price swings. The price band restricted maize trade to a range of MK45 to MK52 per kilogram (USD150 to USD163 per ton in real terms).

In such a market, there is a reduction in output because price controls lead to lower incentives for producers. Price controls change the way in which equilibrium is reached, as they lead to consumers competing for the goods whose price is controlled. This leads to consumers incurring higher transactions costs associated with searching and queuing (Devarajan, *et al.* 1989). In a controlled market, the summation of the demand for a good from the parallel and official markets is equal to the demand in a control-free market. However, supply in the controlled market is less than the supply in a control-free market. Hence, equilibrium is reached when the transaction costs associated with accessing the price-controlled goods equals the difference between the price of the commodity on the parallel market and the controlled price (Devarajan, *et al.* 1989). The use of partial equilibrium models in such a market is, however, still possible, but it requires the making of assumptions pertaining to consumers and producers of the commodity under analysis. These assumptions are critical as they affect the market outcomes and, in a partial equilibrium framework, they determine the nature in which supply, demand and price are determined.

On the consumer side, there are two alternative assumptions pertaining to consumers' access to the good that is under price control. These are the assumption of costless access/rationing and the assumption of endogenous transaction costs (Devarajan, *et al.* 1989). Implicit in both assumptions is that a parallel market will emerge as a result of government implementing price controls. This is the case for Malawi, as evidence exists which shows that after the implementation of a price band for maize, 70% of all private markets continued to sell maize at prices that were above the government set prices (Chirwa, 2009).

The assumption of costless access/rationing implies that households that purchase the good that is controlled are able to access it without incurring any additional costs associated with searching and queuing. This implies that these households are able to buy the good either in the official or unofficial markets at the official prices or at prices that are above the control prices respectively. For simplicity, this assumption assumes that consumers buy from the unofficial market but are not fined for doing so. Costless rationing essentially increases consumer incomes and, as such, can lead to increased demand and therefore production if the good is a normal good; or to lower demand and therefore reduced production if the good is an inferior good (Devarajan, *et al.* 1989). The assumption of costless rationing would apply in cases where the government provides rationed access of the price-controlled goods to consumers who are legally entitled to access it. For the Malawi maize sector, this assumption would not hold, as government does not ration the amount of maize that consumers can access, despite the implementation of price controls.

The alternative assumption of endogenous transaction costs assumes that consumers of a good compete to access the good that is under price control. This entails that they incur higher transaction costs associated with searching and queuing. Equilibrium in such a market is reached when consumers become indifferent to buying the good in the official market and the parallel markets. Consumer indifference only occurs when the transaction costs that consumers incur equal the difference between the price of the good in the official market and the price in the parallel market (Nguyeni *et al.* (1989) cited by Devarajan, *et al.* 1989). The modelling of the Malawi maize market assumed endogenous transaction costs in both the national and local maize markets. This is because this assumption holds in cases where the government sets the control price below the free market equilibrium price (Devarajan, *et al.* 1989). This is the case for Malawi, as studies conducted by Jayne *et al*. (2008) showed that the ceiling price for maize trade for 2008 set by government was 15.3 % lower than what maize producers had anticipated.

Given the endogenous transaction cost assumption, the following has been taken on board in modelling the Malawi maize market in a partial equilibrium framework:

- *Maize demand or consumption at either the national or local level remains unaffected.* This is because economic theory has demonstrated that a combination of the good demanded in a price-controlled market and the parallel market equals the demand in a control-free market. Thus, demand for a good does not change with price control under the assumption of endogenous transaction costs.
- *Maize supply in both the national and local maize markets is lower*. This is because in the face of price controls, producers market their output in both the official and parallel market. This is based on empirical evidence which shows that in markets with price controls, producers do not completely abandon the official market, even if the controlled price is below the free market price (Devarajan, *et al.* 1989). In such cases, the market outcome is that the aggregate amounts of the price-controlled good supplied is always less than the amount of the good supplied in the market that is free of price controls. Therefore, for the maize market for Malawi, this was taken into account in forecasting maize production at both the national and the local economy level.

3.4 MACRO-MICRO LINKAGES AND MODEL CONSISTENCY

The macro-economic partial equilibrium maize model and the household-level income data were linked in a one-way top-down fashion using micro-accounting techniques. One-way top-down linkages are those in which macro-economic level effects are fed into the household level, thus creating unidirectional links from the macro-component to the micro-component of the model. The micro-accounting linkage method is a non-parametric arithmetic approach that assumes a stable within household group distribution and employment structure. Households are classified into different categories and following a macro-economic policy shock, growth rates in incomes or other variables such as per capita consumption are obtained from the macro-component. Household group specific growth rates are then applied separately to each household category, thus providing the post-shock level of income or any other variable that is under consideration.

The micro-accounting method was selected as it is computationally suitable for the household data that was available at the primary level in this study. In addition, micro-accounting methods are advantageous as they are relatively straight forward to use and hence are highly suitable for developing country analysis in which there is often the lack of financial resources and data (Agénor, *et al.* 2005). In addition micro-accounting techniques are capable of capturing the heterogeneity in households (Lay, 2006).

The micro-accounting method has two main short falls. First, the method does not completely take into account the differences amongst individual households within each household category. This is because the method applies category-specific growth rates instead of household level ones; thus assuming unrealistically that the intra-category distribution of income remains constant after a shock. Second, there is the assumption that macro-economic shocks will not change the initial sector of activity in which households are involved (Agénor, *et al.* 2005). Despite this, micro-accounting methods still remain relevant although the policy shocks to be simulated have the potential to alter the employment structure of the rural economy in Malawi. The applicability of the results are however relevant only in the short to medium; and not in the long term.

In linking models at different levels, it has to be assured that the aggregate information in the macro-component of the model is disaggregated to the micro-level in a manner which is consistent (Peichl, 2009). Inconsistency between the two components can occur due to either data measurement errors in each component or due to the difficulties of deriving theoretical concepts at the micro-level (Kavonius, 2010). The use of the top-down linkage approach, in which price changes from the macro-component are translated into income changes at the household level, removes the concerns pertaining to inconsistencies between the macro and micro components of the macro-micro model. This is because the top-down linkage approach has the advantage that modelling of the macro and micro components is done separately with changes in equilibrium prices providing a link between the two components. In such cases, there is no need to reconcile data of the macro and micro components, as the two components are separately consistent (Vos, *et al.* 2004:13).

3.5 CHAPTER SUMMARY

This chapter has provided an in depth description of the theoretical foundations on which the analytical framework of this study is based. The key emphasis of the chapter was on the theoretical foundations of the micro-component of the analysis. This was followed by a brief overview of the macro-economic partial equilibrium maize model that will be used for simulating policy shocks in Chapter 6, the technical details of which will be provided in greater detail in Chapter 5.

CHAPTER 4

QUANTIFYING THE IMPACT OF AGRICULTURAL INNOVATION SYSTEMS ON RURAL LIVELIHOODS

4.1 INTRODUCTION

The purpose of this chapter is to provide evidence of the impact of AIS driven research interventions on rural livelihoods. In so doing, the chapter demonstrates that the paradigm shift in agricultural research from a top-down linear approach to a holistic approach driven by innovation systems concepts has contributed towards changing the rural household economy by creating greater linkages between rural households and the market economy. The first part of the chapter provides a descriptive summary of some demographic and socio-economic characteristics of the sampled households to better understand the community under study. The second part presents the results of a logistic regression model of participation in the ERI intervention and the results of the single differencing analysis to determine the impact of AIS driven research interventions on rural livelihoods. The last part of this chapter presents a description of the different household typologies found in the study area and the description of their income portfolios. The results of the last section will be used in Chapter 6 to test the hypothesis that macro-economic policy shocks affect rural households differently as a result of differences in their income portfolios and household typology.

4.2 METHODOLOGY

4.2.1 Place of study and data collection

The study was conducted in the Ukwe Extension Planning Area (EPA) in Lilongwe District in the Central Region of Malawi. Households were sampled from Katundulu, Mphamba and Kango villages. Katundulu and Mphamba villages formed the intervention communities where the Enabling Rural Innovation (ERI) was piloted (as described in Chapter 2); while Kango village was the area where a counterfactual was established. Purposive random sampling was used to select study participants from the intervention community while simple random sampling was used to select study participations from the counterfactual community. A semi-structured questionnaire was used to sample a total of 303 households in the study area, with the counterfactual community sample size being double that of the intervention community sample size in order to allow for better matching of households (Ravallion, 2003). Households from the counterfactual community that did not match with those in the intervention community in terms of pre-existing observable social economic and farming systems characteristics were dropped from the analysis in order to reduce bias and to increase robustness.

4.2.2 Data analysis

This section provides a description of the analytical tools employed to meet the objective of this chapter. This includes a discussion of quasi-experimentation; propensity score matching and logistic regression modelling that have been used in the study to establish a valid counterfactual to overcome sample selectivity bias and to overcome the problems associated with attributing changes in observable livelihood outcomes to specific interventions.

4.2.2.1 Impact evaluation of livelihood outcomes

The choice of evaluation technique in micro-economic impact studies depends on the nature of the question to be answered, the available data and the way in which the participants were selected for the programme (Blundell & Costa, 2007 cited by Bourguignon, *et al.* 2008). In studies where the intervention has already occurred, the evaluation technique has to be one that is able to compare the outcomes of those that were part of the programme and those that were not part of the programme (counterfactual), but who are otherwise similar to the programme participants; and in so doing, establishing the effects or impact of the programme.

Hence, the key to a good impact evaluation is the estimation of what would have occurred in the absence of the intervention (Martinez, 2009). Since impact evaluations are carried out after the programme has started or finished, as is the case in this study, *ex-post* changes in outcome variables are used as a measure of impact. The problem with this is that there are many other observable and non-observable time variant characteristics which may alter outcome variables for participants. As such, it becomes difficult to attribute changes in the outcome variables to a specific intervention. This is because comparison of the before and after changes in the outcome variable can lead to either over or under estimation of programme impacts. To overcome this problem, commonly called the attribution problem, it therefore becomes necessary to use data on outcome variables from the counterfactual. A valid counterfactual must have very similar observable pre-intervention characteristics to the participants with the only difference being programme participation.

The availability of data from non-participants is, however, in itself also insufficient for attributing differences in outcome variables to a programme, as changes in the outcome variables for participants may also arise from "selection bias" in that participants may have been purposefully selected (Ravallion, 2003; Ravallion, 2005). This entails that those non-participants who are used for comparison purposes must, in addition to having near-identical pre-intervention characteristics, be those who would have had an equal chance of being selected for participation in the intervention, hence overcoming selectivity bias. In the absence of randomisation, which equalises the probability of participation in an intervention thus removing selection bias, matching techniques, specifically Propensity Score Matching (PSM), becomes the solution to the establishment of a valid counterfactual (Baker, 2000; Ravallion, 2003).

According to Ravallion (2003), the underlying concepts of PSM are that two groups are identified, one that took part in the intervention denoted $H_i = 1$ for household *i* and another that did not participate in the intervention demonstrated $H_i = 0$. Intervention households are matched to non-intervention households on the basis of the probability that the non-participants would have participated in the intervention and this probability is called the propensity score. It is given mathematically as follows:

$$P(X_i) = Prob(H_i = 1 | X_i) \quad (0 < P(X_i) < 1) \qquad (4.1)$$

Where

X_i is a vector of pre-intervention control variables

These pre-intervention control variables are those which are based on knowledge of the programme under evaluation and on the social, economic and institutional theories that may influence participation in the intervention. The vector can also include the pre-intervention values of the outcome variables. Propensity score matching is not able to reproduce the results of randomisation if the variables that influence participation in the intervention are not properly defined.

PSM is driven by two main assumptions:

- The H_i's are independent over all i's
- The assumption of "conditional independence" or "strong ignorability" which says that outcomes are independent of participation given the variables that determine participation (X_i). In addition, outcomes are also independent of participation given $P(X_i)$ as they would be in a randomised experiment.

PSM equalises the probability of participation across the population just as in randomisation. However, the difference is that PSM achieves this based on conditional probabilities which are conditional on the variables determining participation (X_i).

In this study, propensity scores for each household in the sample were estimated using logistic regression modelling. Using the estimated propensity scores, matched pairs of households were established on the basis of the proximity of propensity scores of the probability of participation in the ERI initiative between the intervention and counterfactual samples. Unmatched counterfactual households were dropped from the analysis in order to remove bias and to increase robustness (Rubin & Thomas, 2000 in Ravallion, 2003). The best matched or "nearest neighbour" to the j^{th} intervention household is the counterfactual household that minimises $[P(X) – P(X_j)]^2$ over all j*'s* in the set of counterfactual households.

A typical PSM estimator of the average impact of any intervention takes the following form (Ravallion, 2003):

$$\Delta\overline{Y} = \sum_{j=1}^{T} \omega_j (Y_{j1} - \sum_{i=1}^{C} W_{ij} Y_{ij0}) \qquad (4.2)$$

Where:

Y_{j1} is the post intervention outcome variable for the j^{th} household in the intervention

Y_{ij0} is the outcome indicator of the i^{th} counterfactual household matched to the j^{th} intervention household

T is the total number of interventions/treatments

C is the total number of counterfactual households sampled

W_{ij} 's are the weights applied in calculating the average outcomes of the matched counterfactual households

ω_j are the sampling weights used to construct the mean impact estimator

To avoid contamination by endogeneity of access to the ERI program, the regression model for ERI program participation (which was estimated to generate PSM scores) was run only for the matched comparison group. Hence the estimator in such cases becomes as follows:

$$\Delta\overline{Y} = \sum_{j=1}^{T} \omega_j \left[\left(Y_{ij} - X_j \hat{\beta}_0 \right) - \sum_{i=1}^{C} W_{ij} \left(Y_{ij} - X_i \hat{\beta}_0 \right) \right] \qquad (4.3)$$

Where $\hat{\beta}_0$ is the Ordinary Least Squares (OLS) estimate for the counterfactual matched group.

The impact estimator is approximated without any arbitrary assumptions about functional forms and error distributions, as PSM does not require a parametric model linking programme participants to outcomes (Ravallion, 2003). This makes PSM superior to non-experimental regression-based approaches.

4.2.2.2 ERI programme participation model

A logistic regression model of participation in the ERI initiative was estimated in order to determine the probability of a household participating in the intervention by generating propensity scores. Participation in ERI was therefore modelled as a dichotomous dependant variable determined by a set of exogenous variables that were crucial for determining participation in the ERI intervention as determined at the onset of the program.

In this case, the innovation platform which was established in Ukwe Extension Planning Area worked together to select an appropriate community within the EPA for piloting the ERI initiative based on a criteria that included all year-round road accessibility; availability of a motivated local-level extension agent; willingness of other development partners working in the community to take an active role in the initiative; and the existence of interest in the community for further agricultural research and development (Sangole, *et al.* 2003). In addition to this, individual households within a selected community also had the opportunity to decide whether they wanted to participate or not.

Given these considerations, the exogenous variables that were included in the model for ERI program participation included the frequency of contact with extension agents prior to the ERI initiative, the sex of the household head, and level of participation in other development initiatives prior to the ERI initiative as well as the size of the household. The functional form of the model is given below:

$$PART = f\left(EXT\_CONT, SEX\_HHEAD, PRE\_PART, HHSIZE\right) \quad (4.4)$$

Where:

PART	Participation in ERI (0 = Non-participant, 1= Participant)
EXT_CONT	Frequency of contact with extension agents
SEX_HHEAD	Sex of the household head (0= Female, 1= Male)
PRE_PART[4]	Index of previous participation of the household in other development initiatives (0=Low, 1=Intermediate, 2= High)
HHSIZE	Size of the household (people eating from the same harvest)

A major assumption of logistic regression modelling is that the data has a binominal distribution taking the following form (Gujurati, 1992):

$$Y_i \sim B(n_i, p_i) \text{ for } i = 1 \ldots\ldots n \quad (4.5)$$

Where

Y_i is participation in the intervention

p_i is the unknown probability of participation

n_i are the observable outcomes of participation for each household

[4] This is a categorical variable whose results will be presented separately for the different types of previous participation level in order to show that the odds of participating in ERI may differ depending on the level of previous participation. This is a common and acceptable way of reporting categorical variables in logistic regression results. See http://128.97.141.26/stat/stata/webbooks/logistic/chapter2/default.htm

According to Gujarati (1992), the logistic regression model assumes that there is a set of explanatory variables that can inform the final probability of participation. Because of this assumption, the explanatory variables can be thought to be in a *k* vector X_i. If we model the natural log of the odds of the unknown binomial probability p_i as a linear function of the X_i's, we get the following:

$$In\left(\frac{p_i}{1-p_i}\right) = B_0 + B_1 x_i + \mu_i; i = 1...n \quad (4.6)$$

Where B_0 and B_i are the intercept and the unknown parameters respectively.

4.3 DESCRIPTIVE ANALYSIS OF SAMPLED HOUSEHOLDS

This section presents the empirical findings of the impact evaluation of agricultural research interventions that are driven by innovation systems on rural livelihoods. It, however, starts by presenting a descriptive analysis of the sampled households; in order to provide greater contextual understanding. An independent samples t-test was carried out to statistically compare the difference in means for various socio-economic characteristics between households in the intervention community and counterfactual community.

4.3.1 Household characteristics

Table 4.1 shows that the majority of the total respondents interviewed were women, with 67.3 % of all respondents being female while only 32.3 % of the respondents were male. The counterfactual community had more female respondents (77.7 %) as compared to the intervention community (46.5 %). Despite this, the majority of households in the study area were male headed, with about 82.2 % of the total sample being male headed and only 17.8 % of the households being female headed. These findings are in line with national demographics which show that nearly 75 % of all households in Malawi are male headed (NSO, 2008a). In addition, it can be seen that the majority of female-headed households were found in the counterfactual community (20.3 %), while the intervention community had fewer households that were headed by females (12.9 %).

Table 4.1: Summary of household respondents and headship

	Total sampled households[5]		Intervention community		Counterfactual community	
	Percentage and number of respondents interviewed					
	N	%	N	%	N	%
Female	204	67.3	47	46.5	157	77.7
Male	99	32.3	54	52.5	45	22.3
Total	303	100.0	101	100.0	202	100.0
	Headship of household: Percentage and number					
	N	%	N	%	N	%
Female	54	17.8	12	12.9	41	20.3
Male	249	82.2	88	87.1	161	79.7
Total	303	100.0	101	100.0	202	100

N = number of respondents % = percentage

The average age of the household heads in the study area was about 40 years, while the average age for spouses was 35 years of age (Table 4.2). The independent samples t-test showed that there was a significant difference between the ages of spouses in the intervention community and counterfactual community, with the spouses in the intervention community being significantly older. Table 4.2 further shows that the average household size in the study area was 4.8 people. The size is similar to the national household size of 4.4 people per household (NSO, 2008b**).** The t-test further indicated that there are statistically significant differences in the marital status of sampled households in the two communities, with more sampled households in the intervention community (87.1 %) being in legally-binding and socially-acceptable marriages than households in the counterfactual (78.7 %). This may explain the larger number of female-headed households in the counterfactual community. In addition, the counterfactual community had a significantly higher number of households that were in polygamous marriages (14.4 %) as compared to the intervention community (10.1 %); and this difference was statistically significant at the 10 % confidence level.

Table 4.2: Household characteristics

Household characteristics	Intervention community	Counterfactual community	t-value
Average age of household head	40.93	39.10	0.004
Average age of spouse	34.85	31.57	2.92*
Average household size	5.02	4.54	1.27
% of households that are married	87.1	78.7	12.15*
% of households in polygamous marriages	10.9	14.4	13.54*

* Significant at 10 % level, ** Significant at 5 % level, *** Significant at 1 % level

An analysis of the level of community engagement and leadership (Table 4.3) showed that more male household members had active membership in farmer groups as compared to

[5] For the socio-economic characterisation, any discussion referring to the sampled households or unmatched households, refers to the total 303 households that were interviewed. For the impact assessment, households in the intervention community were matched to the households in the counterfactual community and these are referred to as the matched sampled size/matched households.

female household members. This can be attributed to Malawian male household members participating more in community activities as compared to females, whose participation is limited by both cultural and social factors (Care Malawi, 2010).Table 4.3 further shows that more household heads (26.7 %) and spouses (6.3 %) in the intervention community had membership in farmer groups as compared to household heads (16.3 %) and spouses (2.8 %) in the counterfactual community. These differences in group membership were f statistically significant at the 10 % confidence level, implying that there was more membership in farmer groups in the intervention community than in the counterfactual community.

Table 4.3: Community engagement and leadership of sampled households

Community engagement and leadership	Intervention community	Counterfactual community	t-value
% of HH heads – membership in farmer groups	26.7	16.3	11.77*
% of spouses – membership in farmer groups	6.3	2.8	14.72*
% of HH – membership of more than one farmer group	5.9	2.5	9.29
% of household head with leadership position	40.6	18.4	59.89***
% of spouses with leadership position	18.4	10.2	0.621

* Significant at 10 % level, ** Significant at 5 % level, *** Significant at 1 % level

Table 4.3 further shows that there were highly statistically significant differences between the numbers of sampled household heads who held leadership positions in the intervention community (40.6 %) and those in the counterfactual community (18.4 %). Leadership positions included traditional posts, community positions and positions arising in farmers' organisations. The difference in leadership position between the two communities arises from the leadership positions that individuals in the intervention community held in farmer groups' and not those in traditional or community engagements. This is because, firstly, the traditional and community organisation of both communities are similar due to their geographical proximity and both are predominantly of the Chewa tribe. As such, the number of available traditional and community leadership positions is more or less the same. Second, as discussed above, more households in the intervention community were involved in farmer groups than those in the counterfactual community. As such, there was a higher probability of an individual in the intervention community having a leadership position as compared to an individual in the counterfactual community, due to the former being more engaged in farmer groups.

4.3.2 Human capital characteristics

An analysis of the human capital characteristics demonstrates that there are more household heads in the intervention community with some level of formal education (84.2 %) than in the counterfactual community (74.5 %). This difference is statistically significant at the 5 % confidence level (Table 4.4). In terms of informal training, Table 4.4 further indicates that on average households in the intervention community had more training than households in the counterfactual community. Intervention community households had on average 2.64 and 1.92 trainings per year five years ago and in the 2007/2008 cropping season, respectively; while counterfactual community households had on average 0.93 and 0.90 trainings per year five years ago and in the 2007/2008 cropping season, respectively. The differences in informal training for the 2007/2008 cropping season and five years ago are statistically significant at the 10 % and 5 % confidence levels, respectively.

Table 4.4: Human capital characteristics

Human capital characteristics	Intervention community	Counterfactual community	t-value
Average number of training in 2008/2009	1.41	0.90	4.71
Average number of training in 2007/2008	1.92	0.90	10.56*
Average number of training five years ago	2.64	0.93	18.63**
% of HH head with some formal education	84.2	74.5	3.28**
% of spouses with some formal education	74.4	76.3	0.629
Average distance from extension office in km	7.5	20.0	810***
% of HH with contact with extension at least once a year	52.6	65.4	1.03*

* Significant at 10 % level, ** Significant at 5 % level, *** Significant at 1 % level

For the 2008/2009 cropping season, the differences in trainings between households in the intervention community and counterfactual community are statistically non-significant. From these findings, it can be seen that differences in informal training between the two communities are less distinct and nearly non-existent in the most recent cropping seasons. This can be attributed to the fact that during the implementation of the ERI initiative, there was emphasis on community capacity building through informal training. However, since it phased out in the 2006/2007 cropping season, it is obvious from these results that existing public agricultural extension agents in the intervention community have not been able to maintain the levels of capacity building.

In contrast to these findings, more households in the counterfactual community (65.4 %) stated that they had frequent contact with a public extension agent as compared to households in the intervention (52.6 %). This difference was statistically significant at the 10 % confidence level. This was the case despite counterfactual community households being on average significantly further from the extension officers' houses and offices (20.0 km) than the intervention community households (7.5 km). Informal interviews with counterfactual community households revealed that the contact with the extension officer in the counterfactual community was more unplanned, and tended to occur on occasions in which the extension officer had to pass through several villages in the counterfactual community to get to the main tarmac road on his way to the city. Community members took such opportunities to gather information and relay their problems to the extension agents.

4.3.3 Farming characteristics

All households in the study area are in a maize-based farming system, in which maize is the predominant staple food crop cultivated in combination with different legumes and cash crops. Other food crops grown in the study area with maize included groundnuts (*Apios americana*), beans (*Phaseolus vulgaris*), sweet potatoes (*Ipomoea batatas*), soy beans (*Glycine max*) and cow peas (*Vigna unguiculata*). Tobacco was the only non-edible cash crop cultivated in the area, while other cash crops that are widely cultivated in other parts of the country, such as cotton and paprika, were not found. Apart from crop cultivation, it is the practice of households to rear livestock and the majority of sampled households (58.3 %) owned livestock. Livestock that was readily found in the study area included pigs, chickens, goats, oxen, donkeys, ducks, guinea fowls, turkey, sheep, dairy cattle, rabbits, and hamsters.

From Table 4.5, it can be seen that the average land holding sizes for households in the intervention community and counterfactual community were 1.72 hectares and 1.23 hectares respectively. These differences in land holding sizes, which are relatively similar to the average national household land holding size of 1.5 hectares (World Bank, 2009), were statistically non-significant. Despite this, further analysis shows that on average, households in the intervention had more separate pieces of land (3.1) and there were more households in the intervention owing a wetland for winter cultivation (94.1 %) as opposed to the counterfactual community, where households had fewer numbers of separate pieces of land (2.1) and fewer households owning a wetland (47.5 %). Both differences were highly statistically significant.

Differences in wetland[6] ownership are because the majority of households in the counterfactual community had sold their wetlands to semi-commercial urban farmers, who flock to the community seeking both wetland and arable upland for cultivation due to its proximity to a tarred road (about 4.5 km). This was not the case for the intervention community as the area was relatively far from a tarred road (approximately 29 km).

Table 4.5: Farming characteristics

Farming characteristics	Intervention community	Counterfactual community	t-value
Average number of separate farm plots	3.1	2.1	1.178***
Average land holding size (ha)	1.72	1.23	0.00
% of households with a wetland	94.1	47.5	673.76***
% of household owning livestock	85.0	45.0	23.84***
% of households hiring additional labour	39.6	19.8	41.09***
% of households receiving remittances	13.9	10.4	3.08
% of households who have access to credit	12.9	6.9	11.56*

* Significant at 10 % level, ** Significant at 5 % level, *** Significant at 1 % level

Analysis of the differences in inorganic fertilizer application between the two communities showed that the majority of households in the intervention community applied inorganic fertilisers on their farms as compared to the households in the counterfactual community. As can be seen in Table 4.6, the differences between households using and not using inorganic fertilisers in the intervention community and the counterfactual community are highly statistically significant for the 2004/2005, 2005/2006, 2006/2007 and 2007/2008 agricultural seasons, but less significant for the 2008/2009 agricultural season. For the intervention community, at least 60 % of all households were using inorganic fertilisers on an annual basis since the 2004/2005 season. In the counterfactual community, it is only in the 2008/2009 agricultural season that the percentage of households using inorganic fertilisers exceeded 60 %. One main reason for the differences in the fertiliser use between the two communities is that the ERI approach encouraged farmers to reinvest in their farm enterprise as part of sustaining their agro-enterprises. Hence, these differences in fertiliser use levels could be an indication of farmers reinvesting in their farms as a result of changes in their decision-making patterns arising from participation in the ERI.

Sources of inorganic fertiliser between the two communities were, however, similar. The main sources from which inorganic fertiliser was obtained were from subsidised coupons, purchasing at the full market price, gifts from relatives, donations from Non-Governmental

[6] Wetlands; which are locally known as *dambos;* are any permanent or seasonal wet land area that are mainly found along rivers and steams and which are populated by herbaceous plants and vegetation. Wetlands are mainly cultivated in Malawi during the short dry winter season (May–July)

Organisations (NGOs), or from farmer groups. Fertiliser received from NGOs was mainly from the Malawi Rural Finance Company, which is a government-operated loan facility that provides fertiliser on a loan basis to rural smallholders.

Table 4.6: Fertiliser use patterns

Fertiliser use patterns	Intervention community	Counterfactual community	t-value
% of household using fertiliser in 2004/2005	59.0	29.2	12.37***
% of household using fertiliser in 2005/2006	68.0	35.1	2.33***
% of household using fertiliser in 2006/2007	72.0	41.1	24.08***
% of household using fertiliser in 2007/2008	80.0	54.0	103.32***
% of household using fertiliser in 2008/2009	83.0	65.8	52.65**

* Significant at 10 % level, ** Significant at 5 % level, *** Significant at 1 % level

It can further be seen from Table 4.6 that in the intervention community and the counterfactual community, the percentage of households utilising inorganic fertiliser has increased each subsequent cropping season since the 2004/2005 cropping season. This can be attributed to the implementation of the fertiliser subsidy programme which made inorganic fertilisers more readily available and accessible in rural areas. This was the case despite only a minority of the respondents in either the intervention community or the counterfactual community having ever received subsidised fertiliser coupons. This is because although not all households received coupons for subsidised fertiliser, farmers often pooled money together to buy inorganic fertiliser at the subsidised price. As such, even farmers who had never received coupons for subsidised fertiliser had in fact accessed it.

Furthermore, the fertiliser subsidy programme had created a parallel market of inorganic fertiliser in the rural area, in that some rural entrepreneurs had started to purchase the coupons for subsidised fertiliser from rural beneficiaries who were not able to find the cash to purchase the subsidised fertiliser. Using the coupons bought, they would purchase the subsidised fertiliser and subsequently sell it in smaller portions to non-beneficiaries or beneficiaries who had not meet their fertiliser needs. The unit price of fertiliser on the parallel market was higher than the subsidised fertiliser price but much lower than the actual market price for the unsubsidised fertiliser. The parallel market was also one of the means through which inorganic fertiliser accessibility and availability had increased in the study area.

Apart from inorganic fertiliser, the results further indicated that the majority of households in either the intervention community (64.0 %) or the counterfactual community (62.4 %) did not incur any other input costs. This was the case, as farmers did not use herbicides or pesticides, and the majority stated that they often recycled their seed. Seed recycling is a common practice in Malawi, in spite of farmers being aware that it can potentially reduce agricultural productivity and efficiency (Lanteri & Quagliotti, 1997). Seed recycling is common practice due to three main reasons- cash constraints, frequent changes in government support policies and the distribution of free seed by both public and private institutions (Smale & Phiri, 1998). Cash constraints by producers prevent producers from purchasing sufficient seed to meet their needs. Changes in government support policies and the distribution of free seed hinders producers' abilities to develop and sustain independent strategies for sourcing seed in each new season.

4.4 IMPACT OF AIS DRIVEN RESEARCH

This section presents the results of the single differencing of livelihood outcomes carried out between intervention households and matched counterfactual households. It starts by presenting a validation of the ERI program participation model used to generate propensity scores for determining a valid counterfactual. This is then followed by empirical results of the impact evaluation.

4.4.1 Generation of propensity scores

The logistic regression model of ERI participation that was estimated to generate propensity scores was a good predictor of participation as demonstrated by the results of two alternative tests of goodness of model fit, the Hosmer and Lemeshow (H-L) statistic and the chi-square test (Table 4.7). The H-L goodness of fit test statistic was 10.310 and non-significant (p=0.244), indicating that the model was a good fit. A rule of thumb for accepting a logistic regression model is that the H-L statistic must be greater than 0.05 and should show non-significance (Hosmer & Lemeshow, 1989). Further, the model has a chi-square statistic of 23.747 which was statistically significant at the 1 % confidence level. This implied that all the predicators that were included in the model were capable of jointly predicting participation in the ERI initiative. As such the model is a good determinant of the factors influencing participation in the ERI initiative. This therefore implies that the model is capable of approximating the probability of a household's participation in the ERI initiative and it is capable of correctly generating propensity scores.

