IMPROVED INPUTS USE, PRODUCTIVITY AND COMMERCIALISATION
IN UGANDA MAIZE PRODUCTION

BY

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A DISSERTATION SUBMITTED TO THE DIRECTORATE OF RESEARCH
AND GRADUATE TRAINING FOR THE AWARD OF THE DEGREE OF
DOCTOR OF PHILOSOPHY (ECONOMICS) OF MAKERERE UNIVERSITY

OCTOBER 2011
Declaration

I, Geoffrey Okoboi, do here declare that this dissertation is my own work and has not been submitted for a Degree Course in any other University.

Signature ........................................ Date ......................................

This dissertation has been submitted with our approval as University Supervisors.

Signed:

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Dr. James Muwanga ........................................ Date

........................................................................................................

Dr. Tom Mwebaze ........................................ Date
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Dedication

To my wife, Violet; daughters, Peace, Patricia and Priscilla; and son, Preston.
Acknowledgements

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Geofrey Okoboi,
Kampala, October 2011.
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### Acronyms and Abbreviations

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<tr>
<td>AAMP</td>
<td>Area-Based Agricultural Modernisation Programme</td>
</tr>
<tr>
<td>CAADP</td>
<td>Comprehensive Africa Agriculture Development Programme</td>
</tr>
<tr>
<td>CIMMYT</td>
<td>International Maize and Wheat Improvement Center</td>
</tr>
<tr>
<td>DANIDA</td>
<td>Danish International Development Agency</td>
</tr>
<tr>
<td>DSIP</td>
<td>Development Strategy and Investment Plan</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agriculture Organisation of the United Nations</td>
</tr>
<tr>
<td>FICA</td>
<td>Farm Inputs Care Centre</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>GoU</td>
<td>Government of Uganda</td>
</tr>
<tr>
<td>ha</td>
<td>Hectares</td>
</tr>
<tr>
<td>IDEA</td>
<td>Investment in Developing Export Agriculture</td>
</tr>
<tr>
<td>IDP</td>
<td>Internally Displaced People</td>
</tr>
<tr>
<td>IFAD</td>
<td>International Fund for Agricultural Development</td>
</tr>
<tr>
<td>IFPRI</td>
<td>International Food Policy Research Institute</td>
</tr>
<tr>
<td>MAAIF</td>
<td>Ministry of Agriculture Animal Industry and Fisheries</td>
</tr>
<tr>
<td>MFPED</td>
<td>Ministry of Finance Planning and Economic Development</td>
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<tr>
<td>ML</td>
<td>Maximum Likelihood</td>
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<tr>
<td>MLM</td>
<td>Multinomial Logit Model</td>
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<tr>
<td>MPM</td>
<td>Multinomial Probit Model</td>
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<tr>
<td>NAADS</td>
<td>National Agricultural Advisory Services</td>
</tr>
<tr>
<td>NARO</td>
<td>National Agricultural Research Organisation</td>
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<tr>
<td>NASECO</td>
<td>Nalweyo Seed Company</td>
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<td>NEPAD</td>
<td>New Partnership for Africa’s Development</td>
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<tr>
<td>NDP</td>
<td>National Development Plan</td>
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<tr>
<td>NTAE</td>
<td>Non-Traditional Agricultural Export</td>
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<tr>
<td>OCI</td>
<td>Output Commercialisation Index</td>
</tr>
<tr>
<td>OECD</td>
<td>Organisation of Economic Cooperation and Development</td>
</tr>
<tr>
<td>OLS</td>
<td>Ordinary Least Squares</td>
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<td>OPV</td>
<td>Open Pollinated Varieties</td>
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<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>PMA</td>
<td>Plan for Modernisation of Agriculture</td>
</tr>
<tr>
<td>PRDP</td>
<td>Peace, Recovery and Development Plan for Northern Uganda</td>
</tr>
<tr>
<td>SFA</td>
<td>Stochastic Frontier Analysis</td>
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<td>SFP</td>
<td>Single Factor Productivity</td>
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<tr>
<td>SPEED</td>
<td>Rural Savings Promotion and Enhancement of Enterprise Development</td>
</tr>
<tr>
<td>t</td>
<td>Tonne</td>
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<tr>
<td>t/ha</td>
<td>Tonne per hectare</td>
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<tr>
<td>TFP</td>
<td>Total Factor Productivity</td>
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<tr>
<td>UBoS</td>
<td>Uganda Bureau of Statistics</td>
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<tr>
<td>Ugx</td>
<td>Uganda Shillings</td>
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<td>UNHS</td>
<td>Uganda National Household Survey</td>
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<tr>
<td>USTA</td>
<td>