Therefore, using propensity scores for participation generated from the logistic regression model, households in the intervention community were matched to households in the counterfactual community on the basis of the proximity of propensity scores. All other households whose propensity scores for participation were far from the range of scores for the intervention households were dropped from the analysis.

Table 4.7: Parameter estimates of the logistic model of ERI participation

	Co-efficient	Significance	Odds ratio
Constant	-1.426	0.136	0.240
PRE_EXT_CONT	-0.157	0.019	0.855
SEX_HHEAD	0.571	0.118	1.771
HH_SIZE	0.092	0.087	1.092
PRE_PART_PREVIOUS[7]		0.003	
PRE_PART_PREVIOUS(1)	-0.559	0.310	0.572
PRE_PART_PREVIOUS(2)	1.486	0.068	4.419
Model Chi square	*23.747****	*Log-Likelihood*	*361.980*
H-L Chi square	*10.310 (p=0.244)*	*Nagelkerke R-square*	*1.205*
N=303			

By dropping all the counterfactual community households whose probability of participation was very far from the households in the intervention community, differences in livelihood outcomes were then compared between households that were more similar and therefore comparable. This can be seen by looking at the differences in the socio-economic characteristics of the matched households (Table 4.8), which are less distinct than differences between households in the entire sample, as discussed above in Tables 4.3, 4.4, 4.5, and 4.6. Some differences in the characteristics of households that were either statistically significant or very significant in the unmatched data set were no longer statistically significant for the matched data sets. Despite greater similarities between the two groups in the matched data set, some differences still exist in terms of the farming characteristics and fertiliser use patterns; which are to be expected, as rural households are not homogenous in nature.

[7] Previous participation is interpreted for the high previous participants and the intermediate/low previous participators separately. This presentation of categorical variables in logistic regression models is common and accepted practice. These results show that those that had high previous participation (pre_previous(2)) in development projects had higher probability of also participating in the ERI. The odds of the intermediate/low (pre_previous (1)) previous participators are shown to be lower.

Table 4.8: Socio-economic characteristics for matched households

	Intervention community	Counterfactual community	t-value
Household characteristics	n = 100	n = 100	
Average age of household head	40.93	38.93	0.393
Average age of spouse	34.85	31.32	4.69*
Average household size	5.02	4.68	0.186
% of households that are married	87.1	80.2	6.36
% of households in polygamous marriages	10.9	17.0	4.28
% of respondents with other occupation apart from farming	24.8	19.8	2.87
% of household heads that are members of farmer groups	26.7	27.7	1.100
% of spouses that are members of farmer groups	6.3	4.5	3.86
% of households that are members of more than one farmer group	5.9	4.0	1.683
% of household head with leadership position	40.6	25.10	23.43*
% of spouses with leadership position	18.4	14.9	0.957
Farming characteristics			
Average number of plots	3.1	2.2	0.217***
Average land holding size (ha)	1.72	1.23	0.218**
% of households with a wetland	94.1	56.4	304.1***
% of household owning livestock	85.0	42.6	15.33**
% of households hiring additional labour	39.6	23.8	22.37*
% of households receiving remittances	13.9	10.9	1.641
% of households who have access to credit	12.9	7.9	5.412
Human capital characteristics			
Average number of trainings in 2008/2009	1.41	1.22	0.791
Average number of trainings in 2007/2008	1.92	1.26	2.61
Average number of training five years ago	2.64	1.02	9.98*
% of household head with some formal education	84.2	75.8	3.12*
% of spouses with some formal education	74.4	80.5	1.27
Average distance from extension office/house in km	7.5	20	403.7***
% of respondents who have contact with extension agent at least once a year	52.6	81.2	21.78***
Fertiliser use patterns			
% of household using fertiliser in 2004/2005	59.0	31.7	6.97***
% of household using fertiliser in 2005/2006	68.0	36.6	4.065***
% of household using fertiliser in 2006/2007	72.0	45.5	21.00***
% of household using fertiliser in 2007/2008	80.0	58.4	42.60**
% of household using fertiliser in 2008/2009	83.0	69.3	21.95*

* Significant at 10 % level, ** Significant at 5 % level, *** Significant at 1 % level

4.4.2 Differences in rural livelihood outcomes

This section presents the results of the single differencing of livelihood outcomes carried out between households in the intervention community and the matched households in the counterfactual community in order to determine the impact of the ERI intervention. This study employed the single differencing method as it involves the *ex-post* comparison of outcome variables between program participants and non-program participants. Single differencing is valid when program and non-program participants have more or less similar outcomes at the onset of a program and also in the absence of baseline data. The main limitation of the single differencing technique is that it does not effectively control for pre-intervention differences in outcome variables between the program and non-program communities. Therefore in cases in which the pre-intervention outcome variables of participations and non-participations differ greatly; single differencing can produce results that are not valid. The use of Propensity Score Matching (PSM) to establish a statistically valid comparator group however significantly reduces biases associated with pre-intervention differences in outcome variables between participating and non-participating groups (Ravallion, 2003).

4.4.2.1 Impact on production outcomes

The ERI intervention impacted upon many aspects of household production with statistically significant differences being observed for the outcomes pertaining to livestock production, upland crop production, value of maize production and asset ownership. Differences in maize yields were found to be unaffected by participation in the ERI intervention; implying that the ERI initiative did not have an impact on maize productivity. This finding is plausible because it is possible to increase production without necessarily increasing productivity (Beattie & Taylor, 1985). Hence in the study area it is possible that participating households managed to increase production of maize, not necessarily productivity, by increasing the area under maize cultivation.

An analysis of the value of all upland crops for the households in the study finds that the ERI intervention increased the value of crops produced for participating households by USD812.34 and USD627.10 for the 2007/2008 and 2008/2009 cropping seasons respectively (Table 4.9). The differences in the value of all upland crops were statistically significant at the 1 % and 5 % confidence levels for the 2007/2008 and 2008/2009 seasons respectively.

Table 4.9: Impact of the ERI intervention on production outcomes

Production outcomes (USD)	Intervention community		Counterfactual community		ERI program effect
	Mean	Standard deviation	Mean	Standard deviation	
Total value of livestock	445.03	1620.99	144.82	926.47	300.12*
Total value of upland crop production 2007/2008	1349.48	0.016	537.14	0.0114	812.34***
Total value of upland crop production 2008/2009	992.24	0.0179	365.14	0.0084	627.10**
Value of maize harvest 2007/2008	259.35	308.77	180.01	340.24	79.33
Value of maize harvest 2008/2009	506.76	0.013	219.66	490.80	287.09*
Maize yield 2007/2008 (Tons/hectare)	0.84	1.00	0.85	1.47	0.0055
Maize yield 2008/2009 (Tons/hectare)	1.17	2.61	0.88	1.33	0.287
Total value of assets	550.74	3008.51	159.65	581.58	391.00*

* Significant at 10 % level, ** Significant at 5 % level, *** Significant at 1 % level

Furthermore, the results also show that in the 2008/2009 season, the value of maize produced by intervention community households was significantly higher than for households in the counterfactual community by USD287.09 at the 10 % level of confidence. This was, however, not the case for the 2007/2008 cropping season, as differences in maize production between the intervention community and counterfactual community households were not statistically significant. The difference in value of maize production in the 2008/2009 season cannot be attributed to higher maize prices for producers in the 2008/2009 season, which were at USD295.89 per ton as compared to prices in the 2007/2008 season of USD125.99 per ton; or to price differentials between the intervention community and counterfactual community. This is because an analysis of the farm gate prices for the different communities showed that all households in the study area received the same farm gate prices with no statistically significant differences being observed between maize prices in either community. Second, differences in maize production in the 2008/2009 season cannot be attributed to yield differences, as the results indicate that there were no statistically significant differences in the yields of maize between households in the intervention community and counterfactual community.

The significant differences in maize production between the intervention community and counterfactual community can therefore mainly be attributed to the fact that households in the intervention community cultivated more land than their counterparts in the counterfactual community. This is evidenced by statistically significant differences in the total land-holding sizes and the total number of separate farm plots that households in the intervention community owned and planted as compared to matched households in the counterfactual community. Households in the intervention community owed on average 1.72 hectares of land, while the matched counterfactual community households owed on average 1.23 hectares of land. In general households in both communities tend to cultivate the majority of the land that they own with approximately 95% of the land that is owned being under cultivation in either community in the 2008/09 cropping season. Households in the intervention community cultivated on average 3.1 separate pieces of farm plots; while matched counterfactual community households cultivated on average 2.2 separate pieces of farm plots. The differences in the land ownership and the separate pieces of cultivated farm plots between the intervention community and counterfactual community were statistically significant at the 5 % and 1 % confidence levels, respectively.

Analysis of differences in household assets and livestock ownership shows that the ERI initiative was significant in increasing the value of households' total assets and livestock ownership by USD391.00 and USD300.12, respectively. Both these differences were statistically significant at the 10 % level of confidence. Hence, households in the intervention community had higher valued assets than households in the counterfactual community. An analysis of the differences in livestock prices showed that there were very small differences between the market prices of the three major types of livestock traded in the study area; with the average price for the 2008/2009 season of chickens, pigs and goats not being statistically different between the two communities.

As such, it can be deduced that households in the intervention community had larger numbers of livestock as compared to households in the counterfactual community. This is confirmed by statistical analysis which showed that households in the intervention community owned an average of about 4 or more chickens and one extra pig and goat each as compared to households in the counterfactual community. The differences in the ownership of all three classes of livestock were highly statistically significant.

A major contributing factor to the larger livestock numbers in the intervention community, especially in terms of pig ownership, is that piggery was the agro-enterprise chosen to be developed under the ERI program. Because of this, participation in ERI entailed that households made more investments in the piggery through improved housing, feeding and hygiene; and improved their day-to-day management by keeping a record of all activities pertaining to the piggery. Participating households were trained in the construction of appropriate housing and feed formulation as well as in pest and disease control. In addition, farmer participatory research was put in place to test different feeding options and the cultivating of various types of feeds (Njuki, *et al.* 2007). These changes, together with greater market access arising from the establishment of a marketing committee in the community which was responsible for sourcing markets, led to the establishment of a stable market especially for piglets and this resulted in increased incomes. From informal interviews with participating households, it was revealed that this increased income, in combination with changes in the decision-making processes of participating households, enabled them to invest more in household assets as well as in other types of livestock.

4.4.2.2 Impact on household cash income

Analysis of the differences in household incomes indicates that the ERI intervention positively influenced cash incomes in both the 2007/2008 and 2008/2009 cropping seasons for the households who participated in the intervention. As can be seen in Table 4.10, households who participated in the ERI intervention had on average USD280.21 and USD340.54 more total income than their counterparts in the counterfactual community for the 2007/2008 and 2008/2009 cropping seasons respectively. The differences in household incomes were statistically significant at the 5 % confidence level.

Table 4.10: Impact of the ERI intervention on household cash incomes

Household cash incomes (USD)	Intervention community		Counterfactual community		ERI program effect
	Mean	Standard deviation	Mean	Standard deviation	
Total cash income from wetland 2008	27.24	87.27	23.67	66.98	3.56
Total cash income from wetland 2009	14.46	32.49	29.79	52.87	-15.39*
Total cash income for 2007/2008 season	511.49	0.0072	231.28	465.61	280.21**
Total cash income for 2008/2009 season	636.21	0.0088	299.56	655.75	340.54**
Total income from livestock sales 2008/2009	51.34	138.48	23.60	186.08	27.78

* Significant at 10 % level, ** Significant at 5 % level, *** Significant at 1 % level

Increased cash incomes can be attributed to the ERI intervention focussing on assisting farmers to develop agro-enterprises in order to meet existing market opportunities as opposed to them marketing any surplus that they grew for subsistence. Hence, intervention communities conducted an analysis of existing market opportunities prior to the onset of the agricultural year in order to determine the type of agro-enterprises that would be most profitable. Through this analysis, the community identified piggery and dry bean cultivation as the most profitability agro-enterprises (Njuki, *et al.* 2007).

Furthermore the ERI intervention negatively affected incomes from the sale of crops cultivated in the wetland during the short dry season. Farmers in the intervention community had lower incomes from the wetlands as compared to households in the counterfactual community, with incomes in the intervention community being lower by USD15.39 in the 2009 winter season. This difference was statistically significant at the 10 % level of confidence. This was the case despite more households in the intervention community having wetlands as compared to households in the counterfactual community; with 94.1 % and 56.4 % of all sampled households in the intervention community and counterfactual community owning a wetland, respectively.

The winter season, which involves the cultivation of wetlands along rivers and streams, using residual moisture or irrigation, is a critical season for many rural producers in Malawi. For resource-poor farmers, cultivation during the winter season is mainly used for seed production. Hence, the majority of resource-poor smallholders who market a large portion of their harvest from the winter season are left without sufficient seed for the next rainy season; and are thus less prepared for the onset of the main cropping season. One key area of the ERI intervention was to build the capacity of households to better understand their farming systems and opportunities as well as threats to their livelihoods. Hence, the lower returns in sales from the wetland can be attributed to households in the intervention using the winter cultivation as an opportunity to retain seed for the main cropping season.

4.4.2.3 Impact on household training and group membership

An assessment of the ERI initiative's impact on membership of farmer groups and the number of trainings attended by a household was also carried out. Table 4.11 indicates that five years ago when ERI was in full implementation, households in the intervention community attended on average 1.62 more trainings than households in the counterfactual community. This difference was statistically significant at the 10 % level of confidence. These results are an indication that the ERI initiative provided participating communities with significantly more training opportunities than those that are provided by the local agricultural extension officers.

Table 4.11: Impact of the ERI intervention on trainings and group membership

Trainings and group membership	Intervention community		Counterfactual community		ERI program effect
	Mean	Standard deviation	Mean	Standard deviation	
Total number of farmer groups per HH	0.35	.0.865	0.49	0.074	-0.139
Average number of trainings five years ago	2.64	5.67	1.02	3.86	1.62*
Average number of trainings in 2007/2008	1.92	5.29	1.26	3.66	0.66
Average number of trainings in 2008/2009	1.14	4.43	1.22	3.55	-0.08

* Significant at 10 % level, ** Significant at 5 % level, *** Significant at 1 % level

Further observations, however, showed that after the ERI initiative phased out in the 2006/2007 season, there were no statistically significant differences in the number of trainings attended by households in the intervention community and the counterfactual community for either the 2007/2008 or 2008/2009 agricultural seasons. This can be attributed to the phasing out of the ERI intervention that led to local agricultural extension officers reverting to pre-ERI training strategies in the intervention communities, which entailed less training. The results therefore indicate that the ERI initiative during its implementation had a positive impact, in that it increased the number of trainings that a household attended. This finding is logical as informal trainings and other capacity building activities were a major component of the ERI initiative. Hence, following its phasing out, the number of trainings for individuals in the participating communities and the counterfactual community were not statistically different.

Analysis of the differences in famer groups shows that the ERI initiative did not have a statistically significant impact on households' membership in farmer groups. This implies that households' participation in farmer groups between the two communities was not statistically different. This finding is surprising, as the ERI initiative worked towards establishing and strengthening farmer organisations, as it recognised that the most important success factor for increasing market access was well-established farmer organisations (Kaaria, *et al.* 2008).

4.4.2.4 Impact on fertiliser use patterns

The impact of the ERI intervention on fertiliser use patterns in the intervention community was assessed by analysing the differences in the number of 50 kg bags that farmers used per hectare of farm land. Inorganic fertilisers, in combination with hybrid seeds and good rainfall, play a crucial role in ensuring maize production and food security in Malawi. Hence, purchasing inorganic fertiliser demonstrates a household's decision-making patterns in terms of reinvestment in their farm enterprise. Table 4.12 shows that there were statistically significant differences between the amounts of inorganic fertiliser applied between the intervention community and counterfactual community households in the 2004/2005, 2005/2006 and 2006/2007 agricultural seasons at the 1%, 5% and 10% confidence levels respectively.

Table 4.12: Impact of the ERI intervention on fertiliser use patterns

Fertiliser use patterns (no. of 50 kg bags)	Intervention community		Counterfactual community		ERI program effect
	Mean	Standard deviation	Mean	Standard deviation	
2004/2005	1.24	1.85	0.567	1.55	0.679***
2005/2006	1.38	1.87	0.624	1.12	0.761**
2006/2007	1.50	1.88	0.858	1.38	0.644*
2007/2008	1.68	1.97	1.38	3.39	0.297
2008/2009	1.95	2.49	1.77	6.18	0.171

* Significant at 10 % level, ** Significant at 5 % level, *** Significant at 1 % level

Between the 2004/2005 and 2006/2007 cropping seasons, households in the intervention community applied on average nearly one extra 50 kg bag of inorganic fertiliser as compared to households in the counterfactual community. This difference can be attributed to the ERI intervention, as the increased market outcomes acted as incentives for households to reinvest in technology, such as inorganic fertiliser, in order to sustain their agro-enterprise. In general, the study finds that all households in both communities were applying an amount of fertiliser that was below the recommended rates for Lilongwe Agricultural Development Division (LADD) where the communities are located. The recommended fertiliser application rate for home consumption for LADD is the application of two bags of 23:21:0+4S and three bags of Urea which has 46 % nitrogen. For production for the market, the recommended application rate is one bag each of 23:21:0+4S and Urea (Benson, 1999). Table 4.12 further shows that it is only households in the intervention community that were close to reaching the recommendation for the market production, with a mean of 1.92 (50 kg) bags of inorganic fertiliser being applied per hectare for the 2008/2009 year.

Further observation shows that in more recent years, the differences in the amounts of inorganic fertiliser applied are less distinct. In the 2007/2008 and 2008/2009 cropping seasons, the differences are non-significant between the intervention community and counterfactual community. This can be attributed to the increased availability of fertiliser due to the implementation of the full fertiliser subsidy programme in the country. The implementation of the fertiliser subsidy programme increased the availability and accessibility of inorganic fertiliser throughout the rural areas of the country, hence increasing the opportunity for all farmers to access inorganic fertiliser. This was the case despite informal interviews with farmers revealing that initially when the fertiliser subsidy programme had started in the 2005/2006 season, farmers tended to sell their coupons for cash. They would then use part of the cash received to purchase a small amount of fertiliser (e.g. one 20 kg bucket) and to meet other household needs. In the intervention community, it was found that in subsequent years as farmers become more organised under the ERI programme, they refrained from the practice of selling their subsidised coupons. Hence, the increased fertiliser use in the intervention community can further be attributed to not only the implementation of the fertiliser subsidy programme but also to improved and better decision making on the part of farmers as a result of the ERI intervention.

In conclusion, it has been demonstrated that rural livelihood outcomes pertaining to crop and livestock production, income, asset ownership and fertiliser use are significantly impacted upon by AIS driven research interventions. In-depth analysis, however, demonstrates that although participating households have more robust livelihoods during the intervention, phasing out of the research programme reduces the effects on livelihoods.

4.5 HOUSEHOLD TYPOLOGIES AND INCOME PORTFOLIOS

The second objective of this study aims to demonstrate the impact on livelihood outcomes of macro-economic policy shocks and policy sequencing, depending on participation in agricultural research interventions that are driven by innovation systems concepts, socio-economic characteristics and resource endowments. In order to assess the effects of differences in resource endowments and socio-economic characteristics in the sampled households, household typologies were developed and income portfolios for the different household categories were analysed. These are presented in the following two sections.

4.5.1 Household typologies

Household typologies offer a useful tool for stratifying households into homogenous units with minimal internal differences which provide an opportunity for developing appropriate disaggregated policy recommendations. Variables used for developing the typologies were based on the knowledge that causes heterogeneity between households. These included value of assets (USD), farm sizes (acres), number of farm plots and household sizes (Table 4.13).

Table 4.13: Summary of the cluster solution

Cluster	Intervention community			
	Mean value			
	Value of assets USD)	Farm size (acres)	Number of farm plots	Household size
1	92.14	3.2	2.4	5.1
2	318.62	5.6	4.2	4.7
3	1605.06	5.6	2.6	6.4
	Counterfactual community			
1	976.41	11.96	5.0	4.0
2	119.55	4.34	2.8	5.9
3	41.78	2.06	1.6	3.72

Clustering was done separately for households in the two communities to allow for differences in livelihood outcomes that may arise from the ERI program. Using the agglomerative hierarchical clustering technique, three distinct clusters were formed in both the intervention community and the counterfactual community. Divisive non-hierarchical clustering was employed as an alternative approach in order to validate the cluster solutions

To determine the significance of the differences between the mean values of the variables used for clustering, a one-way Analysis of Variance (ANOVA) was carried out. The results of the ANOVA for the intervention community and counterfactual community are presented in Tables 4.14 and 4.15 respectively. From Table 4.14, it can be seen that in the intervention community, statistically significant differences exist between the three clusters that have been identified. These differences exist for the farm size, the value of assets and the number of farm plots which are all highly statistically significant. The mean household sizes were, however, found to be non-significant between the three clusters in the intervention community. This implies that the household sizes in the intervention community are generally similar and, as such, household size was not an important variable in describing the differences between households in the intervention community.

Table 4.14: ANOVA results for the intervention community clusters

Variable		Intervention community				
		Sum of squares	Degrees of freedom	Mean square	F-ratio	ρ
Value of assets (USD)	Between groups	2.11	2	1.06	105.41	0.000
	Within groups	9.82	98	1.00		
	Total	3.09	100			
Farm size (acres)	Between groups	149.70	2	74.85	15.29	0.000
	Within groups	479.51	98	4.89		
	Total	629.22	100			
Number of farm plots	Between groups	79.53	2	39.76	87.51	0.000
	Within groups	44.53	98	0.454		
	Total	124.06	100			
Household size	Between groups	12.64	2	6.32	0.92	0.403
	Within groups	675	98	6.88		
	Total	687.64	100			

For the counterfactual community, Table 4.15 shows that there are high statistically significant differences between the mean values for all the variables used to obtain a cluster solution. Hence, in the counterfactual community, the three clusters formed differ significantly in terms of the value of assets, the farm size, the number of farm plots and the household size. The results of an ANOVA generally indicate that differences exist between at least one pair of the clusters in terms of the mean values for the variables used for clustering. This is the case for the clusters in both communities.

The ANOVA results do not, however, provide information about the pair of clusters that are similar or dissimilar from one another. *Post hoc* tests are hence used to determine the actual differences between pairs. In this study, the Tukey's Honestly Significant Difference (HSD) test was used for such pairwise comparisons. *Post hoc* tests are only carried out on variables whose F-statistic in the ANOVA was statistically significant. This implies that for the intervention community, the household size was dropped from the *post hoc* test as had an F-statistic that was non-significant. Appendix 1 (Tables A4.1 and A4.2) present the results of the Tukey's HSD test for the intervention community and counterfactual community, respectively.

Table 4.15: ANOVA results for counterfactual community clusters

Variable	Counterfactual community					
		Sum of squares	Degrees of freedom	Mean square	F-ratio	ρ
Value of assets (USD)	Between groups	5.303	2	2.65	140.336	0.000
	Within groups	3.760	199	1.88		
	Total	9.062	201			
Farm size (acres)	Between groups	483.676	2	241.84	59.695	0.000
	Within groups	806.188	199	4.051		
	Total	1289.864	201			
Number of farm plots	Between groups	93.920	2	46.66	60.974	0.000
	Within groups	152.284	199	0.765		
	Total	245.604	201			
Household size	Between groups	229.563	2	114.78	32.057	0.000
	Within groups	712.536	199	3.581		
	Total	942.099	201			

The *post hoc* test for the intervention community shows that in terms of the value of assets, all the three clusters in the intervention community are statistically different from each other, with cluster one having lower monetary value of assets than either cluster two or three; and cluster three having higher monetary value of assets than cluster two. In terms of farm size, the results indicate that there is a statistically significant difference between the farm size of cluster two and cluster one; but cluster two is not significantly different from cluster three in terms of land ownership. Furthermore, the results indicate that households in cluster two had on average more separate farm plots than either cluster one or three; and that there is no statistically significant difference between clusters one and three in terms of ownership of separate farm plots.

For the counterfactual community, the results of the Tukey's HSD *post hoc* test show that cluster one differs significantly from both cluster two and three in that it has significantly higher means for the values of assets, the farm holding size and the number of separate farm plots. Cluster two has lower-valued assets, fewer numbers of farm plots and low land holdings as compared to cluster three. In terms of household size, the results show that cluster two differs significantly from cluster three in that households in cluster two had larger household sizes than those in cluster three. There are, however, no statistically significant differences between cluster one and three or clusters one and two in terms of the household sizes.

Validation of the identified clusters was done by applying an alternative clustering method to the agglomerative hierarchical clustering technique. Divisive non-hierarchical clustering was hence used as the alternative clustering technique. ANOVA was carried out to ascertain the existence of differences between the clusters formed and the Tukey's HSD test was applied *post hoc* to determine actual differences between specific pairs. Results of the divisive non-hierarchical clustering (Appendix 1) are consistent with the results of the agglomerative hierarchical clustering technique. Although small differences exist in terms of the cluster sizes, the results of the two clustering algorithms are generally similar.

Final profiling of the clusters was based on those variables that had a significant F-statistic from the ANOVA as well as on differences observed on additional variables. For this study, the total household income for the 2008/2009 cropping season, fertiliser use in the 2008/2009 cropping season and the value of upland maize harvest for the 2008/2009 agricultural season were used as the additional profiling variables. These additional variables are those that are able to indicate the potential for differences in livelihood outcomes between the clusters. Validation focuses on variables included in the clustering, while profiling of clusters focuses on variables not included in the cluster solution (Hair, *et al.* 1995:454). ANOVA results of the three clusters in both the intervention and counterfactual communities for the additional profile variables are given in Tables 4.16 and 4.17, respectively.

ANOVA results indicate that differences exist between the three identified clusters in both communities. For the intervention community (Table 4.16), differences exist for the three clusters in terms of the value of the 2008/2009 maize harvest, fertiliser use and total income for the 2008/2009 agricultural season. For the counterfactual community (Table 4.17), the three clusters have differences existing for only the 2008/2009 total income and the value of maize harvested in the 2008/2009 season, but not for the inorganic fertiliser use for the same season.

Table 4.16: ANOVA results for intervention community (profile variables)

Variable (2008/2009)	Intervention community					
		Sum of squares	Degrees of freedom	Mean square	F-ratio	ρ
Total income (USD)	Between groups	2.908	2	1.454	11.524	0.000
	Within groups	1.236	98	1.262		
	Total	1.527	100			
Fertiliser use (no. of 50 kg bags)	Between groups	56.802	2	28.401	4.955	0.009
	Within groups	561.708	98	5.732		
	Total	618.511	100			
Value of maize harvest (USD)	Between groups	5.252	2	2.626	8.468	0.000
	Within groups	3.039	98	3.101		
	Total	3.565	100			

Actual differences between pairs of clusters for the additional profile variables were obtained by conducting the Tukey's HSD test. For the counterfactual community, inorganic fertiliser use was dropped from the *post hoc* test as the F-statistic in the ANOVA was non-significant. Results of the Tukey's HSD *post hoc* tests (Appendix 1) show that cluster three in the intervention community has positive significant differences from either cluster one or two with higher mean incomes, higher value of maize harvest, and largest number of 50 kg bags of inorganic fertilisers applied for the 2008/2009 cropping season. Clusters one and two do not have any statistically significant differences between them in terms of fertiliser use and the value of maize harvest for the 2008/2009 agricultural season. However, there is a statistically significant difference between income for the 2008/2009 season with households in cluster two having higher incomes than those in cluster one.

Table 4.17: ANOVA results for counterfactual community (profile variables)

Variable (2008/2009)	Counterfactual community					
		Sum of squares	Degrees of freedom	Mean square	F-ratio	ρ
Total income (USD)	Between groups	4.719	2	2.359	76.720	0.000
	Within groups	6.120	199	3.075		
	Total	1.084	201			
Fertiliser use (no. of 50 kg bags)	Between groups	39.595	2	19797	0.989	0.374
	Within groups	3984.75	199	20.024		
	Total	4024.35	201			
Value of maize harvest (USD)	Between groups	2.363	2	1.818	80.195	0.000
	Within groups	2.917	198	1.473		
	Total	5.879	200			

For the counterfactual community, cluster one has the highest level of total income and value of maize harvest for the 2008/2009 cropping season as compared to the other clusters, and these differences were statistically significant. Cluster three, on the other hand, had the lowest levels of either total income and value of maize harvest in the 2008/2009 season. These findings for the counterfactual community are consistent with the findings from both the agglomerative hierarchical and divisive non-hierarchical clustering techniques. This clearly distinguished three clusters, with cluster one having the highest mean values for all variables under consideration and cluster three having the lowest.

Based on the cluster analysis solution as well as the validation results, the study finds that in the counterfactual community, there are three very distinct household typologies; while in the intervention community, there are three overlapping household types. In the counterfactual community, the three distinct household types are the low resourced, medium resourced and large resourced households. Although the first two categories have similarities, there are very distinct differences in terms of land ownership. Table 4.18 provides a summary of each of the household typologies from the counterfactual community.

Table 4.18: Description of household typologies in the counterfactual community

Households characteristics	Household resource group		
	Low resourced (62%)	**Medium resourced (37%)**	**Large resourced (1%)**
Asset value	Assets valued between USD0 to USD338	Assets valued between USD0 to USD600	Assets valued between USD750 to USD1000
Farm size	Size range: 0.162–2.23 ha About 1–3 pieces of land	Size range: 0.162–5.06 ha About 1–6 pieces of land	Size range 2.18–9.31 ha About 2–8 pieces of land
Fertiliser use (2008/2009)	Applied between 0 and 6.1 50 kg bags	Applied between 0 and 6.18 50 kg bags	Applied between 2.3 and 6.8 50 kg bags
Maize harvest	Valued in between USD1.16 to USD650	Valued in between USD11 to USD2800	Valued in between USD905 to USD2600
Annual cash income	Ranged from no income to USD1860	Ranged from no income to USD600	Ranged from USD1186 to USD5600
Educational attainment	Spouses: 40.8 % no formal education Household heads: 46.4 % attended but did not finish primary school Participation in extension trainings (2008/2009): 21.6 %	Spouses: 43.2 % attended but not finished primary school Household head:45.9 % attended but did not finish primary school Participation in extension trainings (2008/2009): 29.7 %	Spouses: 66.7 % no formal education Household heads: 66.7 % no formal education Participation in extension trainings (2008/2009): 0 %
Age range	19 to 78	18 to 87	30 to 63

*All monetary values are for the 2008/2009cropping season

Table 4.19 provides a summary description of each of these household types for the intervention community. In the intervention community, there was an overlap in the household typologies and the three categories of households can be categorised into low resourced households, large resourced households with low cash income, and medium resourced households with high cash income.

Table 4.19: Description of household typologies in intervention community

Households characteristics	Household resource group		
	Low resourced (56%)	**Medium resourced with high cash income (5%)**	**Large resourced with low income (39%)**
Asset value	Assets valued between USD0 to USD405	Assets valued between USD1198 to USD2044	Assets valued between USD15 to USD1400
Farm size	Size range: 0.40–2.63 ha About 1–3 pieces of land	Size range: 1.32–2.63 ha About 2–4 pieces of land	Size range: 0.73–8.09 ha About 3–6 pieces of land
Fertiliser use (2008/2009)	Applied between 0 and 16 50 kg bags	Applied between 2.28 and 8.24 50 kg bags	Applied between 0 and 6.97 50 kg bags
Maize harvest	Valued in between USD4.64 to USD6900	Valued in between USD600 to USD10446	Valued in between USD35 to USD5000
Annual cash income	Ranged from no income to USD2900	Ranged from USD500 to USD5000	Ranged from USD63 to USD4700
Educational attainment	Spouses: 40.4 % no formal education Household heads: 38.6 % attended but did not finish primary school Participation in extension trainings (2008/2009): 28.1 %	Spouses: 60 %attended but not finished primary school Household heads: 4 % attended but not finished primary school Participation in extension trainings (2008/2009): 40 %	Spouses: 33.3 % attended but not finished primary school Household head: 28.2 % attended but did not finish primary school Participation in extension trainings (2008/2009): 20.5 %
Age range	23 to 79	30 to 63	24 to 68

*All monetary values are for the 2008/2009cropping season

In conclusion the typology development exercise has demonstrated that households in the study area are differentiated in terms of not only physical resource endowments such as land ownership but also based on household staple food production, income earnings and input usage. These differences are not only found between different communities in the study area but also between households within the same community. The implications of these findings are that policy changes that affect the labour market, maize input and output markets as well as pricing and marketing of inorganic fertiliser will result in inter and intra community differences. Furthermore these findings imply that there is diversity in living standards amongst the poor in rural Malawi. This therefore entails that households respond differently to risks that arise either from nature factors or from man-made factors such as market reforms and policy changes. The simulation analysis in Chapter 6 tests this hypothesis and provides insight into how the use of innovation systems in agricultural research and development contributes to household decision making and reaction to policy changes that transmit through the market.

4.5.2 Household income portfolios

Using the household typologies that were identified, an analysis of each type of household's income portfolio was carried out. In this study, household income is not synonymous with cash income. Rather, it includes cash income earned from various employments; non-cash income earned from the sale of labour and other on and off-farm employment; income earned from the marketing of agricultural crops and livestock produce; and the imputed value of all crops harvested which are retained for home consumption. Imputed values are calculated on prevailing retail prices as that is the price that households would pay if they needed to purchase it. The ten different sources of household income that were identified are described in Table 4.20.

The largest share of household cash income in many poor rural communities in Sub-Saharan Africa comes from crop sales (Ellis, 2006). Through the pricing of staple food commodities such as maize which are regulated by government, rural households find that the incomes that they earn in marketing staple food crops; and the value of the crops that they produce and retain for consumption link them to the market economy. The linkages created by staple food production and sales is, however, not very robust, as staple food products provide less income and require little or no inputs (Davis, *et al.* 2002).

Table 4.20: Sources of income

Source of income	Description
All upland crops except maize	Value of all upland crops harvested in the main rainy season with the exception of maize that were sold at market prices; and the imputed value of crops kept for home consumption.
Salaried employment	Summation of income earned from both part and full-time salaried employment that was non-farm in nature.
On-farm seasonal employment	Summation of income from on-farm seasonal employment which during the main cropping season is mainly labour employment.
Off-farm seasonal employment	Income from semi-skilled and skilled work, such as carpentry, brick making/burning, brick laying and house building, which takes place usually just prior to the rainy season.
Non-agro based enterprise	Income from income-generating activities that were not agro-based. Common non-agro based commercial enterprises included operation of a general grocer and the selling of second-hand clothing.
Agro-based enterprise	Income from marketing own produce from own farm or crops brought from other farmers or areas. Also includes income from sale of processed goods, such as cooked and baked food stuff.
Livestock	Value of all livestock sold during a cropping season.
Wetland crops	Total income from all crops cultivated during the short dry winter season using either irrigation or residual moisture.
Remittances	All income not earned but received from relatives or through other channels.
Maize income	Income from maize included the computed value of maize sold, maize exchanged for other commodities and maize kept for household consumption.

As a result of this, rural households have little backward and forward production linkages to the rest of the economy (Davis, *et al.* 2002). However, in non-industrial communities such as the area for this study, income from staple food production provides the only valid linkages to the market economy. Aggregate household income was therefore estimated as an arithmetic function which summed the real and imputed income earnings from the ten different income sources. Estimates for income were computed for the household as one as opposed to it being disaggregated by household members due to the lack of disaggregated data.

An analysis of the income portfolios for the 2008/2009 cropping season for the different household types shows that there were differences in terms of the share of income from different sources for within and between households in the intervention community and the counterfactual community (Table 4.21). In the intervention community, for the low and large resourced households, maize contributed 49 % and 30 % of the total income, with all other upland crops contributing 42 % and 55 % of total income, respectively. For the medium resourced households, the main source of income was other upland crops (excluding maize) which contributed about 92 % of the total income. Maize contributed approximately 6 % of the total income.

Table 4.21: Income portfolio compositions (%)

Source of income*	Household typology by community		
	Low resourced	Medium resourced	Large resourced
	Intervention community		
Maize	49	6	30
All other upland crops	42	92	55
Livestock	2	1	11
All other sources	7	1	4
	Counterfactual community		
Maize	42	28	3
All other upland crops	33	56	64
Livestock	1	1	30
All other sources	7	6	1
Employment	17	9	2

*The values include both the real market earnings and the imputed value of non-marketed crop and livestock goods

In general, households in the intervention community had three main sources of income. These are income from the sale of maize; income from all other upland crops (excluding maize); and income from other sources, which constituted the income from both off and on-farm seasonal employment, other salaried employment, income from agro-based and non-agro-based commercial enterprises, and income from crops cultivated in the wetland and remittances. The last category of income (other sources) generally contributed to the smallest proportion of total income in all the three household categories. Income from livestock marketing was a small contributor towards total income in the low (2 %) and medium (1 %) resourced households, with only households in the large resourced category earning about 11 % of their total income from livestock.

In the counterfactual community, the low and medium resourced households received the largest share of their total income from crop production. For the low-resourced households, maize and all other upland crops constituted the largest and second largest share of income at 42 % and 33 %, respectively. For the medium resourced households, all other upland crops and maize production constituted the largest and second largest contributor at 56 % and 28 %, respectively. Employment which included on and off-farm labour employment and any full and part time employment, was the third largest contributor to total income for both the low and medium resource-endowed households, with contributions of 17 % and 9 % to total household income, respectively. Employment played a bigger role in the income portfolio of households in the counterfactual community than in the intervention community. This can be attributed to the proximity of the counterfactual community to a tarmac road. In addition, the proximity to the tarmac road makes the counterfactual community an attractive area for urban semi-commercial farmers who purchase land (both upland and wetland) from the locals. These semi-commercial farmers also provide employment to households in the counterfactual community, as they hire both men and women throughout the cropping season.

Apart from these major sources of income in the counterfactual community, both the low and medium resourced households also received a considerable amount of their incomes from other sources. These sources included incomes from remittances, non-agricultural commercial enterprises, agro-based commercial enterprises, and income from crops cultivated in the wetland. All other sources contributed approximately 7 % and 6 % in the low and medium resourced households, respectively. Income from livestock sales contributed about 1 % of total income in both the low and medium resourced household categories. For the large resourced households in the counterfactual community, all upland crops except maize contributed to approximately 64 % to the total income; followed by livestock, which contributed 30 % of the total income. This household type is the only one in this study in which livestock income contributed a significantly large share of total income. Apart from all other upland crops and livestock, other income sources for the large resourced households included maize (3 %), employment (2 %) and all other sources (1 %). Employment comprised any salaried employment, off and on-farm employment, while other sources of income included income from the sale of wetland crops, remittances, and income from both agro and non-agro-based commercial enterprises.

4.6 CHAPTER SUMMARY

It has been demonstrated that statistically significant differences exist between households in the intervention community and counterfactual community; which can be attributed to the ERI initiative. Positive impacts of ERI have been demonstrated for different livelihood outcomes, including production, income generation, fertiliser use patterns, as well as trainings and membership of farmer groups for households in the communities in which it was implemented. Hence, AIS driven research interventions have the potential to impact upon and change the livelihood outcomes of rural households within the maize-based farming system in Malawi by creating greater opportunities for linking the communities to markets. These findings provide the proof for the first hypothesis.

In addition, identified household typologies showed that low-resourced households have less diversified income portfolios; and concentrate more on earning income from casual wage employment with high dependence on subsistence food production as compared to better-off households. Income from maize was, however, a key contributor to household incomes for all typologies, with low-resource households having a larger share of their income emanating from maize as compared to better-off households. The implications of these findings are that macro-economic policy shocks that transmit through maize prices have the potential to impact differently upon the incomes and therefore livelihood outcomes of different households in the two communities. This hypothesis is tested using simulation analysis in Chapter 6. However, prior to this, Chapter 5 provides a basis for understanding maize price formation in Malawi maize markets and will develop a full partial equilibrium maize model which will be used to test the above-mentioned hypothesis.

CHAPTER 5

DYNAMICS OF THE MALAWI MAIZE MARKET

5.1 INTRODUCTION

This chapter provides insight into the structure and dynamics of the maize market in Malawi, with particular emphasis on the factors determining price formation within national and local maize markets and on unravelling the price discovery mechanism within farm/household-level maize markets. These analyses are carried out in order to discover the nature of the linkages between the farm/household, local and national maize prices and markets and, in so doing, put in place a framework which can be used to assess the impact of macro-level policy changes on the livelihood outcomes of rural smallholder farmers who engage in the marketing of maize. In essence to better appreciate the price transmission mechanism between the three price levels thus allowing for better understanding of the patterns, trends and relationships governing price formation in the country which is essential for developing a robust model. Finally, the chapter also aims to validate the maize partial equilibrium model in order to demonstrate its robustness and suitability as a tool for policy analysis.

The ultimate goal of this chapter is to develop a framework that can be used to assess the impact of different agricultural sector policies and other macro-economic policy changes on rural incomes for households that are involved in maize production and marketing. In order to develop such a framework, it is essential to initially understand the dynamics and inter-relationships between maize prices in the farm/household market, the local economy market and the national market; and in so doing, to determine the nature and the extent of linkages between these three levels. The first section of this chapter aims to provide such insight into the dynamics of price formation in the Malawi maize market. It includes a statistic analysis of price discovery mechanism at the farm/household level using primary data from households as described in Chapter 4; a statistical and visual analysis of the inter-relationship between maize prices within the country and with regional maize markets and an econometric analysis of the factors influencing price formation at the local and national level. These sections inform the development of a partial equilibrium maize model which is then described in detail in the last section of this chapter, and which is used in Chapter 6 to simulate the impact of different policy changes on rural household incomes.

5.2 DESCRIPTION OF THE DATA

Time series data from 1989 to 2008 was used to estimate single equation models for the maize market and to build the partial equilibrium framework. For consistency, data should be obtained from a single source (Mukhatar & Muhammad, 2009:67). However, due to lack of such a comprehensive source, data was obtained from various data bases. These included the World Bank, Food and Agricultural Organization of the United Nations, the Malawi Ministry of Agriculture, the Malawi National Statistical Office, The Malawi Department of Meteorological Services, and the United Nations Conference on Trade and Development. Data from international data bases was validated with industry players and government experts to ensure accuracy. Table 5.1 presents the mean values for area of maize planted, maize yields, domestic maize production, domestic maize consumption, per capita maize consumption, national producer price of maize (ADMARC) and the local price of maize (Nsundwe), and imports and exports for the period 1989 to 2009. The full data sheet is provided in Appendix 2 and results of the tests for stationarity for all the data are given in Appendix 3.

Table 5.1: Various maize production and marketing data in Malawi

	1989-1994	1995-1999	2000-2004	2005-2009
	Thousand hectares			
Area planted	1300.88	1142.23	1238.58	1206.68
	Tons per hectare			
Yield	0.925	1.15	1.05	1.40
	Thousand tons			
Domestic production	1194.50	1312.83	1278.94	1672.48
Domestic consumption	1491.72	1551.51	1602.79	1713.38
Maize imports	298.26	241.08	324.35	83.72
Maize exports	0.949	2.31	0.718	42.19
Ending stocks	2.21	2.37	2.15	4.34
Local production (Ukwe EPA)	17.57	20.12	21.15	23.22
Local consumption (Ukwe EPA)	97.62	90.80	92.68	97.14
	Kg/capita			
Per capita maize consumption	157.91	153.51	139.22	136.47
	Millions			
Population	9.53	10.11	11.53	13.39
	USD per ton			
ADMARC price	144.14	179.05	175.33	177.92
Local price (Nsundwe market in Ukwe EPA)	113.72	139.97	155.34	167.10
US yellow maize (FOB Gulf)	107.03	119.41	98.82	154.41

As can be seen from Table 5.1, maize production and domestic maize consumption have been increasing steadily since 1989; with the average national maize production rising from 1 194 500 metric tons between 1989 and 1994 to 1 672 480 metric tons between 2005 and 2009. Similarly, average domestic maize consumption has been steadily increasing; with the national average annual consumption rising from 1 491 720 metric tons between 1989 and 1994 to 1 713 380 metric tons between 2005 and 2009. On per capita basis however it can be seen that consumption has a slow but decreasing trend with per capita maize consumption decreasing from 157.91 kg/capita between 1989 and 1994 to 128.47 kg/capita between 2005 and 2009. This change represents nearly a 23% decline in per capita maize consumption over the 20 year period (1989 to 2009). The decrease in per capita maize consumption can be attributed largely to a rapidly rising national population with the average population rising from 9.53 million between 1989 and 1994 to an average of 13.39 million people between 2005 and 2009. In addition, the decreasing trend in per capita maize consumption can also; to a smaller extent; be attributed to a growing urban population that consumes less maize. In addition changes in government policy in the early 2000's that led to greater market liberalization of the economy could also have contributed to the decline in per capita maize consumption due to the availability of cheaper alternative food stuffs; especially for urban consumers.

It can further be seen that maize yields have consistently risen in the country, with the average yield rising from less than one ton per hectare between 1989 and 1994 to 1.40 tons per hectare between 2005 and 2009. The area of maize planted, on the other hand, does not have a clearly discernable pattern; with the average acreage decreasing from 1 300 880 hectares between 1989 and 1994 to 1 142 230 hectares between 1995 and 1999. However, between 2000 and 2004, the average area planted with maize increased to 1 238 580 hectares; but decreased slightly again between 2005 and 2009, to 1 206 680 metric tons.

Maize price data for the national producer price of maize (ADMARC) and the local maize price for the Nsundwe market was collected from the Ministry of Agriculture and Irrigation in Malawi. From Table 5.1, it can be seen that both the ADMARC maize price and the local maize price have an increasing trend, with the average ADMARC maize prices rising from USD144.14 per ton between 1989 and 1994 to USD USD177.92 per ton between 2005 and 2009. The average local maize price for the Nsundwe market also rose from USD113.72 per ton between 1989 and 1998 to USD167.10 per ton between 2005 and 2009. In comparison to the international maize price, it can also be seen that although the yellow maize price generally decreased between 2000 and 2004; the general trend since 1989 is an upward one with the average yellow maize price increasing from USD107.03 in between 1989 and 1994 to an average of USD154.41 in between 2005 and 2009. Maize price data was used to assess trends in price levels over time as well as the nature and direction of price transmission within the maize market in Malawi. It should be noted that the terms ADMARC maize price and the national producer price of maize are used interchangeably.

5.3 PRICE FORMATION IN THE MALAWI MAIZE MARKET

Understanding the behaviour of maize prices in Malawi is important for determining the structure of the maize market and the linkages existing between the national, local and farm/household maize markets. In addition, price discovery is essential for formulating effective policies for ensuring food security. This section provides an in-depth analysis of the relationship between local maize market prices and national (ADMARC) prices using both quantitative and qualitative methods. Its aim is to assess the relationship between maize prices at the national, local and farm/household level and, in so doing, provide an insight into the macro-micro linkages that exist between rural smallholder farming households that produce and market maize and the macro-economy.

As stated in Chapter 1, the Malawi maize market is comprised of three levels (Figure 1.1). The farm/household market consists mainly of rural individual households that are both producers and consumers of maize. The price prevailing in the farm/household market is the farm gate price which is also referred to as the farm/household price in this chapter. This is the price at which producers sell to roving traders that travel to their villages and communities and the price at which farmers sell to each other within a community. In addition the farm gate price is also the equivalent price at which maize is exchanged for other crops and services in any community

The second market is the rural market which is found in rural trading centres across the country and it can be seen as a ‘central’ market for a specific rural locality that comprises several villages and communities. The price prevailing in the rural market (rural economy) is referred to in this study as the local price with the Nsundwe market being used as a case study. In the local market, there are different types of maize trade that take place. First producers; who choose not to sell at the farm gate price; sell their maize to either larger buyers/traders stationed at the local market or to consumers. Second the roving traders who buy maize at the farm gate price from producers also sell maize to the larger traders. For example in the study area, it was found that individual roving traders were buying maize from producers (at the farm gate price) in both the intervention and counterfactual communities and selling it at a higher price (the local market price) to Mulli Brothers Ltd- a large agricultural trading firm that had set up buying points in the local market.

Finally, there is the integrated national maize market controlled by government and in which the Agricultural Development and Marketing Corporation (ADMARC) price prevails. ADMARC depots can be found in some but not all rural trading centres in the country and as such producers also have the option of directly selling to ADMARC. In many instances producers prefer to sell to private traders who start buying maize from farmers at the onset of the harvest period while ADMARC takes longer as it awaits the announcement of the official ADMARC price. In many instances private traders offer a lower price than ADMARC, however many farmers often are cash strapped and opt for the lower price offered at the onset of the harvest season by private traders.

5.3.1 Understanding farm/household-level maize price formation

At the farm/household level, the dynamics of maize pricing are far more complex as compared to the national or local market level. This is due to the nature of the rural household economy, which is limited by the absence of cash income, and the extremely important role that maize plays in the diets and nutritional attainment of many rural households in Malawi. In addition, it is complicated by farmers who are both producers and consumers of maize. In Katundulu village, the intervention community in this study, farmers used maize as a form of currency to purchase salt from hawkers (Figure 5.1). These hawkers are the smallest unit in terms of maize traders and they have on average 2 to 3 bags (50 kg) of maize, which they exchange for salt on a monthly basis. The hawkers in turn sell the maize to households in the residential areas in the city of Lilongwe for a much higher price. Households that use maize as currency are those that are food self-sufficient. However because they have no alternative sources of income apart from farming, they lack the cash with which to purchase other essential goods and services. Apart from salt, many other goods such as labour, clothing and services are exchanged for maize.

Figure 5-1: Use of maize as currency

Apart from using maize as a currency, the study also finds that there is a thriving maize market at the village level. Households that are food secure normally keep sufficient amounts of maize for their own consumption and then use the surplus to either pay labourers for work on their farm during the cropping season, or market it as a cash crop. In this study, at the onset of the 2009/2010 agricultural season, a 20 kg tin of maize was sold for approximately USD4.64 (MK650), which is about USD0.23 per kg. This price, which was 30 % lower than the prevailing ADMARC maize price for the 2009/2010 agricultural season of USD0.34 per kg, was considered very high for the households that were selling maize in the study area.

In general, it is the most productive households that market part of their maize harvest. This is illustrated in Table 5.2, which shows the average number of bags (50 kg's each) of maize harvested per household in both communities in the 2007/2008 and the 2008/2009 cropping seasons and the patterns of maize marketing. On average, households that sold maize in either the 2007/2008 or the 2008/2009 cropping season had higher maize harvests in both communities than households that did not sell maize. This is demonstrated by households who sold part of their maize in the intervention community harvesting on average 45 and 65 bags (50 kg's each) of maize in the 2007/2008 and 2008/2009 seasons respectively; as compared to households that did not sell maize who harvested on average 16 and 34 bags (50kg's each) of maize in the same respective cropping seasons.

Table 5.2 Average maize harvest for sellers and non-sellers of maize

	Maize marketing	Cropping season	
		Number of bags (50 kg[8]) harvested per season	
		2007/2008	2008/2009
Intervention community	Sells maize	46	65
	Does not sell maize	16	34
Counterfactual community	Sells maize	29	28
	Does not sell maize	11	9

The findings are similar in the counterfactual community. Households that sold maize harvested on average more maize than households that did not sell their maize. Households selling maize harvested on average 29 and 28 bags (50 kg) of maize in the 2007/2008 and 2008/2009 seasons respectively; as compared to households that did not sell maize, who harvested on average 11 and 9 bags (50 kg) of maize in the 2007/2008 and 2008/2009 cropping seasons, respectively.

An analysis of the unit prices that individual households received for their maize demonstrates that households in the intervention community received on average USD0.20 per kg of maize, while households in the counterfactual community received on average USD0.18 per kg of maize in the 2008/2009 season. From scatter plots of the unit prices received by different households in each community, it can be seen that in the intervention community, households received more or less similar prices, with very few households deviating from the average price of USD0.20 per kg (Figure 5.2).

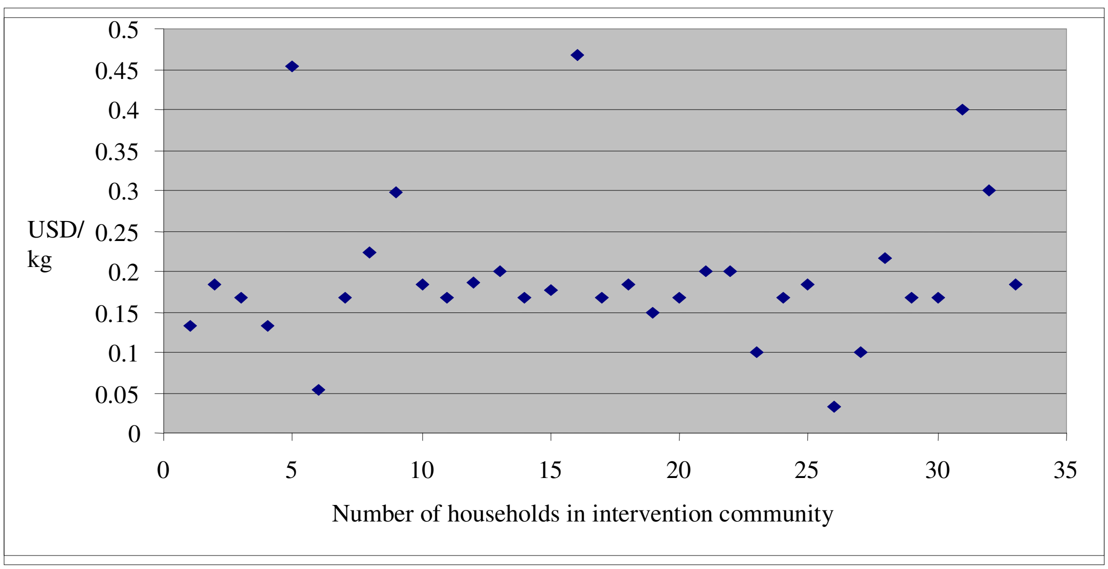

Figure 5-2: Maize unit price variations in the intervention community

[8] Production quantity was not reported in kg equivalent because actual bags of maize were not weighed. However farmers package de-cobbed harvested maize in 50 kg sacks. Reporting in number of bags therefore provides room for actual verification of the weight.

For the counterfactual community, however, it can be seen from the scatter plot in Figure 5.3 that the unit price per kilogram of maize that households received was more varied as compared to the unit prices that households in the intervention community received. There are two major reasons for the differences between the scatter plots of the unit prices in the two communities. First from the descriptive analysis of the two communities in Chapter 4, it was seen that the counterfactual community is closer to a tarred road and, hence, producers have greater accessibility to more markets and traders who offer different prices. This is in contrast to the intervention community, which is far from a tarred road and hence less accessible to different markets. Ideally, given that there are more market outlets, it would have been expected that counterfactual community households could get higher prices as compared to the intervention community households; as other studies have shown that accessibility to marketing outlets affects the pricing of goods, with communities that are in more remote areas receiving a relatively lower price (Matungul, *et al.* 2001). This was not the case for this study, because households in the intervention community were more organised and as such marketed their maize as a group. This is the second reason for the observed differences in the variability of unit prices between the two communities.

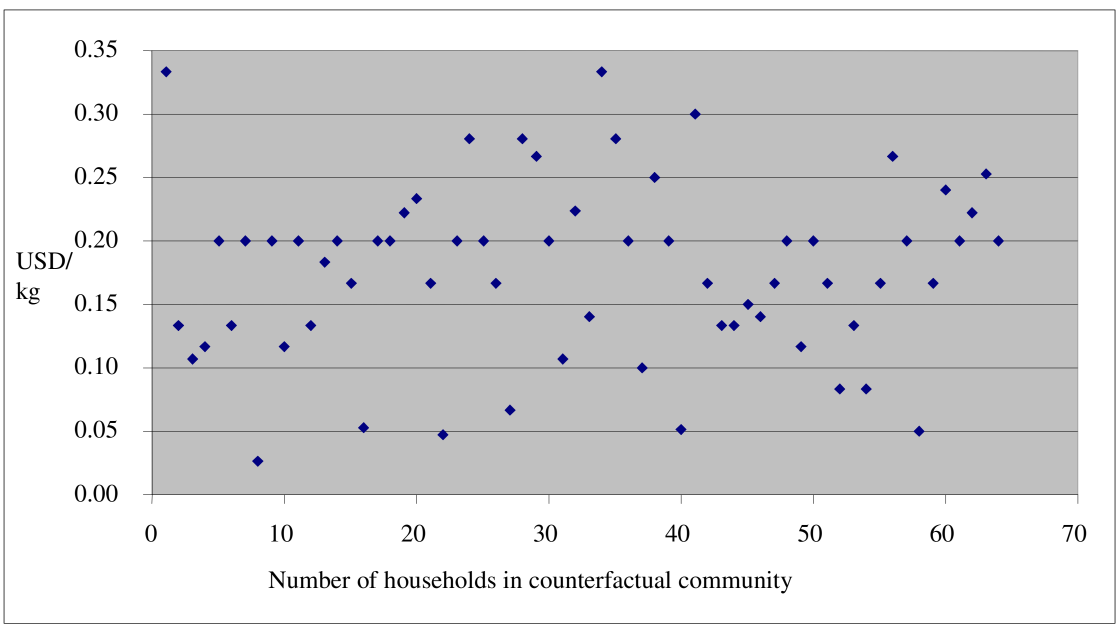

Figure 5-3: Maize unit price variations in the counterfactual community

Under the ERI program, households in the intervention community had organised themselves into a group in order to find marketing opportunities for the piggery agro-enterprise. However, this study finds that the same group that had been organised for the piggery enterprise also used their newly-attained marketing skills to negotiate for marketing of other crops, including maize. Through this organisation, members of the group who wanted to sell their maize were able to negotiate for a better price. Observed differences in unit prices in the intervention community are attributed to some households selling their maize either before or after a price had been negotiated by the group with the traders. Most households that sold in an individual capacity received a lower unit price, with very few obtaining a higher unit price.

A general statistic analysis of the price differences between the farm gate price, the local market price (Nsundwe) and the ADMARC price of maize shows that the farm gate price is consistently lower than either the local market price (Nsundwe) or the ADMARC price. In Table 5.3, it can be seen that the farm gate price for the households sampled in this study was 37.9 % and 11.5 % lower than the local market price (Nsundwe) for the 2008/2009 and 2009/2010 cropping seasons, respectively. In the 2007/2008 season, it can, however, be observed that the farm gate price was equal to the local market price. This can be attributed to maize prices being generally low throughout the country in the 2007/2008 season, with the ADMARC maize price of USD128.68 per ton being at its lowest since the 2002/2001 season.

Table 5.3: Variations in maize unit prices across different markets

	Unit price (USD/kg)	Absolute difference	% difference
	2007/2008 cropping season		
ADMARC price	0.13		
Local market price Nsundwe)	0.12	0.01	7.7
Farm gate price	0.12	0.0	0.0
	2008/2009 cropping season		
ADMARC price	0.33		
Local market price (Nsundwe)	0.29	0.04	12.1
Farm gate price	0.18	0.11	37.9
	2009/2010 cropping season		
ADMARC price	0.34		
Local market price Nsundwe)	0.26	0.08	23.5
Farm gate price	0.23	0.03	11.5

The low prices observed in the 2007/2008 agricultural season can be attributed to inflated production estimates. The inflated production estimates led to a government decision to export maize. This resulted in food shortages and high maize prices at the end of the 2007/2008 season (Jayne, *et al.* 2010), which are reflected in the ADMARC and local maize markets for the 2008/2009 season with the ADMARC price and the local market price

(Nsundwe) rising by nearly 20 % and 17 %, respectively. The farm gate price also rose in the 2008/2009 cropping season, but at a lower rate of 6 %. In the 2009/2010 cropping season, however, this trend is reversed with the farm gate price continuing to rise by 5 %, whilst the ADMARC maize price rose by only 1 % and the local price decreased by 3 %.

Variations in the farm gate price and price differentials between the farm/household price and the local or national level prices can be explained by three inter-related reasons. First, the remoteness and isolation of rural smallholder producers arising from poor road networks and the lack of reliable transportation implies that accessing markets with higher maize prices is difficult and ultimately very costly. Hence, in the case where rural producers are aware of a market with higher prices, they are unable to participate in it as a result of the high transaction costs that they would incur. Second, rural producers are further isolated due to poor information technology and community networks. This entails that maize traders who provide the main market for rural maize producers often have more information than the producers about the prices of maize prevailing in other markets. Hence, rural producers are not able to negotiate effectively for higher prices as they lack the necessarily market information.

In addition, price formation at the farm gate level is also greatly influenced by producer price expectations, which are formed mainly on the basis of prices from the previous season. This is because farm gate prices and negotiations are based on lagged information that producers themselves have gathered and on the information that maize traders are willing to share. Hence, the producers of maize often lack sufficient information with which to negotiate their prices as they have lowered expectations based on lagged maize prices.

5.3.2 Understanding national and local level maize price formation

The pricing of maize differs at the farm/household level, the local economy and at the national level due to the nature and structure of the country and the thriving rural economies that vary spatially across the country. At the national level, prices for maize are set by government based on national annual production estimates, the supply and demand structure of the country, as well as on welfare considerations for low-income consumers. In addition, the government also sets the maize price to ensure that smallholder producers are able to obtain a price that encourages production and reinvestment in the farm. Furthermore regional prices of maize also influence the ADMARC maize price as in times of food shortages; maize is imported from the region (mainly South Africa). However since the Malawi maize market is not fully liberalized, government often buffers the effects of regional and international maize price fluctuations (to ensure food security) and as such transmission is often low. The government buffers regional and international maize price fluctuations using import and export bans and price controls.

The national producer price governs the purchase and selling price of maize in all government markets that are operated by ADMARC, which is a government parastatal responsible for buying and selling food crops throughout the country. The national producer price is the same throughout all ADMARC markets in the country regardless of the spatial differences in production and availability of maize. The ADMARC maize price is announced through the radio and other communication media at the end of the cropping season.

On the other hand, the local market maize price is the prevailing price in different local markets throughout the country. For this study, the local market price that was used was the average annual price for maize prevailing in the Nsundwe market, which is the biggest and closest in proximity to the households in the study area. Ideally, price should be competitively set depending on the supply and demand dynamics as well as the prices of substitutes and complements. In Malawi, this is not the case as the maize market is uncompetitive, which leads to direct government intervention (Jayne, *et al.* 2010). Government intervention has taken place in many forms in Malawi, with the private sector initially being excluded from maize trade. After liberalisation of the maize market in 1994, the private sector has played a greater role in maize trade, but with government still controlling maize trade through price interventions and export bans.

5.3.2.1 Maize price transmission

To better understand the relationship between the ADMARC price and other prices in local maize markets in the country, co-integration analysis was carried out. Six local markets were included for Malawi and consisted of two markets from each of the three regions in the country; Mzuzu and Mzimba markets from the Northern Region, the Lunzu and Limbe markets from the Southern Region, and the Lilongwe and Nsundwe markets from the Central Region.

As a pre-testing for co-integration analysis and to determine the degree of stationarity, the Augmented Dickey-Fuller (ADF) test was carried out to test for the presence of unit roots. As can be seen in Table 5.4, all the maize price time series from the six local markets and the ADMARC market have ADF statistics that are, in absolute terms, greater than the MacKinnon crucial values.

Table 5.4: ADF unit root tests for maize prices

Maize market	ADF Statistic	MacKinnon critical value	Durban-Watson statistic
ADMARC	-3.84	-3.83***	1.98
Nsundwe	-3.15	-3.02**	2.09
Lilongwe	-4.06	-3.83***	2.07
Lunzu	-3.90	-3.83***	1.82
Limbe	-4.12	-3.85***	2.11
Mzimba	-2.82	-2.65*	1.89
Mzuzu	-3.18	-3.02*	1.96

Test critical values: *** at 1 % level, ** at 5 % level and * at 10 % level

This implies that the null hypothesis of non-stationarity for the price time series can be rejected; with the ADMARC, Lilongwe, Lunzu and Limbe price series having the null hypothesis rejected at the 1 % level of confidence; Nsundwe at the 5 % level of confidence; while Mzimba and Mzuzu prices having the null hypothesis of non-stationarity being rejected at the 10 % level of confidence. Since all the maize prices were stationary (in differences and not in levels), an analysis of the long-run relationship between each of the six local prices with the ADMARC maize price was also carried out. The Johansen co-integration test was used to determine if the maize prices in the local markets are integrated with the ADMARC price.

Table 5.5: Results of the Johansen co-integration test

Maize market	Eigenvalue	Trace statistic	0.05 critical value	Hypothesised no. of CE(s)[9]
Nsundwe	0.673	27.092	18.397	None*
	0.320	6.962	3.841	At most 1*
Lilongwe	0.662	30.718	18.397	None*
	0.462	11.189	3.841	At most 1*
Lunzu	0.671	24.262	18.397	None*
	0.210	4.246	3.841	At most 1*
Limbe	0.678	29.393	15.494	None*
	0.393	8.992	3.841	At most 1*
Mzimba	0.675	27.146	18.397	None*
	0.318	6.904	3.841	At most 1*
Mzuzu	0.700	28.415	18.397	None*
	0.311	6.717	3.841	At most 1*

[9] Co-integration equation(s)

Further analysis shows that the ADMARC maize price is co-integrated with all the six local market prices (Table 5.5), as the estimated Johansen trace statistic for each of the six markets is greater than the 0.05 critical cut-off values. This implies that each of the six local maize market prices has a long-run equilibrium relationship with the ADMARC maize price.

In addition using Granger causality tests shows that the relationship between the ADMARC maize price and each of the local market maize prices is one way in nature. From Table 5.6, it is evident that the ADMARC price of maize Granger causes local market maize prices, but none of the local market prices Granger causes the ADMARC price. This implies that the lagged values of the ADMARC price can be used to predict current local market maize prices; but lagged values of local maize prices cannot be used to predict current prices of maize in ADMARC markets. This result is expected given the nature of the price system in the country.

Table 5.6: Results of the pairwise Granger causality test

Null hypothesis	Observations	F-statistic	Probability
ADMARC does not Granger cause Nsundwe	18	1.84	0.019
Nsundwe does not Granger cause ADMARC		0.89	0.433
ADMARC does not Granger cause Mzuzu	18	0.74	0.049
Mzuzu does not Granger cause ADMARC		0.64	0.850
ADMARC does not Granger cause Mzimba	18	2.47	0.012
Mzimba does not Granger cause ADMARC		1.83	0.199
ADMARC does not Granger cause Lilongwe	18	1.05	0.037
Lilongwe does not Granger cause ADMARC		0.83	0.451
ADMARC does not Granger cause Lunzu	18	1.65	0.022
Lunzu does not Granger cause ADMARC		0.38	0.686
ADMARC does not Granger cause Limbe		0.78	0.038
Limbe does not Granger cause ADMARC	19	0.12	0.733

These findings show that there is no feedback relation from local maize markets to the ADMARC markets; hence there is the existence of a one-way Granger causality. The implication of this finding is that Goletti and Babu's (1994) radical model of price transmission can apply to the Malawi maize market, in that prices in local maize markets are determined by a combination of the current and past prices of a "central market" and the past prices of the local market itself. In this case, the ADMARC market is the central market. The application of the radical model of price transmission in Malawi may, however, not be able to completely explain all the variation in local maize prices, as the political and geographical division of the country entails that there may be more than one "central" market arising from the existence of regional centres (Central, South and Northern regions) which may create other market networks at the regional level.

The results of the Granger causality tests imply that despite the existence of thriving rural local market economies, macro-level price changes in the national maize market transmit to rural maize markets. It is through this maize price transmission mechanism that rural farming households are affected by macro-level policy changes, as maize is the main staple food crop for the majority of rural smallholder farmers in the country and many farmers depend on local markets for either marketing any surplus maize production or for purchasing maize in times of food scarcity.

Maize prices in Malawi are far more volatile than other prices in the region. Figure 5.4 shows the monthly movements for the six local maize markets in Malawi; four regional markets, namely the South African SAFEX market, Kenya, Zambia and Mozambique; and the Chicago white maize price representing the international maize markets for January 2004 to October 2008. Figure 5.4 shows that Malawi maize markets are more volatile as compared to either regional or international maize markets.

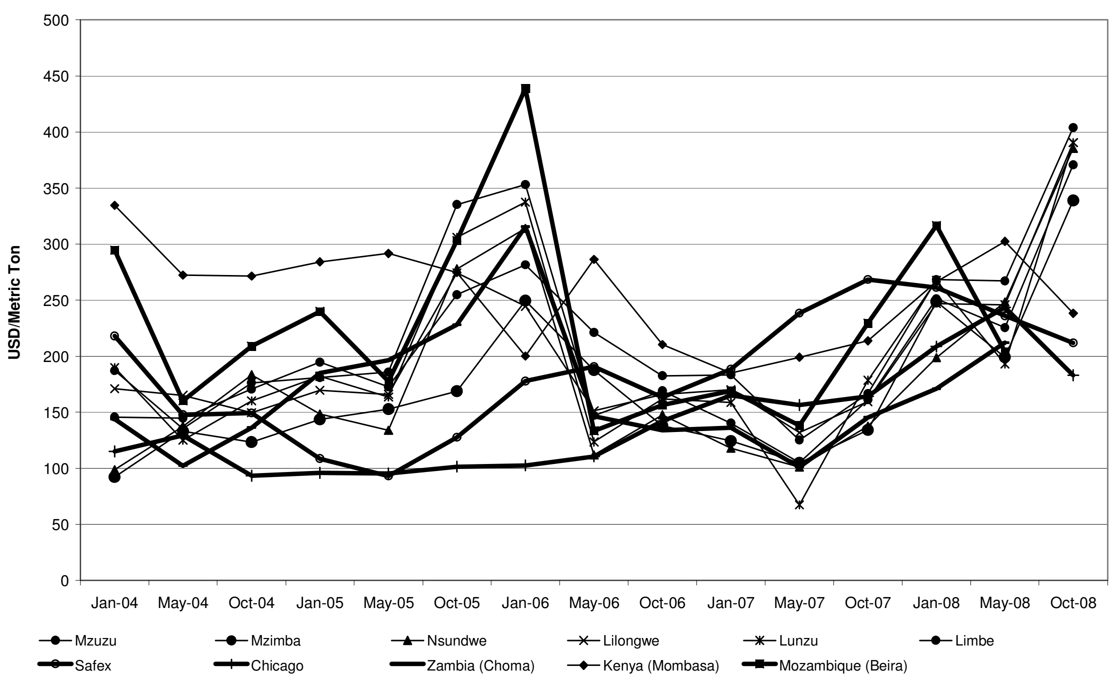

Figure 5-4: Maize price co-movements in selected markets

It is also clear from Figure 5.4 that there is weak co-movement between domestic maize prices in Malawi and the SAFEX white maize price. Correlation co-efficient analysis further shows that there is clearly no linear relationship between maize grain prices in local markets in Malawi with the South African SAFEX market (Table 5.7). However, the ADMARC maize price shows a positive but very weak linear relationship with the SAFEX white maize price, as it exhibits correlation co-efficient measures of 0.44 and 0.41 in price levels and in differences respectively. This implies that the ADMARC price tends to either rise or fall with the SAFEX price. However, since the level of correlation is weak, there are other factors that influence maize pricing in national maize markets in Malawi. These include, but are not limited to, government policies that directly affect maize pricing and trade, such as price bands, welfare considerations for low income urban consumers as well as considerations for resource-poor maize producers (FAO, 2009).

Table 5.7: Correlation co-efficient measures

Market	SAFEX	ADMARC
Levels		
SAFEX	1.00	
Mzuzu	0.15	0.97
Mzimba	0.19	0.96
Nsundwe	0.02	0.98
Lilongwe	0.14	0.98
Lunzu	0.04	0.98
Limbe	-0.08	0.99
ADMARC	0.44	1.00
Differences		
SAFEX	1.00	
Mzuzu	-0.03	0.89
Mzimba	0.07	0.84
Nsundwe	-0.19	0.94
Lilongwe	-0.04	0.97
Lunzu	-0.05	0.97
Limbe	-0.22	0.99
ADMARC	0.41	1.00

An analysis of the relationship between local market maize prices with the ADMARC price shows that there is evidence of the existence of a strong linear relationship between the maize prices in all the six local markets under analysis and the ADMARC price, with the correlation co-efficient for any of the six markets with the ADMARC price not being below 0.96 in levels. This implies that the ADMARC price is a key factor in price formation in local markets in Malawi. Despite inter-regional and intra-regional differences that affect maize price formation in different local markets, it is evident from these results that government policy plays a key role in influencing individual local market prices in different markets throughout the country.

The high correlation measures between the local maize markets and the ADMARC price might, however, be an indication of spurious correlation (Goletti & Babu, 1994). To cater for this, an assessment of the correlations in the price differences was also carried out. As can be seen from Table 5.7 it is evident that although the correlation measures in price differences are slightly lower than those for the price levels (indicating a lower degree of integration), there is still clear evidence of the existence of a strong positive linear relationship between the maize prices in local markets and the ADMARC price in differences.

Since all the six maize prices exhibit a strong linear positive relationship with the ADMARC maize price in both levels and in differences, it was also assumed that local market maize prices have a linear relationship with each other. In order to ascertain this, correlation analysis was also carried for the six local markets. These results are given in Table 5.8.

Table 5.8: Local maize grain market correlation measures

Maize market	Mzuzu	Mzimba	Nsundwe	Lilongwe	Lunzu	Limbe
Levels						
Mzuzu	1.00					
Mzimba	0.96	1.00				
Nsundwe	0.91	0.84	1.00			
Lilongwe	0.94	0.87	0.92	1.00		
Lunzu	0.87	0.81	0.90	0.91	1.00	
Limbe	0.87	0.81	0.96	0.90	0.97	1.00
Differences						
Mzuzu	1.00					
Mzimba	0.95	1.00				
Nsundwe	0.89	0.82	1.00			
Lilongwe	0.94	0.87	0.92	1.00		
Lunzu	0.87	0.80	0.90	0.91	1.00	
Limbe	0.86	0.80	0.95	0.89	0.96	1.00

There is evidence of a strong linear positive relationship between maize grain prices in different local markets within the country. Correlation measures for the price differences are slightly lower than for the price levels, indicating a lower degree of integration. These findings imply that the prices of maize in various local markets in different parts of the country have a tendency to move in the same direction. This finding is expected and can be attributed to the results found earlier, which show that all maize prices in Malawi, regardless of geographical location, are influenced strongly by the ADMARC price.

The influence of geographical effects on maize grain pricing can, however, not be completely ruled out. This is because evidence of the influence of regional differences in maize prices is discernable by looking at the strength of correlation between markets in the same region. This shows that markets such as Mzuzu and Mzimba in the northern region and Lunzu and Limbe in the southern region exhibit nearly perfect correlation, with correlation co-efficient measures of 0.96 and 0.97 respectively. Although positive correlation between markets in different regions exists, it is weaker as compared to the correlation between markets in the same region. This implies that there are intra-regional factors that influence the pricing of maize. These are factors related to regional and local maize supply and demand, the availability of both formal and informal maize markets, and differences in road networks and accessibility which affect local producers' ability to access more lucrative markets. In addition transport costs associated with moving maize grain from rural production areas to urban and peri-urban markets further influences maize prices in local markets that are in urban and peri-urban centres with prices in such markets being higher.

Another key issue that is clear from Figure 5.4 is that maize price volatility in Malawi is influenced by seasonal variations in maize grain stocks. First, in January of every year since 2004, with the exception of 2006, it can be seen that maize prices in all the six local markets are generally high. This can be attributed to the majority of poor smallholder farmers often experiencing food shortages during the month of January, as their maize grain from the previous season gets depleted while the current crop is still in the field. This period, dubbed the "hunger period", is characterised by food shortages which lead to high local market maize prices. Surplus maize producers tend to keep their maize until this period in order to take advantage of the higher maize prices prevailing in local maize markets. The hunger period is further characterised by surplus maize producers milling maize and packaging it into small packets which are sufficient for one or two meals and which cost relatively higher than either maize grain or milled maize at other times of the year. It is mainly rural smallholder farmers who are not food self-sufficient who depend on such milled maize.

Figure 5.4 further shows that maize prices in the six local markets tend to be lower during the month of May. This can be attributed to the availability of maize during the period of the main harvest. This period, the majority of poor smallholder farmers sell their maize in order to meet short-term cash needs (Jayne, *et al.* 2010). As such, they are unable to take advantage of the higher maize prices that prevail during other times in the year when maize grain is scarce.

Another important contributor to maize price volatility in Malawi is unfavourable climatic conditions. As can be seen from Figure 5.5, an analysis of the annual maize prices for the ADMARC market and the Nsundwe market shows that the movement of maize price is associated with erratic weather conditions. Price spikes are observed in the 2001/2002 and

2005/2006 cropping seasons, following droughts that lowered maize production in those seasons.

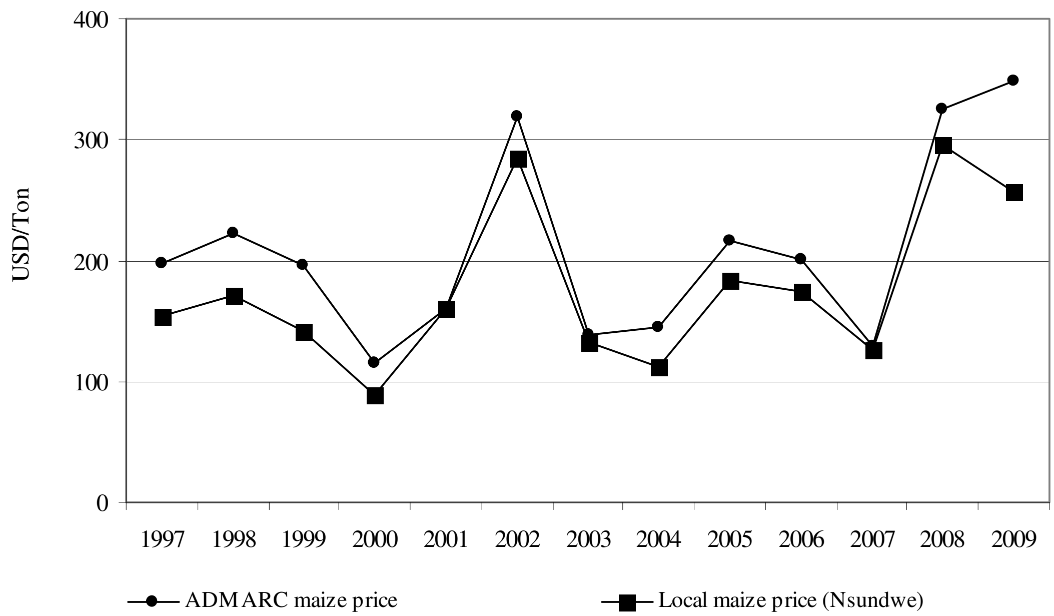

Figure 5-5: Maize price movements over time: 1997-2009

Furthermore, analysis of monthly maize price changes showed that in 2005, monthly maize grain prices in all six markets in Malawi increased greatly; with price increases of 32.2 %, 52 %, 39.4 %, 46.4 % and 44.5 % being observed between May and October of 2005 for the Mzuzu, Nsundwe, Lilongwe, Lunzu and Limbe markets, respectively. These price spikes can be attributed to the drought that affected agricultural production in the 2004/2005 cropping season. The price hike for the 2008/2009 season can be attributed to the government's official maize production estimates being very high in the 2007/2008 cropping season, which led to government exporting maize to other countries in the region. This policy decision caused maize scarcity in the country, hence the higher maize prices (Jayne, *et al.* 2010) in the 2008/2009 season.

In addition, the markets in the central region (Lilongwe and Nsundwe) and in the southern region (Limbe and Lunzu) exhibited maize price monthly increases that were greater than 40 % at the beginning of the 2005/2006 agricultural season. Northern region markets were, however, less volatile and this can be attributed to the majority of smallholder farmers in the northern region of the country being food self-sufficient, as households have more diversified food baskets with households consuming other staple food crops such as rice and cassava. This is in contrast to other parts of the country, especially the Southern Region where the majority of households are unable to meet their subsistence food requirements and hence depend largely on the market. Additionally the Southern Region is densely populated with households cultivating on much smaller pieces of farm land (NSO, 2008b) and some parts are highly prone to annual droughts and flooding (IFPRI, 2009). As a result of these differences, the food security situation in the northern part of the country is often more favourable than in the southern region (FEWSNET, 2010).

5.3.2.2 Parity price analysis

To further understand the Malawi maize market and to assess the incentives for maize production in the country, an import and export parity price analysis was carried out, with the South African white maize price being taken as the 'world price' or the reference price of maize for Malawi. The import parity price for maize in Lilongwe was calculated as the price of white maize in South Africa (Gauteng) plus transport costs, insurance and tariffs. Figure 5.6 presents a comparison of the wholesale ADMARC maize price, import parity price, export parity price and the volumes of maize imports from 1988 to 2009. As can be seen in the figure, between 1988/1989 and 2008/2009, ADMARC maize prices were more often either above or approximated import parity price. Very high differences between the ADMARC wholesale price and the import parity price were observed in the 1992/1993, 1997/1998, 2001/2002 and 2007/2008 agricultural seasons, with the first three seasons being years in which the country was hit by droughts. The higher price for the 2007/2008 agricultural season cannot, however, be explained by climatic factors, as government maize production data indicate that this was a good harvest year (Jayne, *et al.* 2010).

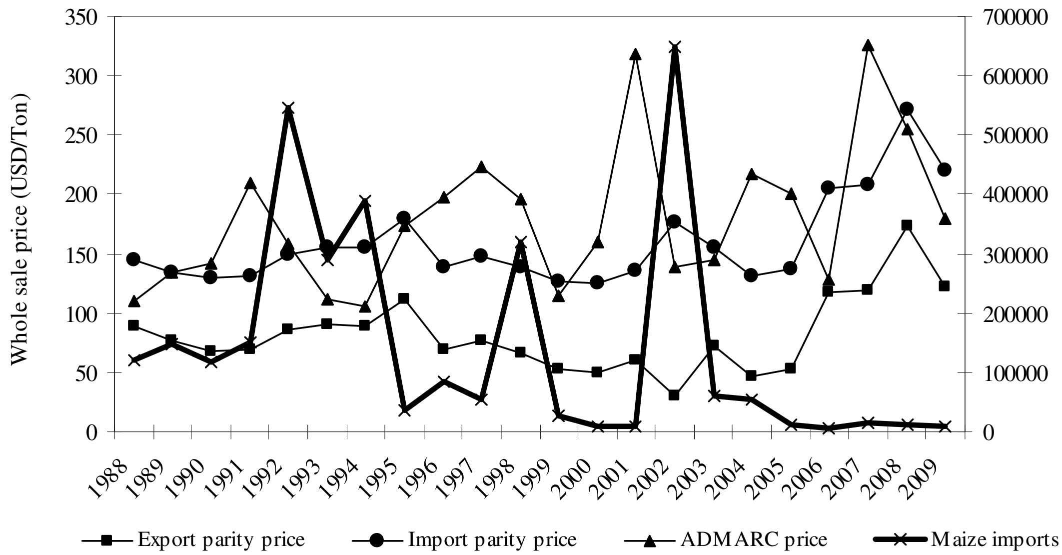

Figure 5-6: Import and export parity price analysis

Further observation shows that, apart from the years in which the country was hit by drought, Malawi maize imports are generally non-responsive to changing domestic prices. In theory, when wholesale domestic prices are higher than import parity price, it provides incentives for traders to import goods into a country, as the imported good is cheaper than a locally-produced good (FEWSNET, 2008). From the observation above, it can be seen that despite the ADMARC price being above or approximating import parity price, imports were not responsive. This is expected as government is the sole importer of maize. It is only in the 1992/1993 and 2002/2003 cropping seasons in which high maize prices are positively correlated with maize imports. These are both years of extreme droughts in which Malawi experienced severe food shortages. In these years, it can also be observed that there is a lag between high maize prices and large maize imports which shows the delays in response by government. For the 2007/2008 season, it can also be seen that the domestic wholesale price for ADMARC maize was much higher than the import parity price (as high as price differentials observed for both the 1992/1993 and 2002/2003 cropping seasons). However, in this season, maize exports remained low and non-responsive. As stated earlier, this is attributed to the government's official maize production estimates being very high in the 2007/2008 cropping season, which led to government exporting maize to other countries in the region.

There are several issues that arise from these observations. First, government policy and government's perception of the domestic food security situation of the country determine to a large extent imports. This is clearly evidenced by government importing large volumes of maize in the 1992/1993 and 2002/2003 cropping seasons as opposed to the 2007/2008 season. Government viewed the first two seasons as years of maize scarcity; while the latter agricultural season, although exhibiting equally high maize prices, was not deemed an emergency. As a result of this, maize imports in Malawi are non-responsive to price changes and it is clear that government regulates maize trade and pricing in the country. Further, these observations imply that the Malawi maize market is not well integrated with regional maize markets. Hence, with the exception of years of very low food production, domestic maize prices in Malawi are unlikely to be impacted upon by regional maize price changes.

These findings concur with the statistical analysis carried out earlier which showed that there is no evidence of co-movement between local maize markets in Malawi and regional markets. The ADMARC price, however, exhibited a weak linear relationship with the SAFEX maize price. Hence, it is plausible to postulate that the world price of maize (SAFEX) has a weak but inconsistent influence on the ADMARC maize price. This is especially the case in years of droughts and in years of food shortages. Since the majority of maize imported into Malawi is from South Africa (Dana, *et al.* 2006), in years of droughts and food shortages (1992/1993, 1998/1999 and 2002/2003), the SAFEX white maize price has a stabilising effect on the domestic maize price, because as imports reach the country, they reduce the gap between supply and demand and hence lead to a lowering of the domestic price.

5.3.3 Modelling of national and local maize prices

The statistical and parity price analysis carried out above has provided an insight into the relationship between domestic and regional maize prices as well as between national and local-level maize prices in the country. Using this understanding of economic theory and empirical evidence, it becomes possible to develop quantitative single equations for modelling maize prices at both the local and national levels, which will feed into the partial equilibrium model for maize that this chapter aims to develop. This section provides an overview of the methodology used to validate each estimated equation, the exogenous variables in each model as well as the actual estimated equations. Correlation matrices for all equations presented in this chapter can be found in Appendix 4.

5.3.3.1 Model validation

The estimated equations were validated using a combination of statistical methods. Validation is the most important step in model building, as it ascertains the predictive ability of the estimated model (Snee, 1977). There are three main statistical methods for evaluating the goodness of fit of a model. These are the corrected R-Square statistic, the overall F-test and the Root Mean Square Error (RMSE). For robustness, this study employed all three statistical quantitative techniques to test the goodness of fit of the estimated regression equations.

The corrected R-Square ($\overline{R^2}$) statistic is the proportional improvement in the prediction from the regression model compared to the mean and it measures the percentage in the dependant variable as explained by the estimated equation (Gujarati, 1992). As such, it indicates the goodness of fit of the model. The corrected R-Square statistic has been chosen for use as opposed to the R-Square statistic, as the former is concerned with the explained and unexplained variances in the dependant variable and thus accounts for the number of degrees of freedom. In this way, the corrected R-Square statistic is able to indicate the goodness of fit of an estimated equation without regard to the number of independent variables that have been included in the model (Pindyck & Rubinfeld, 1991).

Whereas the R-Square statistic indicates the relative fit, the RMSE indicates the absolute fit of the model to the actual data and it is derived from the square root of the variance of the residuals. The RMSE is the most important and frequently-used criteria for measuring goodness of fit of a model if the main objective of modelling is for simulation purposes (Ferris, 1998), as it measures the deviation of the estimated variable from its true path. The RMSE has also been chosen as the main statistical test for model validation in this study, as it is able to overcome the conflicting interests of model interpretability and goodness of fit. The RMSE is able to do this as it takes into account the number of parameters that have been included in a model and, as such, it does not improve as more parameters are added to the estimated model (Browne & Cudeck, 1992). As a rule of thumb, a model is accepted as a good fit of actual data if the RMSE does not deviate much from zero (Browne & Cudeck, 1992). The F-Statistic was used to test the overall goodness of fit of the estimated equations in order to test for significance of the estimated equations and the ability of all the independent variables to effectively predict the dependant variable.

5.3.3.2 Equation for the ADMARC maize price

The national producer price of maize (ADMARC) was modelled (Equation 5.1) as an endogenous variable that is dependent upon a set of exogenous variables. These variables consist of the import parity price of maize; the ratio of domestic maize production to domestic maize consumption; a dummy variable capturing the further liberalization of the ADMARC (see Appendix 5 for historical basis); and a dummy variable capturing direct government price policies. The dummy variables have been included as they capture the effects of government policy instruments on the pricing of maize in the country.

$$ADMARC = f(IPP, PROD/CONS, DUM:INT, DUM:LIB) \qquad (5.1)$$

Where:

IPP Import parity price in USD/ton (SAFEX maize price)

$PROD/CONS$ Ratio of maize production to maize consumption

$DUM:INT$ Dummy variable: Government price policy interventions (0/1)

$DUM:LIB$ Dummy variable: Reforms in maize marketing (0/1)

The empirical estimation of the ADMARC maize price is presented in Table 5.9.

Table 5.9: Equation for the ADMARC maize price

	ADMARC maize price (USD/ton)		
	Parameter	t-value	Elasticity
Intercept	179.20	5.319***	
IPP	0.23	2.39	0.26
Prod/Con	-22.01	-2.181*	-0.12
DUM:LIB	-71.56	-3.765**	
DUM:INT	137.23	2.241	

$\overline{R^2}$ =0.503 *DW = 1.963* *RMSE=0.035* *F-value=6.058***

* Significant at 10 % level, ** Significant at 5 % level, *** Significant at 1 % level

The estimated equation for the ADMARC maize price had a corrected R-Square statistic of 0.503, implying that at least 50.3 % of the total variation in the ADMARC price is captured by the estimated model. Furthermore, the estimated ADMARC maize price equation had an RMSE that was not far from zero (0.035) and an F-value of 6.058 that was statistically significant at the 5 % level of confidence, implying that the estimated model as a whole is capable of effectively capturing changes in the actual ADMARC maize price.

Results of the estimated equation showed that the dummy variable capturing the liberalization of maize marketing in Malawi (ADMARC_LIB) was statistically significant at the 5 % level of confidence in negatively influencing the ADMARC maize price. This implies that the liberalization of government marketing board (ADMARC) led to a reduction in the ADMARC maize prices. This can be attributed to the type of liberalization which took place in Malawi which mainly involves the reduction of the trading operations of ADMARC in order to allow for the growth of the private sector and to improve the efficiency of the parastatal (Jayne, *et al.* 2008). The liberalization allowed ADMARC to be more efficient and to lower the price at which it sold maize. Additionally due to the closure of ADMARC satellite deports throughout the county; there was an increase in private traders in local rural economies. Due to the lack of regulation, information asymmetries and isolation of many rural households; private traders offered a price that was below the ADMARC maize price. Hence the majority of smallholder producers received lower prices than the ADMARC maize price as a result of the liberalization of ADMARC.

In addition the ratio of production to consumption was statistically significant at the 10% level of confidence in negatively influencing the ADMARC maize price. This implies that increases in the ratio of maize production to consumption would lead to lower maize prices as maize supply would be greater than domestic demand. This finding is in line with existing theoretical and empirical evidence which stipulates that the ratio of production to consumption is key to changes in prices of food commodities with an increasing ratio leading to a reduction in food prices; while a decreasing ratio contributing to increased food prices (Pinstrup-Andersen, *et al*. 1999).

In terms of elasticities, it can be seen that the ADMARC maize price is inelastic, with a 10 % increase in the ratio of domestic maize production to domestic maize consumption leading to a 1.2 % decrease in the ADMARC price. In addition, a price transmission elasticity of less than one is observed (0.26). However, this is expected as it was demonstrated earlier that there is low price transmission between the ADMARC maize price and world maize prices. This is the case despite economic theory stipulating that world prices are frequently the main source of variation in domestic prices (Baffer & Garner, 2003). The findings of this study are, however, feasible, as empirical evidence has demonstrated that agricultural markets differ from other types of markets in that there is often little or no transmission of international prices to domestic agricultural markets (Baffer & Garner, 2003; Fafchamps, *et al.* 2003).

In conclusion, the equation of the ADMARC maize price shows that the ADMARC price is influenced to some extent by the world price of maize and the local supply and demand dynamics. In addition, government policies in the form of direct price interventions and institutional reforms of the maize marketing boards in the country are also key contributors towards variability of the national maize price. This equation essentially stipulates that maize markets are to a large extent affected by government control. This finding is in agreement with the empirical results (statistical and parity price analysis) from earlier in this chapter which demonstrated that government policy is one of the main drivers of the ADMARC maize price and maize trade in general.

5.3.3.3 Equation for local maize price (Nsundwe)

The equation for the local price of maize (Nsundwe) was estimated as an endogenous variable that is dependent upon a set of exogenous variables which included the ADMARC maize price; total maize consumption for Ukwe Extension Planning Area (EPA) where Nsundwe market and the rural communities under study are located; a dummy variable capturing the effects of the 2001/2002 drought; and a dummy variable capturing the effects of over-inflated crop estimates for Ukwe EPA for several years (1989-1991, 1993-1996, 1999, 2007).

$$PPMZ_{loc} = f(ADMARC, DUM02, LCON, DUM:UKWE) \qquad (5.2)$$

Where:

$ADMARC$	ADMARC maize price (USD/ton)
$DUM02$	Dummy variable capturing effects of the 2001/2002 drought (0/1)
$LCON$	Total estimated local maize consumption for Ukwe EPA (thousand tons)
$DUM:UKWE$	Dummy variable capturing the effects of overestimated crop estimates for Ukwe EPA

The empirical estimation of the local maize price is presented in Table 5.10.

Table 5.10: Equation for the local maize price (Nsundwe)

	Local maize price (USD/ton)		
	Parameter	**t-value**	**Elasticity**
Intercept	141.59	2.18	
ADMARC	0.10	2.06**	0.91
DUM02	97.48	5.02	
LCON	-0.012	-9.52	-0.01
DUM:UKWE	-45.68	-4.73	

$\overline{R}^2$ *= 0.630* *DW =1.98* *RMSE= 0.048* *F-value=52.813****

* Significant at 10 % level, ** Significant at 5 % level, *** Significant at 1 % level

The estimated model for the local price of maize in the Nsundwe market had a corrected R-Square statistic of 0.630. This implies that at least 63 % of the total variation in the local maize price had been captured by the estimated equation. In addition, the equation had an RMSE that was not far from zero (0.048) and an F-value of 52.813 that was highly statistically significant. This implies that overall; the estimated equation effectively captures actual local maize prices in Nsundwe market.

The results in Table 5.10 suggest that local maize prices are inelastic with respect to either the ADMARC maize price or the level of maize consumption in the area. However, local maize prices are generally more sensitive to the ADMRC price than to local maize consumption. This is because a 10 % increase in the ADMARC maize price would lead to a 9.1 % increase in local maize price in the Nsundwe market. These findings are in line with the Granger causality tests and the correlation tests carried out earlier in this chapter, which demonstrated that there is a one-way causality between the ADMARC maize price and the Nsundwe maize market price; with the ADMARC price greatly influencing the Nsundwe maize market price. Further, the correlation measures showed that there is a high degree of correlation between the ADMARC maize price and the Nsundwe maize price, with more than 90 % of the total variation in the different local markets (including Nsundwe) being attributable to the ADMARC price. The statistical results of the estimated model also concur with these findings, as they show that the ADMARC price of maize is statistically significant in positively influencing the local maize price in the Nsundwe market at the 5 % level of confidence.

In addition, a 10 % increase in local maize consumption in Ukwe EPA would lead to a 0.1 % decrease in the local maize price in the Nsundwe market. This effect is basically the result of household maize consumption in rural areas of Malawi being mainly dependent upon own production (Equation 5.10). As such, increases in household consumption are mainly the result of higher own production, implying lesser demand from the market and therefore a lowering of market prices. However, as is seen here, this effect is very weak as there are always households in the rural areas of Malawi that depend on the market to supplement their subsistence maize requirements. This finding is generally plausible as empirical evidence has shown that changes in staple food prices are the result of the interaction and a combination of various factors that include changes in consumption (Dorélien, 2008; Southgate, 2009).

In general, the equation for the local price of maize shows that there is high price transmission between the local maize price in the Nsundwe market and the ADMARC maize price; and variability in the Nsundwe maize market price can be explained mainly by changes in the ADMARC maize price.

5.4 MODEL SPECIFICATION, ESTIMATION AND VALIDATION

This section provides a description of the partial equilibrium model that was developed for the maize market in Malawi. The model is based on economic theory and an understanding of the economic and production dynamics of the maize sub-sector, as revealed by the price discovery analysis provided earlier in this chapter and from literature. A summary of the model is provided in Figure 5.8.

The Malawi maize model is a multi-equation partial equilibrium model that is recursive in nature and consists of the national maize market and the local economy maize market. At the national level, the maize market has four blocks consisting of domestic supply, domestic demand, prices, and the model closure which encompasses the trade block. The different blocks are made up of both exogenous and endogenous single equations. The local economy block can be considered as being "exogenous" to the national maize market; however, it is linked to it via a price-linkage equation with the ADMARC maize price. Despite the local economy block being "exogenous" to the national maize market, it also consists of both exogenous and endogenous single equations. The following sections describe each block of the model providing the results of the estimated equation, the validation of the equations, as well as the statistical and economic interpretation of the results. The last section provides a description of the feedback effects within the model and the linkages of the household to the local economy and the national maize market. The price blocks are not described here, as these have been described earlier in this chapter (Section 5.3.3).

It should be noted that the estimation of maize production and supply functions is based on both economic theory and understanding of the maize-based farming system in Malawi, which is characterised by farmers who are both producers and consumers of maize and hence are affected by both demand and supply-side dynamics. Another key issue is that the majority of farmers within the maize-based farming system in the country do not substitute maize with any other crops. This has two implications. First, in the absence of substitute goods, the homogeneity condition will not strictly hold and, as such, the standard errors of the estimated models may be biased upwards; thus reducing the magnitude of significance of the estimated coefficients (Fuglie, *et al.* 2002). However, this is a reasonable trade-off so long as the estimated equations reasonably reflect the real maize-based farming system in Malawi. As such, it is expected that all estimated demand and supply-related equations will exhibit price inelasticity, as this is a sign that the commodity under analysis has no close substitutes (Tewari & Singh, 1996). Second, in the absence of substitutes, the symmetry matrices cannot be estimated as there are no cross-price elasticities.

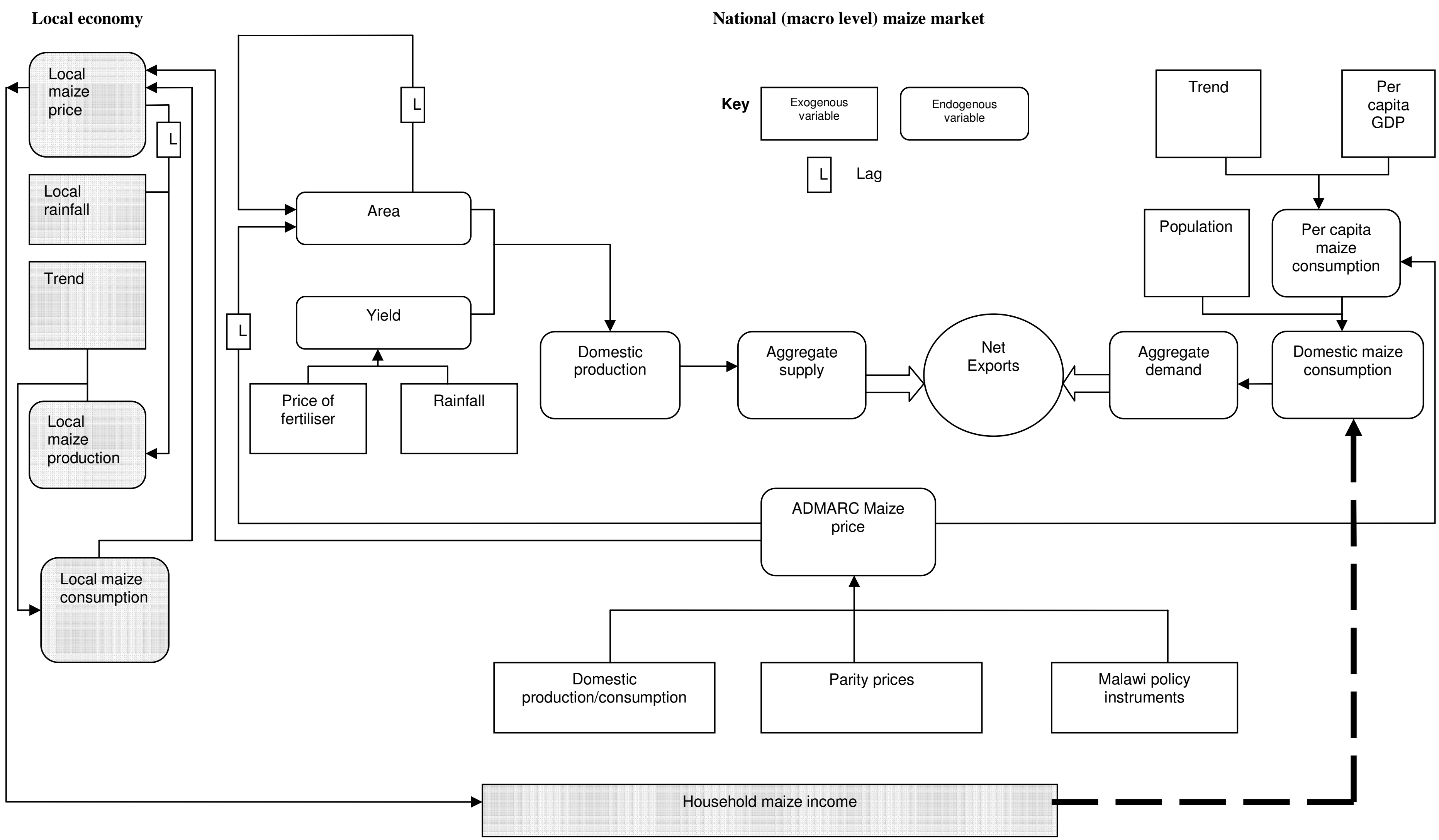

Figure 5-7 Structure of the Malawi maize model

5.4.1 The domestic supply block

Total domestic maize supply is the sum of domestic production and lagged ending stocks (beginning stocks). Domestic maize production was calculated as an identity of total area planted multiplied by the total yield. Domestic production can be represented as follows:

$$DPROD = area * yield \qquad (5.3)$$

Where:

DPROD	Domestic production of maize (thousand tons)
area	Area of maize planted used as proxy for area harvested (thousand hectares)
yield	Yield of maize per unit area (tons per hectare)

The area of maize was modelled (Equation 5.4) as a partial adjustment function of the lagged ADMARC maize price; the lagged area of maize planted; and a dummy variable capturing the years in which the Ministry of Agriculture recruited new staff after a ten-year period of non-recruitment combined with a retraining of all field level extension agents (1991-1994, 1996, 1998, 2002, 2006). The equation is given below:

$$\text{area} = f\,(ADMARC_{t-1}, area_{t-i}, DUM:agri) \qquad (5.4)$$

Where:

$ADMARC_{t-1}$	Lagged price of maize in ADMARC markets (USD/ton)
$area_{t-i}$	Lagged area of maize planted (thousand hectares)
$DUM:agri$	Dummy variable: Public recruitment and extension service retraining (0/1)

Frequently, area harvested is modelled as a partial adjustment function with the current maize prices and the prices of other crops (Agcaoili & Rosegrant, 1995). For maize production in Malawi, the price of substitutes has not been included in the model, as the majority of smallholder farmers within the maize-based farming system are also consumers of their own crop and hence do not produce solely for the market and, as such, they do not substitute maize for other crops regardless of the price. The lagged ADMARC maize prices have been used as opposed to current maize price, as Malawi does not have a futures market; hence, prices are announced at the end of the cropping season. As a result of this, farm production decisions are based on the prices from past seasons.

The empirical estimation of the equation for area of maize planted is presented in Table 5.11.

Table 5.11: Equation for area of maize planted

	Area of maize planted (hectares)		
	Parameter	t-value	Elasticity
Intercept	1802.2	1.550	
$ADMARC_{t-1}$	0.006	0.075	0.013
$area_{t-1}$	0.653	2.978**	0.021
DUM:agri	104.59	0.506***	
$\overline{R^2}$ =0.678 DW =1.98 RMSE=0.043 F-value=7.901**			

* Significant at 10 % level, ** Significant at 5 % level, *** Significant at 1 % level

The estimated equation for the area of maize planted has a corrected R-Square statistic of 0.678. This implies that at least 67.8 % of the total variation in the area of maize harvested in Malawi has been captured by the estimated equation. In addition, the estimated equation is a good estimate of actual area of maize planted, as it has an RMSE that is not far removed from zero (0.043) and overall model F-value of 7.901 which is statistically significant at the 5 % level of confidence. This implies that the model as a whole is able to significantly explain the variation in the area of maize harvested.

An analysis of the estimated parameters indicates that the lagged area of maize planted and the dummy variable capturing government recruiting and training of existing field level extension agents were both found to be statistically significantly in positively influencing the area of maize planted at the 10 % and 1 % significant levels respectively. These findings imply firstly that government efforts to improve the agricultural extension service system in the country led to increases in the acreage of maize that was harvested. It is possible that in years without this government program, farmers might have planted the same area of land but harvested less due to the lack of proper agricultural advisory services. Furthermore one key criterion for training a field extension agent was their performance. Hence it is possible that field extension officers had greater motivation in the years in which this program was in place to work harder so as to be selected for the training program. Secondly the positive significant result for the lagged area of maize planted variable implies that the area of land that farmers planted in a past season will influence the area that is cultivated in next season. This is especially the case for Malawi as farmers have very small land holding sizes with little or no prospects for acquiring additional land or for expanding their cultivation.

In terms of elasticities, it is clear that the area of maize planted is inelastic in terms of the lagged price of maize and the lagged area planted. The lagged ADMARC price has an elasticity of 0.013, implying that a 10 % increase in the lagged ADMARC price would lead to an increase of 0.13 % in the area allocated to maize. The lagged area of maize planted has an elasticity of 0.021, implying that a 10% increase in the lagged area of maize planted would lead to a 0.21 % increase in the area of maize planted. These findings are not surprising. Firstly, the inelasticity of the area of maize planted to the ADMARC maize price arises because the majority of smallholder farmers are not influenced by market signals, as the majority produce for own consumption, and hence decisions to plant depend largely on the assessment of subsistence requirements. The inelasticity of the area planted to the lagged area of maize planted is also not surprising, because it has been well documented that the majority of rural farming households in Malawi have insufficient land for their own cultivation. As such, there is repeated cultivation on the same piece of land (Kanyama-Phiri, 2008) with small increases in area planted or harvested over time; possibly arising from cultivation by land constrained households on marginal land and small increases in cultivation of maize by the estate sector.

Maize yield was modelled (Equation 5.5) as a function of rainfall; the retail price of inorganic fertiliser (unsubsidized price of fertilizer), a shift variable capturing the change in the input fertilizer subsidy program from a targeted input program to a full fertilizer subsidy program; and a dummy variable capturing the effects of changes in government legislature pertaining to support and development of small-scale maize irrigation schemes in the country (DUM:agr2).

$$\text{yield} = f(\text{rainfall}, PFERT, DUM:agri2, \text{Shift06}) \quad (5.5)$$

Where:

rainfall	Average rainfall in Malawi (mm)
$PFERT$	Price of fertiliser in the country (USD/ton)
$DUM:agri2$	Dummy variable: small scale irrigation scheme legislation (0/1)
Shift06	Shift to a full fertilizer subsidy program (0/1)

Typically, yield functions are estimated as a function of past yields in combination with other variables (Agcaoili & Rosegrant, 1995). Lagged yields were, however, not included in this study, as empirical evidence demonstrates that crop yield variability in Malawi is mainly due to climatic factors; especially erratic rainfall which results in recurrent droughts in some years and floods in others (Kanyama-Phiri, 2008).

The empirical estimation for the yield of maize is represented in Table 5.12.

Table 5.12: Equation for yield of maize

	Yield of maize (Tons/hectare)		
	Parameter	**t-value**	**Elasticity**
Intercept	0.010	1.194	
Rainfall	0.002	5.749***	1.80
PFERT	-0.003	-1.759*	-0.52
Shift 06	0.5	2.621*	
DUM:agri2	-0.05	-3.831**	

$\overline{R}^2$ =0.789 *DW =2.23* *RMSE=0.013* *F-value=20.67****

* Significant at 10 % level, ** Significant at 5 % level, *** Significant at 1 % level

The estimated equation for the yield of maize has a corrected R-Square statistic of 0.789 implying that at least 78.9 % of the total variation in the yields of maize in Malawi is captured by the estimated model. In addition, the estimated equation is a good estimate of actual maize yields in the country, as it has an RMSE that is not far removed from zero (0.013) and it has an F-value of 20.67 that is highly statistically significant. This implies that the estimated model as a whole is significant in effectively explaining the variation in yields of maize in Malawi.

Rainfall was found to be highly statistically significant in positively influencing maize yields. This implies that an increase in rainfall would lead to an increase in the yields of maize. This finding concurs with the elasticity of rainfall which shows that maize yields in Malawi are elastic with respect to rainfall with rainfall having an elasticity of 1.80. Thus a 10 % change in rainfall in a given season would lead to an 18 % increase in maize yields. Given these findings, it is not surprising to find that the reforms in smallholder maize irrigation were found to be statistically significant in negatively influencing maize yields at the 5 % level of confidence. This finding further shows that water availability is a key factor influencing maize yields in the country. This is because in many instances, irrigation schemes that were left to smallholders become less efficient and in many cases communities were unable to maintain irrigation schemes due to high maintenance and the lack of proper managerial skills.

Yields are, however, inelastic with regards to the retail price of inorganic fertiliser. The yields decreased by 5.2 % as a result of a 10 % increase in the retail price of inorganic fertiliser. The negative relationship between price of fertilizer and yields is expected because an increase in the retail price of inorganic fertiliser would lead to a reduction in the yield of maize. This is further seen with the retail price of fertilizer being statistically significant at the 10 % level of confidence in negatively affecting maize yields. In practice, this arises because smallholders do not have sufficient cash at the beginning of the cropping season when inorganic fertiliser is readily available. As such, any increases in the price of inorganic fertiliser entails that smallholder farmers buy insufficient amounts of fertiliser, which they apply sparingly either to a large piece of farm land or which they apply to a smaller fraction of their farm. Both methods reduce the yields per unit area.

Furthermore, the results show that the shift in the input support program towards a full input fertilizer subsidy program in the 2005/06 season was also statistically significant at the 10 % level of confidence in positively influencing maize yields.

Beginning stocks were derived (Equation 5.6) as an identity and they were equal to the lagged ending stocks.

$$BSTOCK = ESTOCK_{t-1} \tag{5.6}$$

Where:

$BSTOCK$	Beginning stock (thousand tons)
$ESTOCK_{t-1}$	Lagged ending stock (thousand tons)

5.4.2 The domestic demand block

The demand for a commodity is a function of its own price, the price of substitutes and complements, and per capita income (Ferris, 1998). Domestic maize demand in Malawi is mainly composed of domestic human consumption, with some maize going towards seed and feed or industrial use and ending stock. Data for seed/feed and industrial use in Malawi is unreliable and difficult to obtain. Therefore, total domestic maize demand was taken as a function of domestic consumption, and endings stock with seed/feed and industrial use were taken as exogenous and incorporated in the mathematical calculation of aggregate domestic demand. Therefore, domestic maize consumption (domestic human demand) was estimated as an identify that is equal to per capita maize consumption multiplied by the population (Equation 5.7):

$$DCONS = PCC * POP \tag{5.7}$$

Where:

$DCONS$	Domestic maize consumption (thousand tons)
PCC	Per capita maize consumption (tons/capita)
POP	Total Malawi population (millions)

Per capita maize consumption was modelled (Equation 5.8) as a function of a trend variable capturing changing food baskets over time; the ADMARC price of maize; real per capita GDP; a dummy variable capturing the effects of years of emergency food relief (1992, 1997, 1998, 2002) and a dummy variable capturing a government policy which allowed the export of large amounts of maize out of the country based on extremely high production estimates.

$$PCC = f(ADMARC, trend, rPGDP, DUM:relief, \text{Policy}:XP) \tag{5.8}$$

Where:

$ADMARC$	Price of maize in ADMARC markets (USD/ton)
$trend$	Trend variable: 1988= 0 and 2015=29
$rPGDP$	Real per capita GDP (USD/capita)
$DUM:relief$	Emergency food relief years
$\text{Policy}:XP$	Policy to exports large volumes of maize (0/1)

The empirical estimation for per capita maize consumption is represented in Table 5.13:

Table 5.13: Equation for per capita maize consumption

	Per capita maize consumption (kg/capita)		
	Parameter	**t-value**	**Elasticity**
Intercept	110.881	1.583	
ADMARC	-0.201	-3.074**	-0.233
Trend	-0.015	-3.228**	-0.001
rPGDP	0.395	3.487**	0.474
DUM:relief	14.20	3.955**	
Policy:XP	-18.00	-2.961*	
$\overline{R}^2$ =0.897	DW =1.59	RMSE=0.028	F-value=35.874***

* Significant at 10 % level, ** Significant at 5 % level, *** Significant at 1 % level

The estimated equation for per capita maize consumption has a corrected R-Square statistic of 0.897, implying that at least 89.7 % of the total variation in per capita maize consumption is captured by the estimated equation. In addition, the model has an RMSE that was not far from zero (0.028) and an F-value of 35.874 that was highly statistically significant, implying that as a whole, the estimated equation effectively and significantly approximates actual per capita maize consumption in Malawi.

Analysis of the estimated parameters shows that first the ADMARC maize price, the trend variable capturing changing food baskets over time and the policy allowing large volumes of maize exports from the country were statistically significant in negatively affecting per capita maize consumption in the country. The ADMARC maize price and the trend variable were negatively significant at the 5 % level of confidence while the policy of allowing exports was negatively significant at the 10 % level of confidence.

The implications of these findings are three fold. As the ADMARC price increases, per capita consumption of maize decreases as individuals are less able to afford the staple food crop. This effect however is small as demonstrated by the elasticity of price of -0.233 which implies that a 10 % increase in the ADMARC price would lead to a 2.33 % decrease in maize consumption per capita. Thus in general per capita maize consumption is inelastic with respect to price. Second in terms of the trend variable, which was included to capture changes in food baskets over time, the finding is in line with *a priori* expectations; as over time, changes in the economic and social structure of a country are expected to lead to changing food and dietary preferences, with individuals moving away from diets dominated by grains to diets dominated by dairy and animal protein. The effect of the trend variable is small, which was expected as the composition of food baskets in Malawi is fairly constant. The elasticity for the trend variable, of -0.001, implies that with each year, per capita maize consumption decreases by 0.001 %. The elasticity is small because the majority (85 %) of the Malawi population is rural (Kanyama-Phiri, 2008) and rural populations have constant food baskets, with maize being the main staple. Hence, the decreasing trend being captured at the national level is more a reflection of changes in the diets of urban consumers who are relatively small in number. Third, the findings pertaining to the policy of allowing large volumes of exports imply that ill devised policy strategies can negatively and significantly affect the consumption patterns of households in the country. This is because the policy to export maize was based on over inflated maize production estimates. In the years in which it was implemented this policy led to maize shortages within the country.

The results further show that real per capita GDP and the dummy variable capturing years of high food relief aid were both statistically significant in positively influencing per capita maize consumption at the 5 % level of confidence. This implies that as income increases, there is an increase in per capita maize consumption. These results also show that maize is a normal good, as its consumption increases with rising income. Furthermore, the results show that maize is a necessity good in Malawi, as the income elasticity is less than one at 0.474. This implies that if there is a 10 % increase in per capita GDP, then the per capita consumption of maize will rise by 4.74 %. The implications are that as per capita incomes rise, households will increase their consumption of maize, but at a slow pace. This is because maize is the staple food crop and often staple food consumption is inelastic with respect to income. For the dummy variable, the implications are that in years in which food relief aid was high, it had the effect of positively affecting per capita consumption.

In general, the estimated equation for per capita maize consumption is a demonstration that the consumption of maize in Malawi is generally unresponsive to rising food prices or increasing per capita incomes over time. Per capita maize consumption therefore generally remains stable. This concurs with economic theory and other empirical evidence which shows that staple food consumption is highly price inelastic (Jayne, *et al.* 2009), with the poorest households forgoing other goods and services in the face of rising food prices, in order to buy maize at the higher prices (Chirwa, 2010).

The modelling of ending stocks followed Gallagher's approach (1981), as cited by Poonyth *et al.* (2000), as they were modelled (Equation 5.9) as a function of beginning stocks (lagged ending stock), maize production and the prevailing price of maize in ADMARC markets.

$$ESTOCK = f(BSTOCK, DPROD, ADMARC) \quad (5.9)$$

Where:

ESTOCK	Ending stock (thousand tons)
BSTOCK	Beginning stocks (thousand tons)
DPROD	Total domestic maize production (thousand tons)
ADMARC	Price of maize in ADMARC markets (USD/ton)

The empirical estimation for the ending stocks is represented in Table 5.14:

Table 5.14: Equation for ending stock

	Ending stock (1000 tons)		
	Parameter	t-value	Elasticity
Intercept	0.017	2.095*	
BSTOCK	0.41	2.760*	0.50
PROD	0.001	3.683**	0.67
ADMARC	-0.002	-2.400	-0.18

$\overline{R^2}$ *=0.727* *DW =2.15* *RMSE= 0.062* *F-value=15.062****

* Significant at 10 % level, ** Significant at 5 % level, *** Significant at 1 % level

The estimated equation for ending stocks had a corrected R-Square statistic of 0.727, implying that at least 72.7 % of the total variation in the ending stocks was captured by the estimated model. In addition, the model had an RMSE that was not far from zero (0.062) and an F-value of 15.062 which was highly statistically significant, implying that overall, the estimated equation for beginning stocks was able to explain variations in ending stocks in Malawi.

Analysis of the parameter estimates shows that the beginning stock (lagged ending stocks) and domestic maize production were statistically significant in positively influencing ending stocks at the 10 % and 5 % confidence levels respectively; thus implying that an increase in the beginning stocks and an increase in domestic production would lead to an increase in the ending stock.

The elasticities show that the ending stocks are relatively inelastic with regards to the ADMARC maize price; with the ending stocks decreasing by 1.8 %, with a 10 % decrease in the ADMARC maize price. Ending stocks are also fairly inelastic with regards to the beginning stock, with the ending stock increasing by 5.0 % as a result of a 10 % increase in the beginning stock or the lagged ending stock. It is mainly with regards to domestic maize production that the ending stocks show slight sensitivity, with the ending stocks increasing by 6.7 % as a result of a 10 % increase in the domestic maize production. In general, ending stocks in the country are driven by production, implying that seasons in which domestic production has been high lead to larger ending stocks.

5.4.3 The local maize economy

Apart from the endogenous blocks of the maize market (supply, demand, prices and the closure), the Malawi maize model further consists of a block that represents maize markets in rural local economies. These rural local economies have thriving maize markets that are influenced by the ADMARC maize price; as demonstrated earlier in this chapter by the results of the Johansen co-integration test and the Granger causality tests. In this model, the local rural maize market economy under study (Ukwe EPA) was linked to the national maize market via a price-linkage equation with the ADMARC maize price (Equation 5.1).

Local maize consumption was modelled (Equation 5.10) as a function of local maize production; the price of maize in the nearest local market and a dummy variable capturing the years (1995-2002) in which the main bridge on the largest paved road leading to Ukwe EPA was unusable. A household income variable has not been included in the model; although it is known to influence staple food consumption patterns in semi-subsistence communities such as those that are commonly found in Malawi. This is because data on local household income from Ukwe EPA is discontinuous and the method of estimating household incomes in the study area has not been standardised and, as such, differs from year to year. In view of this, the variable for household income was excluded from the model. The maize production variables however caters for the household income variable as maize often accounts for the largest share of household income in rural household income estimations especially for households who do not have lucrative commercial enterprises or large ownership of livestock.

$$CONS_{local} = f(MZ\_PROD, PPMZ_{nsundwe}, DUM:Brdg) \quad (5.10)$$

Where:

MZ_PROD	Maize production in Ukwe EPA (tons)
$PPMZ_{nsundwe}$	Price of maize in the Nsundwe market in Ukwe EPA (USD/ton)
$DUM:Brdg$	Dummy variable: main bridge unusable (0/1)

The empirical estimation for the equation of local maize consumption is represented in Table 5.15.

Table 5.15: Equation for local maize consumption

	Local maize consumption (1000 tons)		
	Parameter	t-value	Elasticity
Intercept	95.8	118.76***	
MZ_PROD	0.18	2.668	0.04
$PPMZ_{nsundwe}$	-0.01	-2.904	-0.01
DUM:Brdg	-7.2	-17.403***	

$\bar{R}^2$ = 0.942   DW =1.80   RMSE= 0.004   F-value=108.998***

* Significant at 10 % level, ** Significant at 5 % level, *** Significant at 1 % level

The estimated equation for local maize consumption had a corrected R-Square statistic of 0.942, implying that at least 94.2 % of the total variation in the local maize consumption was captured by the estimated equation. In addition, the equation had an RMSE that was not far from zero (0.004) and an F-value of 108.998 which was highly statistically significant, implying that the estimated equation as a whole is able to effectively explain the variation of local maize consumption for Ukwe EPA.

The dummy variable capturing the years in which the bridge on the main paved road to Ukwe EPA was impassable was found to be highly statistically significant in reducing local maize consumption. This implies that households in the study area, although producing for their own subsistence food requirements, also rely on maize that comes into the area from other areas. Further analysis shows that in general local maize consumption is inelastic with respect to either production or its own price. This is because a 10 % increase in the local production of maize would lead to a 0.4 % increase in local maize consumption. While a 10% increase in the local market prices would lead to a 0.1 % decrease in local maize consumption. Both the elasticities for price and for production are very small, signifying that local maize consumption is generally unresponsive to either production or market signals.

Local maize production was modelled (Equation 5.11) as a function of rainfall received in the study area; the lagged maize price in the Nsundwe market; and a dummy variable capturing the years in which Ukwe EPA experienced natural disasters ranging from alternating floods with long dry spells and locusts. The yield and the acreage of maize planted/harvested were not included in the model for local maize production; as the available data for Ukwe EPA for these variables was highly inconsistent and discontinuous and therefore unreliable.

$$MZ\_PROD_{loc} = f(\text{rainfall}_{\text{loc}}, PPMZ_{nsundwe_{t-1}}, DUM:ukwe2) \qquad (5.11)$$

Where:

$\text{rainfall}_{\text{loc}}$	Average rainfall in Ukwe EPA (mm)
$PPMZ_{nsundwe_{t-1}}$	Price of maize in the Nsundwe market in Ukwe EPA (USD/ton)
$DUM:ukwe2$	Dummy variable: years with concurrent natural disasters (floods, long dry spells, locusts) (0/)

The empirical estimation for the local maize production is represented in Table 5.16.

Table 5.16: Equation for local maize production

	Local maize production (1000 tons)		
	Parameter	t-value	Elasticity
Intercept	7.3	2.269	
$Rainfall_{loc}$	0.008	5.372***	0.604
$PPMZ_{nsundwet-1}$	0.001	2.010	0.008
Dum:Ukwe2	-2.45	-3.641**	

$\overline{R}^2$ *= 0.670* *DW =2.40* *RMSE=0.064* *F-value = 11.513****

* Significant at 10 % level, ** Significant at 5 % level, *** Significant at 1 % level

The estimated equation for the local maize production had a corrected R-Square statistic of 0.670, implying that 67 % of the total variation in local maize production is captured by the estimated equation. In addition, the model had an RMSE that was not far from zero (0.064) and an overall F-value of 11.513 that was highly statistically significant; implying that as a whole, the estimated model effectively captures the variation in local maize production for Ukwe EPA.

The results further show that the rainfall received in the Ukwe area and the dummy variable capturing the concurrent occurrence of several natural disasters in the same growing season were statistically significant in positively and negatively influencing local maize production at the 1 % and 5 % levels of confidence respectively. For the dummy variable, this implies that the concurrent occurrence of different natural disasters in the same growing season was a significant factor that lowered maize production in the study area. In terms of rainfall, the study finds that local level maize production is influenced very significantly by rainfall. Thus increases in rainfall would affect local maize production very significantly. For Malawi this is especially the case as smallholder farming is heavily reliant on rain fed farming with little or no irrigation. This effect can also be seen with the elasticity for rainfall which shows that a 10 % increase in rainfall would lead to a 6.04 % increase in production.

Although local production is relatively inelastic to rainfall, further analysis shows that rainfall is the key driver as local production is very inelastic to market prices. This is because a 10 % increase in maize prices in the local market would lead to a 0.08 % increase in production in the next cropping season. The effect of maize prices on production is lagged as there is a time span between when production decisions are made and when output is realised. The weak effect of lagged local price shows that rural households do not respond quickly to market forces. Lagged price and not the current price influence area harvested and therefore domestic production; because the majority of smallholder farmers rely mainly on income earned at the end of a cropping season. Based on the past prices (and therefore lagged incomes), decisions for the next season are made.

5.4.4 Model closure

The determination of maize prices in Malawi is a complex matter confounded by government intervention. An analysis of maize trade in the country has demonstrated that maize exports and imports are relatively small in comparison to domestic maize production, implying that maize prices are essentially determined by the dynamics of domestic demand and supply apart from policies. These findings have been reiterated in other recent studies of maize price formation in Malawi (Minot, 2010). Further analysis has, however, demonstrated that since the late 1980s, maize prices in Malawi have approximated import parity prices. In such cases, it is expected that the country would be a net exporter of maize and that domestic prices would largely be determined by world prices, and this would be reflected in a high price transmission rate (Meyer, *et al.* 2006). However, this has not been the case in Malawi due to government intervention. Such a situation is common with agricultural markets as they differ from other types of markets in that there is often little or no transmission of international prices to domestic agricultural markets (Baffer, *et al.* 2003; Fafchamps, *et al.* 2003).

Given this, the Malawi maize market was taken as being under an import parity regime with the ADMARC maize prices being determined by a behavioural price-linkage equation (Equation 5.2). Price-linkage equations define the extent of price transmission from world markets to domestic markets (Helmar, *et al.* 1991; Meyers, *et al.* 1991). As such, they are considered appropriate in markets in which domestic prices are determined by world prices (Pearse, *et al.* 1994; Meyer, *et al.* 2006). The Malawi maize market is not well integrated with world markets as price transmission is insulated by government intervention. Nevertheless, the use of a price-linkage equation is still relevant as trade still takes place; but full price transmission is not allowed as trade flows are constrained by government (Helmar, *et al.* 1991; Meyers, *et al.* 1991). The price-linkage equation that has been specified for this model therefore includes not only import parity prices but also other domestic factors which include direct government price intervention, maize market reforms, as well as domestic demand and supply dynamics which play an important role in determining ADMARC maize prices. This price-linkage equation is most appropriate for the Malawi maize market and it performs well with a corrected R-Square statistic of 0.806 and an RMSE that is not far from zero (0.051). This implies that at least a large proportion of the variation (80.6 %) in the maize price has been captured by the estimated equation and that the model can effectively simulate maize prices over time.

Therefore, the Malawi maize market is under an import parity regime but one in which the level of correlation between the domestic price and world price is less than one due to government control. This has been reflected in the specification of the price-linkage equation for domestic maize prices. Under an import parity regime, net exports are used as a closing identity for the model (Meyer, *et al.* 2006). The model is solved using the Gauss-Seidel iterative algorithm which involves a step-wise iterative process to estimate a solution (Ferris, 1998). The net exports identify is given below:

$$NXPORTS = PROD - DCON + BSTOCK - ESTOCK \qquad (5.12)$$

Where:

$NXPORTS$	Maize net exports (thousand tons)
$DCON$	Domestic maize consumption (thousand tons)
$BSTOCK$	Beginning stock (thousand tons)
$ESTOCK$	Ending stock (thousand tons)

The equation for maize imports (Equation 5.13) was estimated as a function of net exports; a dummy variable capturing years in which the government allowed great private sector involvement in maize trade; a dummy variable capturing government policy reforms pertaining to the National Food Reserve Agency (NFRA); a shift variable for the shift in the input support program to a full input fertiliser subsidy program from the 2005/2006 agricultural season onwards.

$$MPORTS = f\,(NXPORTS, SHIFT06, DUM:Pvt, Policy:NFRA) \qquad (5.13)$$

Where:

$NXPORTS$	Net exports (thousand tons)
$SHIFT06$	Shift to full input fertilizer program (0/1)
$DUM:Pvt$	Dummy variable: Private sector involvement in maize trade (0/1)
$Policy:NFRA$	Dummy variable: NFRA policy reforms (0/1)

The empirical estimation of the equation for maize imports is represented in Table 5.17.

Table 5.17: Equation for maize imports

	Maize imports (1000 tons)		
	Parameter	t-value	Elasticity
Intercept	198.03	3.517*	
NXPORTS	-0.0014	-2.002	-0.001
SHIFT06	-160.20	-3.989*	
Policy:NFRA	56.87	2.214	
DUM:Pvt	442.2	2.012	

$\overline{R}^2$ =0.546 *DW =2.17* *RMSE=0.093* *F-value=2.519**

* Significant at 10 % level, ** Significant at 5 % level, *** Significant at 1 % level

The estimated equation for maize imports had a corrected R-Square statistic of 0.546, implying that at least 54.6 % of the total variation in actual imports has been captured by the estimated equation. In addition, the estimated equation had an RMSE that was not far from zero (0.093) and an F-value of 2.519 which was statistically significant at the 10 % level of confidence, indicating that the estimated model as a whole is capable of effectively capturing the variation in actual maize imports.

Analysis of the parameter estimates shows that the shift variable capturing the effects of the changes that occurred as a result of the government shifting the input support programmes to a full input fertiliser subsidy programme for all rural and estate smallholder maize producers in the 2005/2006 agricultural season, statistically significant in negatively influencing maize imports at the 10% level of confidence. The implementation of a full input fertiliser subsidy programme led to record maize harvests, with maize production estimates reaching 2.7 and 3.4 million tons for the 2005/2006 and 2006/2007 cropping seasons respectively (FANRPAN, 2007). This higher maize production led to a reduction in the amount of maize being imported into the country, as maize imports are mainly to meet domestic food shortages. Hence, the surplus maize production that was seen after the implementation of the full input fertiliser subsidy programme rendered maize importation unnecessary. Further analysis shows that in general, imports are inelastic with respect to net exports; as a 10 % increase in the net exports would lead to a decrease of 0.1 % in total imports. This is the result of maize trade being controlled by government and mainly government policies determining the quantities of maize that are exported or imported.

Maize exports were derived as an identity (Equation 5.14) calculated as the addition of net exports and imports.

$$XPORTS = NXPORTS + MPORTS \tag{5.14}$$

5.4.5 Overall model performance

The corrected R-Square statistic and the F-values were used to test the goodness of fit of the estimated single equations, while the RMSE was used to test the simulation fit. These measures test on a one-by-one basis single equation fit. However, to test for overall model performance, the study employed different types of sensitivity analysis. Firstly, small changes were made to the paths of three exogenous variables (rainfall, population, GDP) in the model. From these changes, it was observed that there were very small changes in the historical simulation of the endogenous variables. Secondly, small changes[10] were made to the co-efficient estimates for the fitted single equations; and it was observed that the historical simulation of the model did not alter significantly as a result of this. From the sensitivity analysis, it can be concluded that the Malawi maize model as a whole is an appropriate representation of the real maize market, as small changes in the paths of some selected exogenous variables and small changes in the parameter estimates of the endogenous variables do not radically alter the performance of the historical simulation; as is the case in the real world (Pindyck & Rubinfeld, 1991).

In addition, a visual method of graphically plotting each fitted equation against actual data was used to determine how well the estimated equations predict key turning points in the real data. The ability of a simulation model to correctly predict the key turning points in the actual data is an important criterion for model assessment (Pindyck & Rubinfeld, 1991). Figure 5.8 presents the graphs for all the estimated single equations.

[10] Small changes are defined as those that lead to at least a change of within one half of the estimated standard error for the co-efficient (Pindyck & Rubinfeld, 1991)

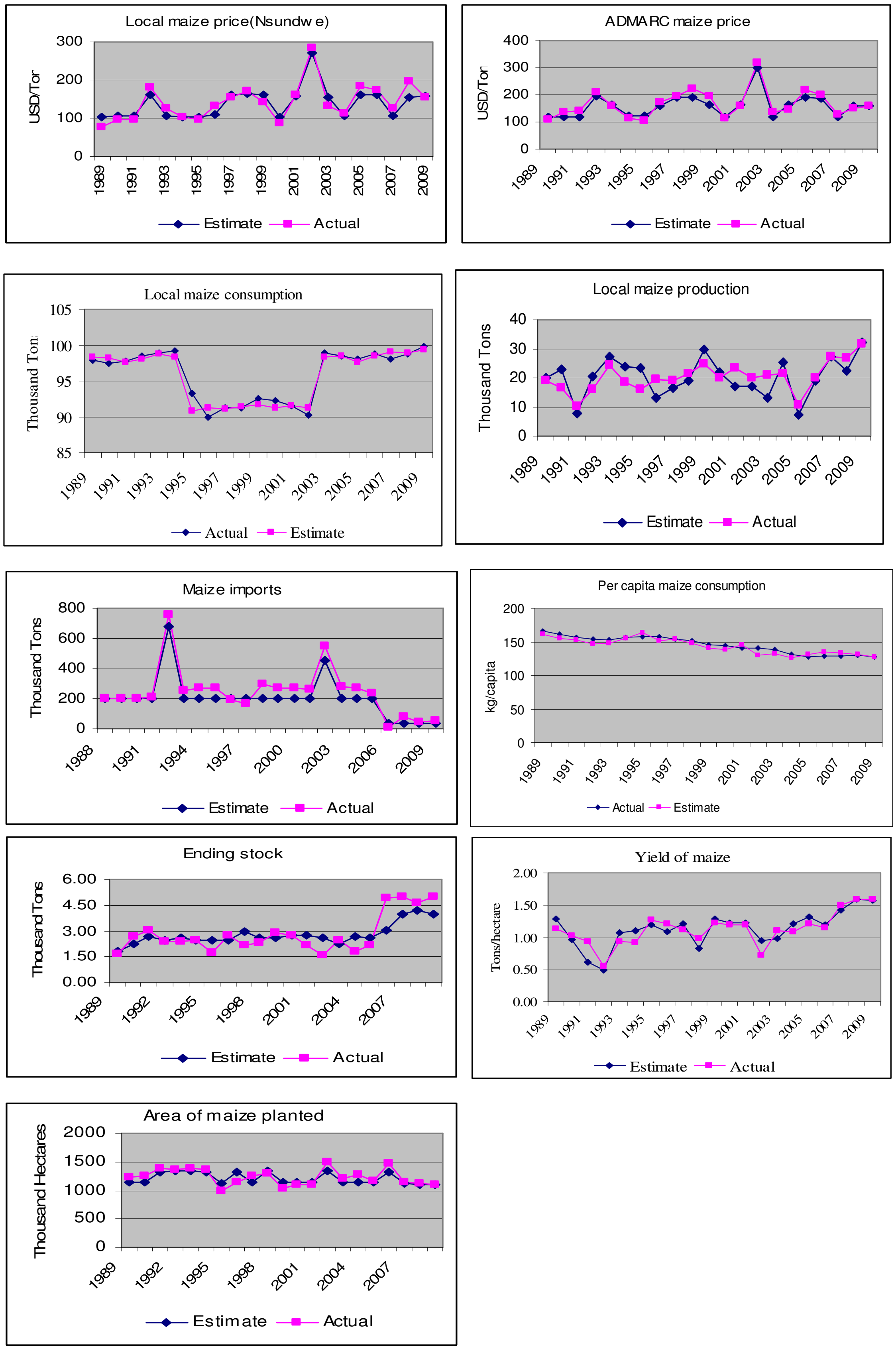

Figure 5-8: Historical simulation graphs

5.4.6 Feedback effects

The feedback effects occurring in the Malawi maize model are such that local population dynamics and changes that occur in local maize production filter through to local maize consumption. This then affects maize prices in local markets, thus creating a recursive system at the local economy level. Local maize consumption in combination with the ADMARC maize price determines prices in local maize markets. Price changes occurring in local maize markets affect farm/household-level maize pricing and this in turn affects household income portfolios. Through this linkage, changes occurring within national maize markets and those occurring within the local economies are felt at the household level and are manifested as changes in household income portfolios. Using this technique, it is possible to develop separate recursive local-level maize models for all the 187 Extension Planning Areas (EPAs) in the country. The ADMARC maize price would remain the same; however, local-level dynamics would lead to different maize prices in different local economy markets in the EPAs, which would result in differing household income portfolios, as is the case in practice. An aggregation of the household incomes from all the different EPA maize models in all local economies in the country would give an aggregate household income variable and changes in the aggregate household income would directly affect domestic maize consumption at the national level.

The estimation of 187 separate local economy household models with household income components is theoretically possible but impractical. Hence, this could be simplified by the use of behavioural models to develop functional forms for the local economy, using either behavioural linkage techniques or a mixture of parametric techniques with micro-accounting to create the macro-micro linkage. The parametric estimation of an aggregate household income variable and the behavioural linkages of the micro-component to the macro-component would change the Malawi maize model from a sequential model without upward feedback effects to a fully-integrated model with feedback from the micro-component (household level) to the macro-component (national level). Alternatively the use of weighted regional averages for the three administrative regions in the country would also be a useful means of generating national regional specific policy recommendations. This relationship is represented in Figure 5.7 by the dashed thick line. The implications of this are that smallholders have forward linkages; however, it is only in aggregation that changes in rural household incomes manifest within national maize markets. Changes in individual household incomes or separate local economies do not manifest in national maize markets and therefore do not show impact in national maize markets; as, separately, these changes are small.

5.5 CHAPTER SUMMARY

This chapter has investigated the dynamics of the Malawi maize market, with the main emphasis being on developing a functioning multi-equation partial equilibrium model of the maize market given government price controls. An establishment of the inter-relationships between farm/household, local economy and national maize market prices, as well as economic theory and existing empirical evidence, has been possible through the local area consumption to create a recursive system of the local maize market. The local maize market is linked through a price-linkage equation with the ADMARC maize price to the national maize market hence effectively showing how transmission of maize prices from national to local markets occurs. Using this system, it is possible to simulate changes occurring within national maize markets to assess how such changes affect rural households that are involved in the production and marketing of maize; thus providing the proof for the second hypothesis. This will be undertaken in the following chapter.

CHAPTER 6

SIMULATION ANALYSIS

6.1 INTRODUCTION

The preceding chapter has shown it is possible to link rural farming households, traditionally deemed to have little or no backward or forward linkages, to the macro-economy using a price-linkage equation of the maize market. Such a linkage allows the simulation of policy shocks and the assessment of how such changes affect rural household incomes. This chapter employs the partial equilibrium maize model that was developed and validated in Chapter 5 to simulate the impact of a combination of macro-economic and agricultural policy shocks on rural household incomes for different household categories. In so doing, it provides credible evidence on which effective policies can be developed. The simulation period is from 2009/2010 to 2013/2014. The chapter initially presents projections for the scenario period for all the endogenous variables and the household incomes. It is on the basis of these "baseline" projections that the impact of the simulated policy shock will be measured against. Further, the chapter provides an analysis of the dynamic responses of the model to maize price changes, in order to provide a better understanding of the model behaviour and its ability to return to an equilibrium point after a disturbance. In so doing, the model is further validated as a tool that is suitable for simulating policy changes.

6.2 BASELINE PROJECTIONS

The impact of the simulated policy shocks will be measured by comparing it against a reference scenario. The reference scenario is a simulation of the Malawi maize model without the simulated policy shock in place. For the household level, this reference scenario is in the form of projected or future household incomes, against which changes in household incomes arising from the simulated policy shocks will be measured.

The baseline will provide a simulation of the maize model under a set of assumptions pertaining to macro-economic policies and climatic conditions of the country. For Malawi, the main assumption is that the current levels of macro-economic performance as well as the existing agricultural policies will remain unchanged for the baseline period; as there are no foreseeable political changes in the country until the 2014/2015 agricultural season, when the country is scheduled to have its parliamentary and presidential elections. Furthermore, it is foreseen that this will be the case; as in the years leading up to the baseline, the country has had greater political will to improve the economy as evidenced by improved fiscal and monetary discipline. Fluctuations in the country's macro-economic variables will arise mainly from exogenous factors, such as changes in global and regional policies and markets as well as general inflation.

There are three main exogenous factors that will continue to influence the maize market over the baseline period. These are the population growth, the real per capita GDP and the exchange rate. These three variables are exogenous to the model only over the baseline period but it is possible in the scenario analysis to alter. The projections of the endogenous variables over the baseline will therefore be mainly based on the forecasted growth rates of these three macro-economic assumptions. The projected values for these variables are provided in Table 6.1.

Table 6.1: Macro-economic indicators/assumptions

	2008	2009	2010	2011	2012	2013	2014
			Millions				
Population	13.66	13.93	**14.99**	15.98	16.89	17.95	18.95
			USD/ton				
Exchange rate	142.41	146.62	**148.98**	152.07	155.80	159.41	163.04
			USD/capita				
Per capita GDP	172.67	171.49	**173.12**	181.00	186.44	190.64	196.88

Baseline projects for the endogenous variables of the model are presented in Table 6.2. These include the area of maize planted, the yield of maize, per capita maize consumption, domestic consumption, domestic production, local maize production and consumption, ending stocks, as well as both the ADMARC maize price and the local market maize price. From Table 6.2, is it clear that maize production will continue to rise over the baseline period as a result of increasing maize yields and not area of maize planted; as the latter remains fairly constant over the baseline with a very small downward trend. Hence, improvements in technology will be the key driver of national domestic production. Local maize production, however, will remain fairly constant with a slow rising pace.

Domestic and local consumption have upward trends, but the rate of growth is very slow. Figure 6.1 shows domestic maize production from 2000–2014 against the ADMARC and local maize prices.

Table 6.2: Baseline projections

	2010	2011	2012	2013	2014
		Thousand hectares			
Area planted	1141.80	1142.61	1142.68	1142.81	1142.94
		Tons/hectare			
Yield	1.77	1.98	2.00	2.03	2.06
		Thousand tons			
Domestic production	3210.00	3350.08	3391.65	3437.65	3499.65
Domestic consumption	2510.04	2394.83	2563.89	2754.00	2723.07
Local consumption	97.48	97.44	97.41	97.51	97.48
Local production	17.60	17.34	17.19	17.83	17.65
		USD/ton			
ADMARC price	194.61	205.76	215.18	220.20	225.49
Local market price	168.51	188.61	199.32	201.93	214.95

Figure 6.1, shows that prior to 2008, extreme maize price hikes in both the local and ADMARC markets were associated with years of low maize production resulting from the prevalence of droughts (2001/2002 and 2005/2006). Over the baseline period, maize prices have an upward, stable trend given assumptions pertaining to prevailing government policies and maize supply and demand dynamics.

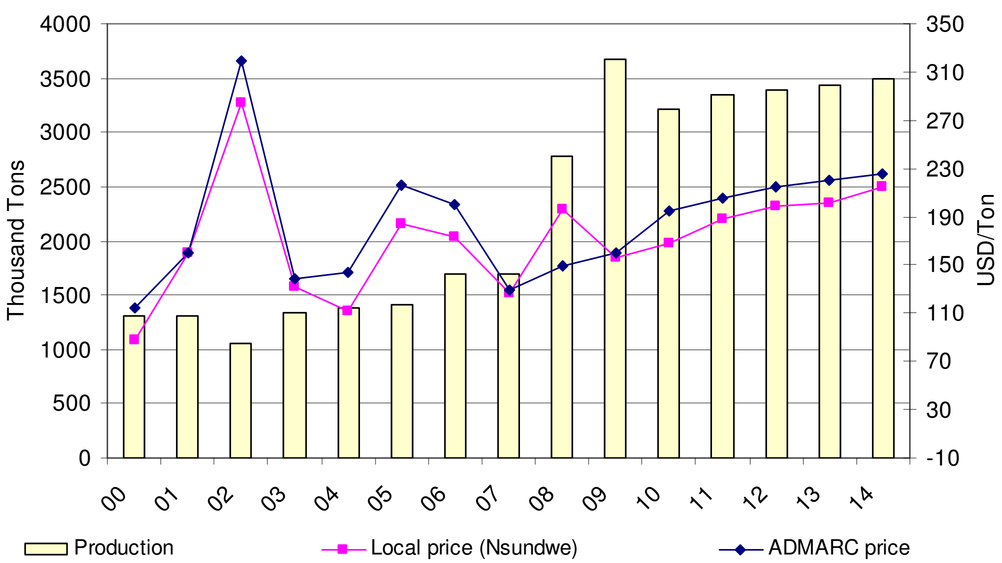

Figure 6-1: Domestic maize production and maize prices (2000–2014)

Household incomes were also projected for the baseline period (Table 6.3). Projections for household incomes are mainly driven by the local and ADMARC maize price; as they exist in the baseline projections, as well as other assumptions that have the potential to affect the dynamics of household income portfolios over the baseline period. Maize prices play a major role in the estimation of household income, as household income portfolios include the imputed and actual values of maize. There are two other main assumptions governing the projections of household incomes. Firstly, at the end of 2008, the outlook for the Sub-Saharan region in general, and Malawi in particular, was positive, with forecasts of high economic growth rates (AfDB/OECD, 2008). This was the case for Malawi as the foundations for faster economic growth had been laid by political changes in the country. However, by the end of 2009, the region had been hit by a great recession that was precipitated by the global financial crisis; which was forecasted to cause a 1 % decline in total output and a decrease of 1 % in per capita incomes by 2009 (IMF, 2009). It was, however, further forecasted that per capita incomes would start to rise once again by 2010.

Table 6.3: Average household income projections in USD

Household type	Agricultural season					
	2008/2009	**2009/2010**	**2010/2011**	**2011/2012**	**2012/2013**	**2013/2014**
	Intervention community					
Low resourced	1192.67	**1163.55**	1229.03	1190.50	1200.04	1208.30
Medium resourced	4695.28	**4725.67**	4791.32	4819.12	4865.05	4910.95
Large resourced	1603.30	**1585.54**	1636.01	1611.62	1621.97	1631.49
	Counterfactual community					
Low resourced	322.70	**321.40**	336.85	328.97	331.41	334.39
Medium resourced	600.38	**601.11**	621.01	614.25	619.32	625.02
Large resourced	2158.67	**2158.65**	2170.07	2172.33	2179.23	2186.29

The second main assumption governing the estimation of future household incomes pertains to general crop production and food security. This is because the estimation of household income, as illustrated in Chapter 4, shows that rural household income is not synonymous with cash income. Rather, it also includes the actual and imputed value of crop production. Given this, projections pertaining to crop production for Malawi were taken into account in projecting household incomes for the baseline period. These were outlooks generated by the Famine Early Warning Systems Network (FEWSNET) and the Ministry of Economic Planning and Development (EP&D) in Malawi. It is against these household income projections that changes arising from the simulated policy shocks will be measured.

6.3 MODEL DYNAMIC RESPONSES

Dynamic elasticities assess how the demand for a good would change over time in response to a change in price or consumers' income. The assessment of the behaviour of the dynamic elasticities of price is critical for a model that has been developed for assessing the impacts of price changes (Pindyck & Rubinfeld, 1991). In this study, the dynamic response of the maize market to a 10 % change in the ADMARC price and the dynamic response of the local maize economy to a 10 % change in the local maize price were analysed. The dynamic elasticities of price for 2010 and the total long-run dynamic elasticities are presented in Tables 6.4 and 6.5 for the entire maize market and for the local economy respectively, to illustrate the current effects as well as the total long-run dynamic elasticities of the price shocks.

Table 6.4: Impact of a 10 % positive change in the ADMARC maize price

Endogenous variables	2010			Total long-run dynamic elasticity (%)
	Baseline	Absolute change	% change (impact multipliers)	
Area planted (1000 hectares)	1141.80	0.00	0.00	0.50
Yield (Tons/hectare)	1.77	0.00	0.00	0.00
Domestic production (1000 tons)	2024.00	0.00	0.00	0.50
Domestic consumption (1000 tons)	2200.04	-47.5	-2.20	-1.50
Local consumption (1000 tons)	97.48	-0.10	-0.10	-0.60
Local production (1000 tons)	17.60	0.00	0.00	0.40
Local market price (USD/ton)	148.52	12.6	8.50	42.50
Intervention household incomes (USD)				
Low resourced	1192.67	0.00	0.00	14.00
Medium resourced	4695.28	0.00	0.00	1.30
Large resourced	1603.30	0.00	0.00	7.50
Counterfactual household incomes (USD)				
Low resourced	322.70	7.30	2.30	13.5
Medium resourced	600.38	8.30	1.40	8.30
Large resourced	2158.67	0.00	0.00	0.70

From Table 6.4, it can be seen that a 10 % increase in the ADMARC maize price would, in both the short run and long run lead to a decrease in both the domestic and local maize consumption. This is because consumption is dependant, amongst other factors, on prevailing market prices. In the long run, Table 6.4 shows that a 10 % change in the ADMARC maize price would lead to an increase in the acreage of maize planted, domestic maize production as well as local maize production. Yields however remain unaffected in either the short run or the long run. Table 6.4 further shows that a 10 % change in the ADMARC price would also affect the local maize economy with the local market maize price being impacted highly with a price transmission pass through rate that is very high in both the short run and the long run.

This agrees with findings from Chapter 5 which demonstrated that local maize markets are well integrated with the ADMARC market.

Further analysis shows that the 10 % change in the ADMARC price translates into changes in household incomes in both communities. In general all the different categories of households are positively affected by the change in the ADMARC price with households in the counterfactual community being affected more in the short run than households in the intervention community. This can be attributed to that maize contributes a larger share to the income of households in the counterfactual community as compared to the intervention community households. In the long run, however, it is households in the intervention community that are affected more by the increase in the ADMARC maize price as compared to their counterparts in the counterfactual communities as demonstrated by slightly larger total long-run dynamic elasticities especially for the low resource and large resource-endowed household categories. This is attributable to that in general; households in the intervention community had higher maize harvests as compared to counterfactual community households. Hence in the long run, incomes for the intervention community households emanating from maize are affected to a larger extent by the increase in the ADMARC maize price. This is because both the real and imputed values of the maize that they market and keep for home consumption or exchange for goods and services would be larger respectively.

Table 6.5 presents the dynamic price elasticities for 2010 and the total long-run elasticity arising from a direct 10 % change in the local maize price. From Table 6.5 it can be seen that a direct 10 % change in the local maize price will lead to a similar decrease in local maize consumption and no change in local production in the short run. In the long run however, the decrease in local consumption is slightly larger as compared to the decrease that occurred from the 10 % change in the ADMARC price. In addition, local production, in the long run, increases by the same percentage (0.40 %) as it did with the 10 % change in the ADMARC price.

Table 6.5: Impact of a 10% positive change in local maize price

	2010			Total long-run dynamic elasticity (%)
	Baseline	Absolute change	% change	
Local consumption (1000 tons)	97.48	-0.10	-0.10	-0.80
Local production (1000 tons)	17.60	0.00	0.00	0.40
Household incomes (USD)		**Intervention**		
Low resourced	1192.67	0.00	0.00	16.5
Medium resourced	4695.28	0.00	0.00	1.50
Large resource	1603.30	0.00	0.00	8.80
Household incomes (USD)		**Counterfactual**		
Low resourced	322.70	0.86	0.27	1.59
Medium resourced	600.38	0.99	0.16	1.97
Large resourced	2158.67	0.00	0.00	0.18

In terms of household incomes, Table 6.5 shows that a 10 % increase in the local maize price leads to larger impacts on household incomes in the long run than a 10 % increase in the ADMARC maize price; with the total long-run dynamic elasticities for all household categories being much larger with the 10 % change in the local maize price than with the 10 % change in the ADMARC maize price. In general, in both communities, households in the lowest resource group had the largest dynamic elasticities in the long run, and in the counterfactual community, this is also observed in the short run.

In conclusion, an analysis of the dynamic response of the Malawi maize model suggests that increases in the ADMARC maize price will in the long run largely affect maize production; with the other variables also being affected, but to a lesser extent. Another major observation from the analysis of the dynamic responses of the model is that direct changes in local maize prices within local maize markets impact upon household incomes to a larger extent in both the short run and the long run. In addition, households in the intervention communities are affected more in the long run by maize price increases occurring in either the local maize markets or national maize markets. Finally, households that fall within lower income groups are more affected by changes in maize prices occurring either at the national or local levels; and this is generally the case in both the short run and the long run.

6.4 IMPACT OF POLICY SHOCKS ON HOUSEHOLD INCOME

Simulation analysis involves the modelling of a system that is in existence and the execution of a scenario on the basis of the model in order to obtain a better understanding of the problem and its potential outcomes. Simulation analysis allows for the quantification of changes in the well-being of different groups within an economy. As such, it has been used widely to plan complicated systems as well as to predict the effects of different interventions on inter-related systems and phenomena (Haveman & Hollenbeck, 1978; Csáki, 1985). This section provides a description of a scenario that is based on existing and real economic events in Malawi as reported in local and international media as well as published and grey literature.

The Malawi economy is highly susceptible to exogenous shocks as a result of the country being highly dependent on donor aid, with over 40 % of the total fiscal budget between 2004 and 2008 being donor funded (Mangani, 2010), and because of it being land locked. Hence, the global financial crisis led to a reduction in donor aid as well as foreign remittances and this resulted into the severe shortage of foreign currency. In addition in 2008 the country had an import bill of approximately USD250 Million arising from increasing fuel and fertilizer costs. The country was unable to fully pay the import bill due to shortage of foreign exchange and as such as by the end of 2010, the situation had not improved and led to the crippling of the economy due to the dependence on imported goods and services. Given this situation the government takes the decision to devalue the Malawi Kwacha by 35 %.

Secondly, in anticipation for the 2014 presidential and parliamentary elections; and in order to ensure votes for the 2014 elections, the main platform for the campaign becomes the fertiliser subsidy programme and government ensures voters that the subsidy in its current form will continue into the foreseeable future. In addition the government puts in place in 2011 a new policy to increase support for smallholder maize irrigation schemes in order to compliment the subsidy program. This has been put in place as evidence has demonstrated that although the ‘smart’ subsidy was a success in Malawi, water availability was a major factor to sustained productivity. In order to have continued donor confidence, the government further takes on recommendations (from the donor community) to further liberalize national parastatals that are currently responsible for maize trade.

The scenario analysis has three shocks which can be categorized into macro-economic policy shocks and agricultural sector shocks as follows:

Macro-economic policy shocks:

- A 35 % sustained exchange rate devaluation of the Malawi Kwacha

Agricultural sector shocks:

- ADMARC liberalization (dummy variable) (Appendix 5 for the historical explanation of ADMARC liberalization and reforms)
- Change in legislation to increase financial and technical support for smallholder maize irrigation (shift variable)

The three shocks filter differently within the model to affect household incomes. The exchange rate devaluation directly affects the import parity price (IPP) which has a direct and positive effect on ADMARC maize prices (Equation 5.1). Changes in the ADMARC maize price will positively impact the local maize prices (Equation 5.2). Local maize prices directly determine estimation of household incomes.

The liberalization of ADMARC will directly and negatively affect the ADMARC maize price (Equation 5.1). This is because one key element of the liberalization of ADMARC is the closure of satellite depots throughout the country. Historically this has led to an increase in private traders in local rural economies (Appendix 5). Due to the lack of regulation, information asymmetries and isolation of many rural households, private traders offer a price that is below the ADMARC maize price. Hence the majority of smallholder producers get a lower price than the ADMARC maize price as a result of ADMARC liberalization. It is this negative effect which is being reflected by the ADMARC liberalization policy shock in the model.

Since ADMARC maize prices have historically approximated import parity prices (Figure 5.6), the negative effect of the simulated policy shock of liberalization of ADMARC entails that ADMARC maize prices shift towards export parity prices. In theory when domestic prices approximate export parity prices, it implies that domestically produced goods become more competitive either regionally or globally (depending on the reference price used in the estimation of parity prices). This provides incentives for export trade which has the potential to stimulate productivity-which in turn can lead to overall growth[11]. This, in theory, is the key driver of the liberalization movement (CIE, 2009).

In the model, the liberalization of ADMARC is captured as a dummy exogenous variable having 0 and 1 for without and with liberalization, respectively (Equation 5.1). This modelling technique can cause problems as it is possible that the price dynamics (such as the actual magnitude of the change in the ADMARC price) arising from the liberalization of ADMARC maybe not be captured by the dummy variable. The linkages in the model that is developed in this study are such that any positive change in the dummy variable for ADMARC liberalization has a negative effect on the ADMARC maize price. The estimated coefficient of the dummy variable of ADMARC liberalization (Equation 5.1) entails that the decline in the ADMARC price arising from liberalization of ADMARC is approximately equal to USD70.00/Ton or MK14.00/kg[12]. An analysis of the import and export parity maize prices for Malawi shows that the difference between import and export parity prices from 1988 to 2009[13] was approximately on average equal to MK15.47/kg. The estimated equation for ADMARC maize prices (Equation 5.1) is therefore able to effectively capture the magnitude of change that would occur in ADMARC maize prices if policy shifted towards greater liberalization of ADMARC.

This entails that the linkages in the model effectively capture the price dynamics in the maize commodity market in the country. This is because the dummy variable for ADMARC liberalization approximates the average magnitude of change; that would be required to shift ADMARC maize prices towards export parity prices[14]; with a small margin of error (-10.55%). The negative effect of the liberalization of ADMARC on the ADMARC maize price will filter to the household incomes through the direct linkage between ADMARC maize prices and local market maize prices-which are linked to household incomes.

The change in legislation to increase financial and technical support for smallholder maize irrigation will directly and positively affect the national maize yields (Equation 5.5). Changes in national maize yields will impact positively upon national maize production (Equation

[11] This may not be case in the presence of government controls which regulate the importation and exportation of goods as is the case in the Malawi maize market.
[12] This is using the exchange rate of USD1:MK200 prevailing in 2011.
[13] Based on 2005 average MK: USD exchange rates.
[14] This is based on historical average differences between import parity prices; export parity prices and ADMARC maize prices from 1988 to 2009.

5.3). The changes in national maize production will affect the production to consumption ratio which has a direct negative impact on the ADMARC maize price. The changes in the ADMARC maize price will filter to household incomes via the local maize price which determines household incomes. The positive effect of the changes in maize yields outweighs the negative effects of the production to consumption ratio on the ADMARC maize price. Hence the irrigation variable will have a positive overall effect on household income as a result of the linkages in the model.

6.4.1 ADMARC liberalization and exchange rate devaluation

The shocks were introduced into the model firstly one by one and then in different combinations. The results of the percentage changes in household incomes for the shocks being introduced one by one are given in Tables 6.6 to 6.8 below.

Table 6.6 presents the percentage changes in household income arising from the shock pertaining to the liberalization of ADMARC to allow greater private sector participation in maize trade. These reforms are introduced into the model from 2011 onwards.

Table 6.6: Income impacts – ADMARC liberalization only

Household category	% changes				
	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014
	Intervention community				
Low resourced	0.00	0.00	-11.68	-10.79	-10.70
Medium resourced (high income)	0.00	0.00	-1.23	-6.06	-6.03
Large resourced (low income)	0.00	0.00	-6.68	-1.09	-1.08
	Counterfactual community				
Low resource	0.00	-8.78	-9.55	-8.77	-8.65
Medium resourced	0.00	-5.55	-6.15	-5.56	-5.51
Large resourced	0.00	0.00	-0.68	-0.60	-0.60

Table 6.7 presents the percentage changes in household income arising from the change in legislation to increase financial and technical support for smallholder maize irrigation. This shock is introduced into the model from 2011 onwards.

Table 6.7: Income impacts – Smallholder maize irrigation shock only

Household category	% changes				
	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014
	Intervention community				
Low resourced	0.00	0.00	2.12	1.83	1.70
Medium resourced (high income)	0.00	0.00	0.22	0.19	0.17
Large resourced (low income)	0.00	0.00	1.21	1.03	0.96
	Counterfactual community				
Low resourced	0.00	1.59	1.62	1.39	1.40
Medium resourced	0.00	1.01	0.88	0.89	0.81
Large resourced	0.00	0.00	0.12	0.10	0.10

Table 6.8 presents the percentage changes in household income arising from a 35% sustained devaluation of the Malawi Kwacha to the US Dollar. The exchange rate shock is introduced into the model from 2011 onwards.

Table 6.8: Income impacts – Exchange rate devaluation only

Household category	% changes				
	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014
	Intervention community				
Low resourced	0.00	7.71	8.91	8.54	8.83
Medium resourced (high income)	0.00	0.70	0.84	0.78	0.80
Large resourced (low income)	0.00	4.08	4.82	4.55	4.71
	Counterfactual community				
Low resourced	6.37	6.49	7.46	7.07	7.24
Medium resourced	3.91	3.96	4.62	4.33	4.43
Large resourced	0.00	0.38	0.46	0.43	0.44

From Table 6.6 to Table 6.8, there are three main observations. First, the shock that leads to a decrease in the maize prices (the ADMARC reforms shocks) has a negative impact on household incomes and the shocks that lead to an increase in the ADMARC maize price (the exchange rate devaluation and the irrigation shock) leads to an increase in household incomes. This can be attributed to the fact that rural household income includes the real and imputed value of maize as such changes in maize prices can affect a household either negatively or positively depending on the composition of a households' income portfolio with the share of income that comes from maize being a key factor and the percentages of maize production that the household actually markets and keeps for home consumption determining the extent to and direction in which they are affected.

The second observation from Tables 6.6 to 6.8 is that the shock that decreased household incomes (the liberalization of ADMARC) negatively affected all household categories in both communities. The effect was however more pronounced in the medium to long term than in the short term with households in both communities exhibiting lower percentage losses of incomes in the first year of the shocks being implemented than in subsequent years. Also in each specific community it is further observed that the households with the lowest resources are more negatively affected by the policy shocks than households that have more resources. This effect can also be attributed to the differences in composition of income portfolios for the different household types. This is because maize generally contributed to a larger share of income for households with lower resource endowments. The better off households had more diversified income portfolios. Hence, any decreases in the price of maize affected the incomes of poorer households to a larger degree because of the greater contribution of maize in their income portfolios. However, further observation shows that this effect is more pronounced in the intervention community than in the counterfactual community; with intervention community households in each specific resource category exhibiting greater losses in income than the corresponding counterfactual community household group for most of the years. This can be attributed to households in the intervention community having larger maize harvests as well as greater participation in the market economy and, as such, having greater linkages with the market economy thus making them more vulnerable to market forces.

The third observation is that the shocks that positively affect incomes (exchange rate devaluation and irrigation legislation shock) lead to increases in incomes for all household categories. In each community it is further observed that households with the least resources have the largest proportional increases in household incomes as compared to better off households. Also it is households in the intervention community that benefit the most as compared to households in the counterfactual communities. This effect can also be attributed to households in the intervention community being more linked to the market economy but in this case these linkages allow them to take advantage of market incentives such as higher maize prices.

6.4.2 The impact of policy coordination on household incomes

The different policy shocks were also introduced into the model in different combinations. Tables 6.9 to 6.12 present the results of the different combinations of the policy shocks on household income. Table 6.9 presents the percentage changes in household income arising from a combination of the shock pertaining to the liberalization of ADMARC and the shock pertaining to change in legislation to allow greater financial and technical support for smallholder maize irrigation. Both shocks are introduced from 2011 onwards.

Table 6.9: Income impacts – both agricultural sector shocks

Household category	% changes				
	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014
	Intervention community				
Low resourced	0.00	0.00	-9.75	-9.13	-9.16
Medium resourced (high income)	0.00	0.00	-1.03	-0.92	-0.93
Large resourced (low income)	0.00	0.00	-5.58	-5.13	-5.16
	Counterfactual community				
Low resourced	0.00	-7.33	-8.08	-7.51	-7.42
Medium resourced	0.00	-4.64	-5.20	-4.76	-4.71
Large resourced	0.00	0.00	-0.57	-0.51	-0.52

Table 6.10 presents the percentage changes in household income arising from a combination of the shock pertaining to the liberalization of ADMARC with the 35 % sustained exchange rate devaluation. Both shocks are introduced from 2011 onwards.

Table 6.10: Income impacts – Exchange rate devaluation and ADMARC

Household category	% changes				
	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014
	Intervention community				
Low resourced	0.00	7.71	-4.32	-3.61	-3.26
Medium resourced (high income)	0.00	6.70	-0.41	-0.33	-0.30
Large resourced (low income)	0.00	4.08	-2.34	-1.93	-1.74
	Counterfactual				
Low resourced	6.37	-3.15	-3.16	-2.61	-2.38
Medium resourced	3.91	-1.92	-1.95	-1.60	-1.45
Large resourced	0.00	0.38	-0.22	-0.18	-0.16

Table 6.11 presents the percentage changes in household income arising from a combination of the shock pertaining to the change in legislation to allow greater financial and technical support for smallholder maize irrigation with the 35 % sustained exchange rate devaluation. Both shocks are introduced from 2011 onwards.

Table 6.11: Income impacts – Exchange rate devaluation and irrigation shock

Household category	% changes				
	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014
	Intervention community				
Low resourced	0.00	7.71	11.23	10.54	10.69
Medium resourced (high income)	0.00	0.70	1.06	0.96	0.97
Large resourced (low income)	0.00	4.08	6.08	5.61	5.70
	Counterfactual community				
Low resourced	6.37	8.18	9.20	8.56	8.73
Medium resourced	3.91	4.99	5.20	5.23	5.34
Large resourced	0.00	0.38	0.58	0.53	0.54

Table 6.12 presents the percentage changes in household income arising from a combination of all the three shocks. All shocks are also introduced from 2011 onwards.

Table 6.12: Income impacts – all shocks

Household category	% changes				
	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014
	Intervention community				
Low resourced	0.00	7.71	-2.21	-1.80	-1.58
Medium resourced (high income)	0.00	0.70	-0.21	-0.16	-0.14
Large resourced (low income)	0.00	4.08	-1.19	-0.96	-0.84
	Counterfactual community				
Low resourced	6.37	-1.01	-1.57	-1.27	-1.03
Medium resourced	3.91	-0.98	-0.98	-0.77	-0.63
Large resourced	0.00	0.38	-0.11	-0.09	-0.08

From Tables 6.9 to 6.12 it is possible to see that the different combinations of policy shocks lead to the same observations in terms of impact on household income with the poorest households either gaining or losing most income depending on the effect of the policy combination. Also households in the intervention community either gain the most or lose the most from a policy combination and the positive or negative effects are more pronounced in the medium to long term as opposed to the short term.

There are two key observations from the different combinations of policies. First it is only the combination of the exchange rate devaluation with the legislation pertaining to smallholder maize production that produces income gains for all household categories in both communities in the medium to long term. Second, all other combinations of the macro-economic policy shock with the liberalization of ADMARC, or with both shocks and a combination of only the agricultural sector shocks leads to losses in incomes for all households in both communities. The losses in incomes from a combination of all the shocks are slightly lower as compared to the losses incurred from any other different combinations of the policies that produced losses; with the combination of the two agricultural sector shocks leading to the highest losses in incomes for all household categories in both communities.

Given that in any economy, macro-economic policy shocks concurrently occur with agricultural sector policy changes, it is important that policy makers make a deliberate concerted effort to analyse the potential impacts of concurrent policy implementation. This also applies to policy making at the sector level. This is because this study has demonstrated that implementing different sector level policies with macro-economic policies or with other sector level policies can lead to negative outcomes for rural smallholder farmers although some of the policies have the potential to benefit households if implementation is done in different combinations.

Furthermore in the face of more agricultural research and development programs moving towards an innovation systems perspective, this is more so imperative as households participating in AIS driven research and development initiatives are more likely to incur greater losses from a combination of policies that negatively affect the pricing of staple food markets because of their greater linkages with the market economy in the medium to long term. All the simulation results have shown that households in the intervention community are affected the most in the face of policy shocks that negatively affect the market. This is so because all household categories in the intervention community had lower decreases in household income than households in the counterfactual community. Given that intervention community households had more diversified income portfolios, these results demonstrate that households that have participated in agricultural research interventions driven by innovation systems concepts are more vulnerable in the long term to market forces as a result of the greater linkages to the market economy. In addition, the simulation analysis has shown that intervention community households are also able to benefit from policies that provide positive market incentives. This is also the result of participating households having greater linkages with the market economy and hence being able to take advantage of market incentives.

The implications of the simulation analysis is that in the face of macro-economic and agricultural policy shocks, AIS driven research interventions have the potential to increase the vulnerability of rural households; particularly households with the lowest resource endowments. Hence, poorer households that participate in AIS driven research interventions are more likely to be negatively affected in the face of macro-economic and agricultural policy distortions than households that are better off. At the same time, participating households are also in a better position to take advantage of market incentives given the implementation of well-coordinated policies.

Therefore in the face of the paradigm shift in agricultural research towards innovation systems perspectives; it is imperative that there be coordinated national policy making. This will require that there be political commitment that will enable mobilization of resources for developing policy guidelines to govern macro-economic and micro-economic policy coordination. In addition, it will also require the establishment of technical institutions to lead the policy coordination and to carry out robust assessments of the possible welfare gains and losses. In addition, technical institutions would be needed to track the general contribution of innovation systems concepts at not only the micro-level but also the macro-level. This will assist to determine the level and type of coordination that is needed but will also provide insight of the depth of innovation systems usage in agricultural research policy and practice within the country.

The findings of the simulation do not in any way invalidate the innovation systems perspective as a means of improving rural livelihoods. However they reflect the potential impact of greater market orientation on rural households-which can occur with any other programs of linking farmers to markets. It is for this reason that AIS driven developmental initiatives focus on strengthening rural livelihoods from not only a market orientation but also from a social and food security perspective; thus reducing the vulnerability of rural household.

6.5 CHALLENGES FACED AND LIMITATIONS

The study was faced with three major challenges. These can be categorised as conceptual understanding of the concept of innovation systems; logistical difficulties encountered in primary data collection; and methodological difficulties. Firstly, the concept of AIS and its practice is still evolving and, as such, misconceptions of its field application existed amongst and between the different stakeholders working in the community where primary data was collected. This problem also arose mainly due to high staff turnover in the organisations that were part of the original innovation platform for the Enabling Rural Innovation (ERI) initiative, which was used as a case study for this research.

Secondly, logistical difficulties were mainly faced during the collection of primary data. The logistical challenge of identifying and tracing programme beneficiaries that were no longer in the study area, such as those who had migrated to other parts of the country, posed a challenge for primary data collection. In many instances, beneficiaries who were no longer in the study area were untraceable and hence not included in the study. Further, the unavailability of the male member of the household during data collection hours was also a major challenge; as the female member, who was more readily found at the household, often lacked the detailed information required in the study arising from her non–involvement in decision making and planning. This problem was rectified by ensuring that, where possible, both the spouses were present for the interview. In many cases, this required revisiting a household.

Another major logistical challenge that was faced arose due to the timing of the study, which coincided with traditional practices of the main tribe in the study area. The data was collected just prior to the beginning of the 2009/2010 cropping season, a time in which the people of the area who are of the c*hewa* tribe hold traditional festivities of the *gulewamkulu* cult in commemoration of the dead, and in which outsiders are not welcome. As a result of the *gulewamkulu* dances, data collection was often delayed as interviews for specific villages where festivities were under way had to be rescheduled. In addition, the country was hit with a crippling fuel crisis in November of 2009 and this delayed data collection immensely.

Methodological challenges included difficulties in reaching service providers involved at the onset of the intervention who possessed critical qualitative information needed in the essential step of approximating a robust, valid analytical model of programme participation for establishing a valid counterfactual. This was overcome by tracing staff who had left the institutions working in the study area as well as interviewing new staff members who were working with the same communities. Finally, the research does not include the development of a dynamic household model. As such, feedback effects from the household level to the macro-economy level were not captured.

6.6 CHAPTER SUMMARY

This chapter has demonstrated that a combination of macro-economic and agricultural policy shocks have the potential to negatively affect the incomes of rural households that participated in AIS research interventions. This is because participating households are made more vulnerable to market forces as a result of the greater linkages with the market economy. In addition, it has been demonstrated that rural households with lower resources participating in AIS driven research interventions are more vulnerable in the face of policy shocks.

However, at the same time, households in intervention communities, especially the poorest households, also stand to gain the most from combinations of policies that provide market incentives because of their greater linkages with the market as strengthened by innovative agricultural research interventions. Thus in order to ensure that the micro-economic level work of AIS driven research and development initiatives is not eroded by macro-economic and agricultural sector policies; it is essential that policies be implemented only after rigorous analysis of the potential gains and losses to different households.

Finally, in order for innovation systems perspectives in agricultural research and development to achieve long-lasting tangible impacts on rural livelihoods, AIS driven research should foster diversification out of agriculture for income, while supporting productivity improvements for food security. There should also be efforts to strengthen the rural household asset base, and, in so doing, building some resilience of the households to risks and shocks associated with agricultural-based livelihood systems. But there is also need for policy coordination to ensure that positive rural livelihood outcomes are not eroded by uncoordinated policy implementation.

CHAPTER 7

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

7.1 SUMMARY

The first objective of this study was to quantify the impact of AIS driven research interventions on rural livelihood outcomes in Malawi. This objective was tackled by using quasi-experimentation with propensity score matching to establish a valid counterfactual and single differencing to measure impact on livelihood outcomes. This objective aimed to demonstrate that AIS driven research interventions have contributed towards changing the rural livelihood economy, as farmers have greater dependence on the market which improves some but not all household livelihood outcomes.

This objective was adopted for this study because, despite the increasing dominance of AIS driven research in Africa, there is a lack of robust quantitative empirical evidence of its impacts. Therefore, this study tested as its first hypothesis the following:

The livelihood outcomes of rural households in communities with AIS driven research programs are higher compared to similar outcomes for rural households in communities without such interventions.

Given that AIS driven research program change the rural household economy by strengthening the linkages that these households have with the market economy, the second objective of the study was to determine the effects of the resultant greater linkages to the macro-economy and to demonstrate the impact of uncoordinated policy making and implementation on rural livelihood outcomes for participating households. The second objective was achieved by using a combination of quantitative and qualitative statistical and econometric tools to delve into the dynamics of the maize market at the farm/household, local economy and national levels; to develop a model that is capable of capturing the maize market dynamics at both the national and local level and the linkages existing within the maize market in the country.

Finally, given the development of a tool that is capable of capturing the dynamics of the maize market and the linkages existing at different levels, the last objective of this study was to simulate macro-economic and agricultural policy shocks in order to provide relevant policy recommendations for informing food and agricultural policy development and for agricultural research programme formulation and implementation in Malawi. In addition, the simulation demonstrated the need for a concerted effort in policy making and thus the need for using a combination of both macro-economic and micro-economic tools in policy analysis especially with respect to policies pertaining to the use of AIS concepts in agricultural research and development.

In order to achieve these last two objectives, the study tested as its second hypothesis the following:

The degree to which rural livelihood outcomes are affected by policy shocks; which transmit through maize market prices; will to a large extent depend upon the socio-economic characteristics of the household; participation in AIS driven research interventions as well as the nature of macro-economic and agricultural sector policy coordination.

7.2 CONCLUSIONS

The findings of this study are that, first, AIS driven research interventions have a positive and significant impact on the livelihood outcomes of rural smallholder farmers in Malawi. Using the Enabling Rural Innovation (ERI) initiative as a case study, this study has shown that AIS driven research interventions have a strong positive impact on some but not all aspects of rural livelihoods, with stronger positive impacts being seen for incomes, upland crop production and fertiliser use, given the absence of government policies that provide subsidised fertilisers. In the presence of a subsidised fertiliser policy, innovative research interventions have a weaker positive impact on fertiliser use. In addition, weaker positive impacts are seen for maize production and training opportunities, given similarities in the geographical location.

Innovative agricultural research interventions therefore have the potential to positively influence the production, incomes, and training opportunities of rural households by increasing the opportunities for networking, information sharing and capacity building. The main shortfall of the ERI was, however, found to be that the sustainability of the positive livelihood outcomes were threatened by the phasing out of the programme. This was because local public agricultural extension agents lacked both the human and financial capacity to maintain the higher level of contact and innovative strategies employed in implementing the intervention. This however could also be a reflection of weaknesses of implementation of the ERI initiative in the study area. This is because Innovation Systems orientation is centred on enhancing the ability of participants to better utilize knowledge and information. This is to be the case even; and especially; in the absence of external assistance. Therefore there is need for further research to analyse the processes and interactions between actors within the ERI framework in order to first validate its shortcomings and second to provide practical solutions.

Second, this study also finds that rural households who are traditionally classified as having little or no backward or forward linkages can be linked to the greater macro-economy through maize markets. Such a linkage is possible as it was demonstrated that prevailing local farm/household maize prices in rural communities are, to a great extent, determined by national level maize prices, which are the result of not only government policies but also supply and demand structures at the national level. Hence, macro-level policy changes that affect demand and supply as well as the pricing of maize at the national level ultimately transmit to the rural household economy. This study therefore developed a functioning multi-equation partial equilibrium model of the Malawi maize market, given government price controls. Using understanding of the inter-relationships between farm/household, local economy and national maize market prices, as well as economic theory and existing empirical evidence, it has been possible through a local area consumption loop to create a recursive system of the local maize market that is linked in a top-down unidirectional manner through a price-linkage equation with the ADMARC maize price to the national maize market. The linkage of rural households to the macro-economy through the maize price is an appropriate mechanism, as changes at the rural economy entail that smallholder farmers have greater dependence on the market.

Using the partial equilibrium model, it was possible to simulate changes occurring within national maize markets to assess the impact of macro-economic and agricultural policy changes on rural households that are involved in the production and marketing of maize. The simulation analysis demonstrated that a combination of macro-economic and agricultural policy shocks has the potential to either positively or negatively affect the incomes of rural households; particularly households that have participated in AIS driven research interventions. Also, the poorest households tended to be affected the most. This was the case in either community and regardless of whether the policy effects were positive or negative. Similarly the poorest households in participating communities were also affected the most in any case. Hence, the stronger market linkages that allow participating households to take advantage of market incentives also make them more vulnerable to policy shocks that transmit through the market.

In conclusion, this study has empirically demonstrated that AIS driven research interventions impact positively upon the livelihood outcomes of rural households by strengthening households' linkages with the market economy. This allows them to take greater advantage of market incentives but also at the same time makes them more vulnerable to macro-economic policy shocks. This study has therefore shown that the analysis of the impacts of the paradigm shift in agricultural research towards AIS orientation cannot be solely contained at the household level; as this would lead to the formulation of inadequate policies that do not take into account the effects of greater market linkages of the rural households.

7.3 POLICY RECOMMENDATIONS

The policy implications of the findings of this study are first that increasing production and productivity and linking farmers to markets may not in itself be enough for long-term sustained livelihood improvement. This is because the resultant greater linkages to the market economy may be detrimental to household livelihood outcomes in the face of macro-economic and agricultural policy shocks. To ensure livelihood improvements and innovation, there is the need for AIS driven research to increase the scale of operation in order to have larger impacts but also to work towards fostering the diversification out of agricultural enterprises for income; while supporting productivity improvements for food security. In addition, any AIS driven research that aims to achieve long-lasting tangible impacts on rural livelihoods should work towards strengthening the rural household asset base; in so doing, building to some extent the resilience of the households to risks and shocks associated with agricultural-based livelihood systems. The household asset base can be strengthened through micro-economic agricultural development programs that encourage greater investment in the farm enterprise in higher value assets.

Second, this study recommends that in order to ensure the sustainability of the positive effects on rural livelihoods and the use of innovation systems concepts, there is the need for grassroots-level agricultural extension staff, such as village technicians and public extension agents, to be supported through increased budgetary support for intervention implementation and capacity building; to enable greater understanding and application of AIS concepts. To ensure that the use of AIS concepts is not isolated to parts of the country where private research and development organisations are working, it is further recommended that there is need to mainstream AIS concepts in all public agricultural research and development initiatives. This will, however, require that there be deliberate and greater budgetary support towards innovation systems mainstreaming in all public agricultural extension and research programmes, and the re-alignment of public agricultural extension and research policy documents. The re-alignment of existing public agricultural extension and research policy documents should be done concurrently with the capacity building of extension agents and the increased budgetary support, in order to ensure effectiveness of the mainstreaming process. Without concurrent implementation of these three strategies, mainstreaming of innovation systems concepts in public agricultural policies runs the risk of becoming synonymous with changing the rhetoric and policy documents, but with no real implementation.

More macro-micro analyses of the impacts of AIS research need to be conducted. Such research should go beyond this study by looking at developing dynamic household-level models that can provide feedback to the macro-component of the model. In addition, future research should work at creating an aggregate household income variable as a means of creating dynamism in macro-micro studies of this kind. Apart from income, future studies should also work on using other welfare indicators such as household food consumption and food security dynamics to analyse the impacts of greater market linkages. These indicators may be in a better position to provide insight into household vulnerability and resilience. In addition, it is also recommended that future studies should aim to assess the use of household expenditure as a means of linking rural smallholder farmers to the macro-economy; thus quantifying linkages of rural households to agricultural input markets. This is an important area of research, as the use of innovation systems in agricultural research changes not only farmers' linkages with the output sector or their incomes, but also the linkages with the input/supplier sectors and household expenditure patterns.

Future agricultural research, policy and practice should also ensure that rigorous impact evaluation plans are put in place during program conceptualization. This is because the ability to demonstrate causality greatly increases the effectiveness of econometric results for influencing policy (Sadoulet & de Janvry, 2010). However absolute causality can only be achieved with the use of randomized control trials (Sadoulet & de Janvry, 2010). Therefore future program design and research should take this into account by designing programs on a roll out basis for equally eligible end users thus ensuring the validity of the counterfactual. Alternatively the use of other methods; which require additional assumptions to demonstrate rigorous causality; need to ensure statistical regularity and robustness checks; thus guaranteeing the validity of the additional assumptions and dismissal of confounding factors (Sadoulet & de Janvry, 2010).

In order for the paradigm shift in agricultural research towards an innovation systems perspective to be effective in sustaining rural livelihoods in Africa, interventions should be implemented only after systematic analysis of the potential consequences of the resultant macro-micro linkages. This will ensure that there is no mismatch between macro-economic policies, agricultural sector policies and livelihood improvement strategies that are driven by innovation systems concepts.

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APPENDICES

Appendix 1: Results of Tukey's *post hoc* tests (cluster solution and validation)

Table A4.1: Results of the Tukey's HSD test for the intervention community

Variable	Cluster	Clusters of comparison	Mean difference	Std. error	ρ
Value of assets (USD)	1	2	-226.48*	47.00	0.000
		3	-1512.93*	105.49	0.000
	2	1	226.48*	47.00	0.000
		3	-1286.45*	107.43	0.000
	3	1	1512.93*	105.49	0.000
		2	1286.45*	107.43	0.000
Farm size (acres)	1	2	-2.4111*	0.45968	0.000
		3	-2.4098	1.03171	0.056
	2	1	2.4611*	0.45968	0.000
		3	0.05128	1.05074	0.999
	3	1	2.4098	1.03171	0.056
		2	-0.5128	1.05074	0.999
Number of farm plots	1	2	-1.8353*	0.14008	0.000
		3	-0.1789	0.31441	0.837
	2	1	1.8353*	0.14008	0.000
		3	1.6564*	0.32020	0.000
	3	1	0.17895	0.31441	0.837
		2	-1.65541	0.32020	0.000

* Statistically significant at the 5 % level

Table A4.2: Results of the Tukey's HSD test for the counterfactual community

Variable	Cluster	Clusters of comparison	Mean difference	Std. error	P
Value of assets	1	2	856.86*	57.82	0.000
		3	934.63*	57.36	0.000
	2	1	-856.86*	57.82	0.000
		3	77.77*	14.40	0.000
	3	1	-934.63*	57.36	0.000
		2	-77.77*	14.10	0.000
Farm size (acres)	1	2	7.62410*	1.18539	0.000
		3	9.90267*	1.17593	0.000
	2	1	-7.6241*	1.18539	0.000
		3	2.27857*	0.29522	0.000
	3	1	-9.90267*	1.17593	0.000
		2	-2.27857*	0.29522	0.000
Number of farm plots	1	2	2.17568*	0.51519	0.000
		3	3.38400*	0.51108	0.000
	2	1	-2.14568*	0.51519	0.000
		3	1.20832*	0.12831	0.000
	3	1	-3.38400*	0.51108	0.000
		2	-1.20832*	0.12831	0.000
Household size	1	2	-1.94595	1.11441	0.191
		3	0.27200	1.10552	0.967
	2	1	1.94595	1.11441	0.191
		3	2.21795*	0.27754	0.000
	3	1	0.27200	1.10552	0.967
		2	-2.21795*	0.27754	0.000

* Statistically significant at the 5 % level

Table A4.3: Results of the Tukey's HSD test for the intervention community (profile variables)

Variable (2008/2009)	Cluster	Clusters of comparison	Mean difference	Std. error	ρ
Total income (USD)	1	2	-387.584*	166.7296	0.057
		3	-0.01703*	374.2143	0.000
	2	1	387.5841*	166.7296	0.057
		3	-0.01316*	381.1149	0.002
	3	1	0.017033*	374.2143	0.000
		2	0.013158*	381.1149	0.002
Fertiliser use (number of 50 kg bags)	1	2	-0.31284	0.49752	0.805
		3	-3.51462*	1.11665	0.006
	2	1	0.31284	0.49752	0.805
		3	-3.20178*	1.13724	0.016
	3	1	3.51462*	1.11665	0.006
		2	3.20178*	1.13724	0.016
Value of maize harvest (USD)	1	2	-77.807	261.4051	0.952
		3	-0.024*	586.7079	0.000

2	1	77.807	261.4053	0.952
	3	-0.02322*	597.5269	0.001
3	1	0.024*	586.7078	0.000
	2	0.023224*	597.5269	0.001

Statistically significant at the 5 % level

Table A4.4: Results of the Tukey's HSD test for the counterfactual community (profile variables)

Variable (2008/2009)	Cluster	Clusters of comparison	Mean difference	Std. error	ρ
Total income (USD)	1	2	265.84*	233.28	0.000
		3	283.35*	231.42	0.000
	2	1	-265.84*	233.28	0.000
		3	175.02*	58.099	0.008
	3	1	-283.35*	231.42	0.000
		2	-175.03*	58.099	0.008
Value of maize harvest (USD)	1	2	185.98*	161.45	0.000
		3	199.67*	160.18	0.000
	2	1	-185.98*	161.45	0.000
		3	136.85*	40.27	0.002
	3	1	-199.67*	160.18	0.000
		2	-136.85*	40.27	0.002

* Statistically significant at the 5 % level

Table A4.5: Summary results of divisive non-hierarchical clustering for both communities

Clusters	Value of assets (USD)	Farm size (acres)	Number of farm plots	Household size	Cluster size
	Mean value				
Intervention community					
1	653.87	5.69	4.25	5.08	12
2	101.78	3.94	2.97	4.96	83
3	1568.15	5.73	3.16	6.33	6
Counterfactual community					
1	976.41	11.966	5.00	4.00	3
2	415.76	3.36	2.5	4.5	12
3	48.56	2.88	2.03	4.55	187

Table A4.6: Analysis of Variance (ANOVA) results for divisive non-hierarchical clustering

Variable		Sum of squares	Degrees of freedom	Mean square	F-ratio	ρ
	Intervention community					
Value of assets	Between groups	2.874	2	1.392	437.228	0.000
	Within groups	3.120	98	3.184		
	Total	3.096	100			
Farm size (acres)	Between groups	45.790	2	22.895	3.846	0.025
	Within groups	583.427	98	5.953		
	Total	629.217	100			
Number of farm plots	Between groups	17.024	2	8.512	7.794	0.001
	Within groups	107.035	98	1.092		
	Total	124.059	100			
Household size	Between groups	10.502	2	5.251	0.760	0.470
	Within groups	677.142	98	6.910		
	Total	687.644	100			

Table A4.7: Results of the Tukey's HSD test for intervention community (divisive non-hierarchical clustering)

Variable	Cluster	Clusters of comparison	Mean difference	Std. error	ρ
Value of assets	1	2	552.0914*	39.36103	0.000
		3	-914.278*	63.72419	0.000
	2	1	-552.09*	39.36103	0.000
		3	-1466.37*	53.87839	0.000
	3	1	914.278*	63.72419	0.000
		2	1466.309*	53.87839	0.000
Farm size (acres)	1	2	1.74540	0.75355	0.058
		3	-0.4167	1.21997	0.999
	2	1	-1.74540	0.75355	0.058
		3	-1.78707	1.03148	0.198
	3	1	0.04167	1.21997	0.999
		2	1.78707	1.03148	0.198

Number of farm plots	1	2	1.27410*	0.32276	0.000
		3	1.08333	0.52254	0.101
	2	1	-1.27410*	0.32276	0.000
		3	-0.19076	0.44180	0.902
	3	1	-1.08333	0.52254	0.101
		2	0.19076	0.44180	0.902

Table A4.8: Analysis of Variance (ANOVA) results for divisive non-hierarchical clustering

	Counterfactual community					
Variable		**Sum of squares**	**Degrees of freedom**	**Mean square**	**F-ratio**	**ρ**
Value of assets	Between groups	7.732	2	3.866	578.159	0.000
	Within groups	1.331	199	6.687		
	Total	9.062	201			
Farm size (acres)	Between groups	244.945	2	122.472	23.324	0.000
	Within groups	1044.919	199	5.251		
	Total	1289.864	201			
Number of farm plots	Between groups	27.866	2	13.933	12.734	0.000
	Within groups	217.738	199	1.094		
	Total	245.604	201			
Household size	Between groups	0.939	2	0.469	0.099	0.906
	Within groups	941.160	199	4.729		
	Total	942.099	201			

Table A4.9: Results of the Tukey's HSD test for counterfactual (divisive non-hierarchical clustering)

Variable	Cluster	Clusters of comparison	Mean difference	Std. error	ρ
Value of assets	1	2	560.6524*	37.70237	0.000
		3	927.8499*	33.99144	0.000
	2	1	-560.652*	37.70237	0.000
		3	367.1975*	17.39359	0.000
	3	1	-927.85*	33.99144	0.000
		2	-367.198*	17.39359	0.000
Farm size (acres)	1	2	8.60417*	1.47914	0.000
		3	9.08431*	1.33355	0.000
	2	1	-8.60471*	1.47914	0.000
		3	0.48015	0.68239	0.762
	3	1	-9.08431*	1.33355	0.000
		2	-0.48015	0.68239	0.762
Number of farm plots	1	2	2.50000*	0.67520	0.001
		3	2.96257*	0.60875	0.000
	2	1	-2.50000*	0.67520	0.001
		3	0.46257	0.31150	0.300
	3	1	-2.96257*	0.60875	0.000
		2	-0.46257	0.31150	0.300

Appendix 2: Data sheet for the Malawi maize sector

Table A5.1: Data sheet for Malawi maize sector

				1988	1989	1990	1991	1992	1993	1994
Supply and demand										
Area harvested	MOA	Hectares	MZARE	1122.52	1227.14	1246.61	1391.87	1368.09	1380.8	1369.14
Yield per unit area	MOA	Tons/Hectare	YLD	1.09	1.03	1.03	0.926	0.55	0.929	0.92
Maize Imports	MOA	1000 Tons	IMMZ	197	200.58	203.23	205.89	760.37	248.79	271.97
Beginning stock				1.8	0.8	1.69	2.65	3.07	2.41	2.42
Domestic maize consumption	MOA	1000 Tons	DMZC	1421	1464	1484	1494.847	1518.03	1528.62	1531.57
Maize Exports	MOA	1000 Tons	EXMZ	0	0.2	1.088	0	0	4.11	1.25
Ending Stock	Computed	1000 Tons	ENDS	0.8	1.69	2.65	3.07	2.41	2.42	2.43
Net Exports	Computed	1000 Tons	NIMP	-197	-200.38	-202.142	-205.89	-760.37	-244.68	-270.72
Production/maize consumption	Computed	Index	PROD/CON	0.865	0.863	0.864	0.862	0.498	0.839	0.823
Per capita maize consumption	Computed	1000 Tons/capita	PCC	170.65	166.35	161.04	156.53	153.77	152.91	156.81
Local Economy										
Local maize production (Ukwe)	Ukwe EPA	1000 Tons	PROD		19.263	16.668	10.327	16.096	24.323	18.746
Local maize consumption (Ukwe)	Ukwe EPA	1000 Tons	AREA_CSP	95	96.8	97	97.8	98.5	98.5	99.8

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Supply and demand													
Area harvested	993.019	1134.39	1252.05	1292.66	1039.03	1099.13	1108.51	1488.44	1218.75	1278.02	1173.77	1482.39	1139.95
Yield per unit area	1.27	1.201	1.112	0.98	1.22	1.185	1.184	0.71	1.102	1.078	1.2056272	1.141	1.49
Maize Imports	270.1	193.97	168.32	299.88	273.14	266.53	256.77	550.35	276.59	271.53	234.15	10.53	74.83
Beginning stock	2.43	1.73	2.78	2.2	2.29	2.88	2.75	2.18	1.56	2.49	1.81	2.18	4.93
Domestic maize consumption	1528.41	1553.88	1558.67	1570.66	1545.94	1567.33	1570.41	1607	1619.1	1650.14	1646.34	1687.76	1722.68
Maize Exports	3.84	2.45	2.67	1.52	1.1	2.24	0	0.94	0	0.41	2.57	11.5	50.62
Ending Stock	1.73	2.78	2.2	2.29	2.88	2.75	2.18	1.56	2.49	1.81	2.18	4.93	4.99
Net Exports	-266.26	-191.52	-165.65	-298.36	-272.04	-264.29	-256.77	-549.41	-276.59	-271.12	-231.58	0.97	-24.21
Production/maize consumption	0.825	0.877	0.893	0.810	0.824	0.831	0.836	0.657	0.829	0.835	0.859	1.00	0.985
Per capita maize consumption	158.287	157.67	154.27	151.6	145.65	144.14	141.04	141.04	138.96	130.88	128.00	128.62	128.69
Local Economy													
Local maize production (Ukwe)	15.936	19.312	18.898	21.679	24.772	20.113	23.481	19.967	20.853	21.372	10.564	19.795	27.283
Local maize consumption (Ukwe)	88.9	90	91.3	91.3	92.5	92.5	93.5	85	95.9	96.5	95.8	98.7	95.6

Appendix 3: Units root tests for time series data

Table A5.2: ADF test results for time series data used in model

Time series variable	ADF Statistic	MacKinnon Critical value	Durban-Watson Statistic	Levels/differences
Domestic maize production	-4.32	-3.82***	1.98	2nd differences
Domestic maize consumption	-2.70	-2.66*	1.36	2nd differences
Ending stock	-4.14	3.83***	1.96	1st differences
Local production	-5.07	-3.85***	1.76	1st differences
Local consumption	-4.12	-3.83***	1.96	1st differences
Area of maize	-2.87	-2.65*	2.00	Levels
Yield of maize	-3.16	-3.02**	1.96	1st differences
Local yield of maize	-3.82	-3.03**	1.98	1st differences
Local area of maize	-3.88	-3.85***	1.45	1st differences
Population	-3.92	-3.85***	2.07	2nd differences
Exports	-3.14	-3.03**	2.03	1st differences
Imports	-4.55	-3.83***	2.01	1st differences
Price of fertiliser	-2.97	-2.65*	1.67	1st differences
Rainfall	-3.26	-3.02**	2.11	1st differences
Local rainfall	-2.89	-2.65*	2.05	Levels

Appendix 4: Correlation matrices for maize market regression models

Table A5.3: Correlation matrix for model of area of maize planted

	DUM: agri	Lagged ADMARC price	Lagged area planted	SUBSIDY
DUM: agri	1.00	-0.096	-0.203	0.432
Lagged ADMARC price		1.00	0.033	-0.387
Lagged area planted			1.00	-0.290
SUBSIDY				1.00

Table A5.4: Correlation matrix for the model of ADMARC maize price

	Dum:INT	Import parity price	DUM:Reforms	Production/consumption
Dum:INT	1.00	-0.107	-0.306	0.113
Import parity price		1.00	0.251	-0.537
DUM:Reforms			1.00	-0.216
Production/consumption				1.00

Table A5.5: Correlation matrix for the model for the local price of maize (Nsundwe)

	ADMARC price	DUM02	Local maize consumption	DUM:Ukwe
ADMARC price	1.00	0.491	-0.350	0.358
DUM02		1.00	-0.374	-0.213
Local maize consumption			1.00	0.126
DUM:Ukwe				1.00

Table A5.6: Correlation matrix for the yield of maize

	Rainfall	PFERT	DUM:agri2	Shift 06
Rainfall	1.00	-0.165	0.254	-0.758
PFERT		1.00	-0.702	0.451
DUM:agri2			1.00	-0.679
Shift 06				1.00

Table A5.7: Correlation matrix for the local maize production

	Lagged local maize price	DUM:Ukwe2	Local rainfall
Lagged local maize price	1.00	-0.107	-0.294
DUM:Ukwe2		1.00	-0.114
Local rainfall			1.00

Table A5.8: Correlation matrix for the local maize consumption

	Local maize production	DUM:BRDG	Local maize price
Local maize production	1.00	-0.144	-0.206
DUM:BRDG		1.00	-0.108
Local maize price			1.00

Table A5.9: Correlation matrix for per capita maize consumption

	DUM:Agri	Shift 06	Rainfall	PFert
DUM:Agri	1.00	-0.165	-0.702	0.451
Shift 06		1.00	0.254	-0.758
Rainfall			1.00	-0.678
PFert				1.00

Table A5.10: Correlation matrix for maize imports

	Net exports	Policy:NFRA	SHIFT06	DUM:Pvt
Net exports	1.00	0.737	-0.812	0.940
Policy:NFRA		1.00	-0.518	0.710
SHIFT06			1.00	-0.734
DUM:Pvt				1.00

Table A5.11: Correlation matrix for ending stocks

	Beginning stock	Domestic production	ADMARC maize price
Beginning stock	1.00	0.338	-0.098
Domestic production		1.00	-0.264
ADMARC maize price			1.00

Appendix 5: ADMARC reforms and impacts

Table A6.1: Historical overall of ADMARC reforms in Malawi

Time line	ADMARC Reform
1971	Formation of ADMARC (mandated to market agricultural inputs, produce; facilitate the development of smallholder sector; and food security role-to buy and sell maize in remote areas)
1987	Monopoly of ADMARC as sole agent responsible for importation, storage and marketing of maize removed. Private sector allowed to engage in maize trade
1987	Partial liberalization of other agricultural commodities (previously only traded by ADMARC)
1990	ADMARC operating 1300 seasonal markets, 3 regional offices and 18 storage depots
1990	ADMARC storage capacity at 468,000 metric ton
Mid-1990's	Maize price band defended by ADMARC revised/removed
2001	Strategic grain reserve function of ADMARC removed and given to National Food Reserve Agency
2002	ADMARC subsidiaries taken over and subsequently taken over by the Ministry of Finance
2002	Disaster and emergency relief function of ADMARC moved to the Office of the President an Cabinet
2002	ADMARC storage capacity reduced to 200,000 metric tons
2004	ADMARC operating 300 seasonal markets, 400 unit markets, 3 regional markets and 9 storage deports

Several studies conducted to access the reforms in ADMARC have shown that there were many impacts. These are summarized in Table below.

Table A6.2: Impact of the ADMARC reforms

Impact of ADMARC reforms			
Impact on private sector	**Impact on markets/prices**	**Impacts on households**	**Other impacts**
Increase in number of input wholesalers and retailers	Differential increase in number of input sellers (number of private traders not positively correlated with absence of ADMRC markets)	Reduced profitability for smallholder famers due to lack of organization and inability to negotiate with private traders	Poor quality of business practice by private traders arising from the lack of regulation and enforcement for fair trading practices
Increase in number of crop buyers	High price volatility within and between communities. High price volatility in prices between pre-harvest and post harvest periods. Both due to lack of competition	Higher transaction and transport costs for input procurement as majority of private traders not engaged in input sales	Widespread claims of cheating on weights and measures by smallholders
Increase in number of crop wholesalers	Interregional and inter-seasonal arbitrage function of ADMARC not successfully taken over by private sector	Smallholders forced to use ADMARC markets in other communities after closure of their own deports	
	Higher margins for traders; and lower competition and efficiency in markets. Lower prices for producers		

Although ADMARC was not cost effective during its full operation; it played a social function by providing the following services which the private sector did not efficiently take over (Kutengule *et al*., 2006):

- Provided a distribution network for affordable maize in the lean season and in times of famine
- Provided benchmark prices and access to information for smallholder farmers
- Acted as reliable source of inputs
- Provided producers with an outlet market to sell their produce
- Provided the only form of market for households in very remote rural areas

Private sector failed to fully step in where ADMARC was withdrawn because of inadequate infrastructure, inefficient factor input markets, market information; credit delivery systems (Kutengule *et al*., 2006)

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Appendix 6: Household/farmer survey questionnaire

University of Pretoria

Department of Agricultural Economics, Extension and Rural Development

Household/farmer questionnaire of the study of the macro-micro linkages between rural livelihoods, agricultural innovation systems and agricultural policy changes in Malawi

A) GENERAL INFORMATION

Respondent's name: ________________ ___________________ Sex: **1=Female** **2=Male**

Relationship to household head: **1. Spouse** **2. Relative of one of the spouses 3. NA (Head)**

District: **1.Lilongwe** EPA: ______________________ Community: **1.Katundulu 2.. Ukwe**

Name of Village:___________________________ Type of village**: 1) Intervention 2) Counterfactual**

Interviewer: ____ Date: _______________________

GPS Coordinates of Household: Northings:_____________________________
Eastings:______________________________
Elevation (m.a.s.l)_______________________

Checked by supervisor/Team leader: Mariam Mapila
Date ____
Comments:
____
____

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B) CROP PRODUCTION AND MARKETING

1) a. How many plots (pieces of land/minda) does the household currently own?_______________ **1b)** Please fill in table below

a) Plot No.	b)Size (**acres**)	c)Location of plot **1) By home 2) Far from home 3) Dimba**	d)Distance from homestead **KM**	e)Farming system **1.Mixed/intercropping 2.Pure stand 3.Fallow 4) partially cultivated with some sides under fallow**	f) Person responsible for managing plot **1. Husband 2. Wife 3) Both**	g)Ownership of plot **1. Own the plot 2. Rented 3. borrowed**	h)How did the household acquire the plot **1) inherited from wife's family 2)Inherited from husband family 3) bought the plot**
1							
2							
3							
4							
5							
6							

1c) in which years did you cultivate the plots named in 1b above? Please fill table below

a).Plot No.	**Please tick all the years that this plot was under cultivation**										
	2008/09	**2007/08**	**2006/07**	**2005/06**	**2004/05**	**2003/04**	**2002/03**	**2001/02**	**2000/01**	**1999/00**	**1998/99**
1											
2											
3											
4											
5											
6											
7											
Total number of plots cultivated in season (add all ticked above)											

2a) What major crops did the household cultivate in the **2008/2009** agricultural season? Fill Table Below

a) Crop cultivated in **2008/09**	b)Total harvest (**Amount**)	c).Harvest units **1. 50 kg bags 2. 90kg bags 3. Oxcarts 4. Weaved big basket 5. Tin pails**	d)Total harvest (**equivalent in KG)**	e)Type of farming practice **1) Mixed cropping 2) pure stand**	f)Total harvest sold (**equivalent KG**)	g)Average price per unit in local market		h)Total amount of money earned (**MK**)
						MK	Unit **1. 50 kg bags 2. 90kg bags 3. Oxcarts 4. Weaved big basket 5. Tin pails**	
Maize (chimanga)								
Beans (nyemba)								
Groundnuts (mtedza)								
Sweet potatoes (mbatata yakholowa)								
Tobacco (fodya)								
Cowpeas (khobwe)								

2b) What major crops did the household cultivate in the **2007/2008** agricultural season? Fill Table Below

a) Crop cultivated in **2008/09**	b)Total harvest **(local measure used)**	c). Harvest units **1. 50 kg bags 2. 90kg bags 3. Oxcarts 4. Weaved big basket 5. Tin pails**	d)Total harvest **(equivalent in kg)**	e)Type of farming practice **1) Mixed cropping 2) pure stand**	f)Total harvest sold **(equivalent kg)**	g)Average price per unit in local market		h)Total amount of money earned (**MK**)
						MK	**Unit 1. 50 kg bags 2. 90kg bags 3. Oxcarts 4. Weaved big basket 5. Tin pails**	
Maize (chimanga)								
Beans (nyemba)								
Groundnuts (mtedza)								
Sweet potatoes (mbatata yakholowa)								
Tobacco (fodya								
Cowpeas (khobwe)								

3a) Do you own a wetland (dimba)? **0) No 1) Yes** **3b)** if No do you rent one? **0) No 1) Yes**

3c) In the **2009** winter season did you cultivate a wetland (dimba)? **0) No 1) Yes** **3d)** If Yes to 4c fill in table below with **2009** winter season production

a)Dimba Crop	b)Total dimba harvest Produced			c)Total dimba harvest sold			
	Amount harvested	Unit **1. 50 kg bags 2. 90kg bags 3. Oxcarts 4. Weaved big basket 5. Big tin pail 6. Small tin pail**	**kg** equivalent	Amount sold	Unit **1. 50 kg bags 2. 90kg bags 3. Oxcarts 4. Weaved big basket 5. Big tin pail 6. Small tin pail**	**kg** equivalent	d)Total amount of money obtained from dimba in 2009 **MK**
Maize							
Green leafy vegetables							
Onions							
Sweet potatoes							
Beans							

3e) In **2008** did you cultivate a wetland (dimba)? **0) No 1) Yes** **3f)** If Yes fill in table below: Wetland (dimba) Production for 2008 winter season

a)Dimba Crop	b)Total harvest			c)Total harvest sold			
	Amount sold	Unit **1. 50 kg bags 2. 90kg bags 3. Oxcarts 4. Weaved big basket 5. Big tin pail 6. Small tin pail**	**kg** equivalent	Amount sold	Unit **1. 50 kg bags 2. 90kg bags 3. Oxcarts 4. Weaved big basket 5. Big tin pail 6. Small tin pail**	**kg** equivalent	d)Total amount of money obtained from dimba in 2009 **MK**
Maize							
Green leafy vegetables							
Onions							
Sweet potatoes							
Beans							

4a) During the last hunger season (February to March 2009) did you sell any fresh produce from your field (mbeu zamunda)? **0) No 1) Yes**

4b) If yes, fill table below?

a)Fresh Crop sold during hunger seasons (**2009**)	b)Total sold during hunger seasons	c).Unit **1. 50 kg bags 2. 90kg bags 3. Oxcarts 4. Weaved big basket 5. Big tin pail 6. Small tin pail**	d)Total sold during hunger season (**Equivalent in kg)**	e)Total amount of money earned (**MK**)
Fresh Maize (chimanga chachiwisi)				
Green Beans (zitheba)				
Fresh groundnuts				

4c) During the last hunger season did you sell any **dry produce** that had been kept for your own consumption (produce from 2007/08 harvest)? **0) No 1) Yes**

4d) If yes, fill table below?

a)Dry produce from **2007/08** season sold in hunger season	b)Total sold during hunger seasons	c).Unit **1. 50 kg bags 2. 90kg bags 3. Oxcarts 4. Weaved big basket 5. Big tin pail 6. Small tin pail**	d)Total sold during hunger season **(equivalent in kg)**	e)Total amount of money earned (**MK**)
Maize				
Beans				
Groundnuts				
Cowpeas (Khobwe)				

4 f) Market access: If you sell your crop produce please fill in table below

a)Name of market where you sell your crop produce	b)Type of market **1)local village market 2) Local community market 3)District market 4)moving market (kabandule) 6. Market in another community**	c)Mode of transport to market **1)by foot 2)by own bicycle 3)by hired bicycle 4)by public transport (minibus)4) by hitchhiking (matola)**	d)Distance to market in **KM**	e) Transport cost to Market in **MK**	f)Time it takes to travel to market (**hours**)	g)Type of road to market **1)all season dirt road 2)Dry season dirt road 3)Tarmac 4) Combination of dirt road and tarmac**	Other costs (please list and put amount in MK in last column	
							Type of Cost	Amount in MK
Ngwangwa								
Lilongwe district market								
Area 25 market								
Lumbadzi market								
Katundulu								
Ukwe								
Msundwe								

4g). When selling maize, who sets the prices?? **1) Self 2) Buyer 3) Both negotiate until reach a price 4) use set government price** ___________________________

4h) When selling other crops who sets the prices **1) Self 2) Buyer 3) Both negotiate until reach a price 4) use set government price** ______________________________

4j) Where do you get information pertaining to the prices of different crops? ____
1) From Radio 2) From fellow farmers 3) From extension officers 4) From posted price board outside ADMARC 5) Do not get any information 6)Other (specify)

C) FERTILIZER USE AND PERCEPTIONS OF FERTLIZER SUBSIDY

5a) Please fill table below with fertilizer use information:

a) Cropping season	b) Did your household apply fertilizer? **0) No 1) Yes**	c) If yes, Total amount of fertilizer applied (**No. of 50kg bags of each type applied**)			d) What was the source of this fertilizer? 1)Subsidized coupons 2)Purchased at full price 3) Received from relatives 4) Received from other sources 5)Other (specify)			Total amount of money spent on all fertilizer for the season (**MK**)
		23:21:0 (Urea)	CAN	Other (specify)	23:21:0 (Urea)	CAN	Other (specify)	
2004/05								
2005/06								
2006/07								
2007/08								
2008/09								

5b) Please fill table below if you received coupons for subsidized fertilizer

a)Cropping season	b) Is the amount of coupons received for fertilizer sufficient for your household fertilizer needs? **0) No 1) Yes**	If no, what do you do to ensure you get sufficient fertilizer 1) Buy coupons from fellow villagers 2) buy coupons from chiefs 3) buy coupons from civil servants 4) Buy extra fertilizer at full price 5) do not apply fertilize to remaining filed
2004/05		
2005/06		
2006/07		
2007/08		
2008/09		

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5c). Apart from fertilizer, did the household incur any other production costs in either the 2008/09 or 2007/08 seasons? **0)No 1) Yes** If yes fill table below?

	2008/09 agricultural season		2007/08 agricultural season	
Name of Inputs	Total amount paid (MK)	Source of input **1. Buy from market 2. Buy from agro dealer shops 3) Buy from fellow villagers 4). Receive from relatives 5) Receive from NGO**	Total amount paid (MK)	Source of input **1. Buy from market 2. Buy from agro dealer shops 3) Buy from fellow villagers 4). Receive from relatives 5) Receive from NGO**
Pesticides				
Herbicides				
Sacks/storage bags				

D). SEED ACQUISITION AND COSTS

5d). Where do you normally obtain seeds for planting your crops and what costs do you incur? Please in table below

	2008/09 agricultural season			2007/08 agricultural season		
Item	Source of Seed **1. Buy from market 2. Buy from agro dealer shops 3) Buy from fellow villagers 4). Receive from relatives 5) Receive from NGO 6. Bought with subsidized coupons 7. Received from farmer organizations**	In the 2008/09 season did you buy this seeds **0. No. 1. Yes**	If you bought, total amount spent on seeds (**MK**)	Source of Seed **1. Buy from market 2. Buy from agro dealer shops 3) Buy from fellow villagers 4). Receive from relatives 5) Receive from NGO 6. Bought with subsidized coupons 7. Received from farmer organizations**	In the 2008/09 season did you buy this seeds **0. No. 1. Yes**	If you bought, total amount spent on seeds (**MK**)
Cereals (maize)						
Grain legumes (beans, groundnuts, cowpeas)						
Cash Crops (Tobacco, Paprika, Cotton)						

E) LIVESTOCK OWNERSHIP AND MARKETING

6a) Do you own livestock? **0) No 1) Yes** **6b) If yes**, fill in table below

a)Type of livestock	b)Mark X on all owned by household	c) Number	d) How did you acquire the first livestock? ***1) bought 2) given by relatives 3)both 1 and 2 4)* group merry go round 5) from NGO**	What is the current price of livestock in the local market? **MK**	If you have sold any livestock in 2008/09 seasons please indicate below	
					Number sold	**Price per unit**
Chickens (Nkuku)						
Pigs (Nkumba)						
Goats (Mbuzi)						
Beef Cattle (N'gombe)						
Dairy cattle						

F) LABOUR AVAILABILITY

7a) How many people in your household (including other relatives) were involved in agricultural production in the last two seasons on a full time basis?

	Number involved in full time cultivation: **2008/09**	Number involved in full time cultivation:**2007/08**	Number involved in part time cultivation: **2008/09**	Number involved in part time cultivation:**2007/08**
Male adults over 18 yrs				
Female adults over 18 yrs				
Teenage boys under 18 yrs				
Teenage girls under 18 yrs				

7b) Did you hire any laborers to work on your farm during the 2008/09 agricultural year? **0) No 1) yes** **7c)** If yes fill in table below?

	Total number hired (for group specify type of group here)	Number of times that they were hired during the season	Activities for which they were hired ***1) Land Preparation 2) Ridge Making 3) Weeding 4)Harvesting 5)decobbing/desheling 6) winnowing***	Form of payment ***1) cash 2) food/crops 3) clothes***	If cash, total cash paid ***MK***	If crops, total value of crops paid ***MK***
Male laborers						
Female laborers						
Groups (church/community/ school groups)						

7d) if community/church/school group what was the purpose of them doing this**? 1) To raise funds 2) Is normal cultural practice in the area 3) Other reason (specify)** ____

G) **INCOME SOURCES**

8a) Apart from farming, do you have any other income generating activity (IGA)? **0) No 1) Yes** **8b) If yes**, fill in the table below

a)Type of Income generating activity	b)Year started?	c)Total amount of money made in the last 12 months **MK**	d) Were do you normally conduct your business or were do you engage for employment? 1) By Home/farm 2) In local market 3) In district market 4)by main tarmac road 5. In nearby town 6. In nearby village 7. in other districts 8. In nearby urban area
1. Full time salaried employment (ntchito)			
2 . On farm seasonal employment (ganyu)			
3. off farm seasonal employment (Kuponda matope, kumang nyumba etc)			
4. Non agricultural commercial enterprise (e.g grocery)			
5. Agro based commercial enterprise (brewing alcohol, selling cooked food items, baking etc)			
6. Piggery			

8c) Do you receive remittances from relatives? **0) No 1) Yes** ____________________

8d) If you said yes to 8c state amount of remittances received in total below.

Cropping season	Estimated total amount (MK)	What percentage was this of the total money you had that year?
2008/09		
2007/08		

8f) Do you have access to credit? **0) No 1) Yes** **If yes please fill table below**

Name of lending institute	Who accessed the credit? **1) Wife 2) Husband**	Type of credit received **1)Cash 2) Inputs**	If cash, amount received (**MK**)	If inputs amount received (use Unit)	How do you receive the credit **1) Individual 2) group**	Rate the repayment conditions **1) Not at all satisfactory 2) satisfactory 3) very satisfactory**	Type of credit institutions **1) local informal 2) Local formal 3). Local individual 4)Formal national organization**
FINCA							
MRFC							
Katapila							
NASFAM							

9 c) Please fill Table below

	In 2008/09 season				In 2007/2008 season?				Five years ago?			
Total number of agricultural related trainings and meetings attended by household												
Total number of agricultural trainings and meetings attended by female member of household?												
Total number of agricultural trainings and meetings attended by male member of household?												
ENUMERATOR: Please tick all **types** of organizations whose trainings household members have attended	CGIAR	NGO	MOA	FO	CGIAR	NGO	MOA	FO	CGIAR	NGO	MOA	FO

G) **ACCESSIBILITY AND AVAILABILITY OF PUBLIC CAPITAL**

11) How long does it take to travel from the household to access the following facilities? Fill in table below with shortest travel time and estimated distance

Public Capital Resource	**Shortest travel time (hours)**	**Distance (km)**	**Public Capital Resource**	**Shortest travel time (hours)**	**Distance (km)**
Primary school			Mobile phone network		
Public Secondary school			An operational animal dip tank		
Heath clinic			Agricultural extension offices		
District hospital			Agricultural extension officer house		
VCT centre			Permanent market		
Borehole			Moving market venue (kabandule)		
Piped water tap			Post office		
Dug well			Public telephone (ground line)		
Public telephone			Public telephone (private phone bureau)		
Tarmac road			Agrodealer		
All year ploughed dirt road			ADMARC		
Public bus depot (stop)			Research Station		

I) ASSETS

12) Please indicate how many of these assets the household owns

Asset	No. of assets	Amount paid per unit (MK)	Perceived current market value MK	Asset	No. of assets	Amount paid per unit MK	Perceived current market value MK
Bicycles				Spades			
Motor cycle				Panga Knives (zikwanje)			
Ox cart (Ngolo)				Hoe (makasu)			
Granaries with food				Mobile phones			
Radios				Television			
Beds				Sofa chairs			
Blankets				Car			
Mattresses				Wheel barrow			
Chairs				Iron sheets roof			
Mats				Window panes on house			

J) HOUSEHOLD CHARACTERISTICS

14) Fill in table below

Questions	Response
1. Age in number of years of household head	
1b) Age in number of years of spouse	
2. Marital status 1=Married; 2=Single (never married); 3=Divorced; 4=Widowed	
2b. Type of Marriage: 1= Monogamy 2= Polygamy (mitala)	
3. Level of education of head of HH? 0=no formal education; 1= Attended and finished primary education (Std1-Std 8); 2. Attended but did not finish primary (dropped out) 3=Attended and finished secondary education (F1-F4) (failed MSCE or did not write exams); 4. Attended but did not complete secondary school (dropped out before exam) 5 = Completed and passed MSCE 6=Certificate 7= diploma 8= Adult Literacy	
3b. Level of education of spouse? ? 0=no formal education; 1= Attended and finished primary education (Std1-Std 8); 2. Attended but did not finish primary (dropped out) 3=Attended and finished secondary education (F1-F4) (failed MSCE or did not write exams); 4. Attended but did not complete secondary school (dropped out before exam) 5 = Completed and passed MSCE 6=Certificate 7= diploma 8= Adult Literacy	
4. How many people are currently leaving with you? Adult (F+M) aged 60+	
Adult females (18-59)	
Adult males (18-59)	
Children (7-17)	
Young children below 6 years	
5. Do you have any other occupation other than farming? 0=No 1=Yes	
6. If yes, which one? 1=School teacher; 2=Village technician (agric); 3 = Money lender 4.Traditional doctor 5.Churhc preacher/pastor 6. Agrodealer 7. Business (grocery) 8. Business (agro base) 9) Business (bicycle hire and carry) 10) More than one of these (put all numbers)	
7. I s the household head, member of any farmer group? 0) No 1) Yes	
8. Are other people in the household members of farmer groups? 0) No 1) Yes	
9.Is the household head a member of more than one farmer group? 0) No 1) Yes	
10. Is the spouse a member of more than one farmer group? 0) No 1) Yes	
11a.Give total number of groups that all household members have membership into	
11b. Does head of household hold any leadership position in the village? 0)No 1) Yes	
11c. If yes to 13a state position 1) Traditional leader 2) Advisor to traditional leader 3)Leader of farmer group 4)church leadership 5)Traditional healer 6) Traditional Birth Attendant	
11d. Does spouse hold leadership position in the village? 0) No. 1) Yes	
11e. If yes to 13c state position 1) Traditional leader 2) Advisor to traditional leader 3)Leader of farmer group 4)church leadership 5)Traditional healer 6)Traditional birth attendant	
12.Do you have a public extension officer in your village/community? 0 = No 1) Yes	
13. Do you have a private extension officer in your village/community? 0 = No 1) Yes	
14. Do you have a village technician in your village/community 0 = No 1= Yes	
15. How often do you come into contact with an extension agent: 0) Never 1)daily 2)Weekly 3) Monthly 4) quarterly 5) annually	

Zikomo Kwambili ***Thank you very much***

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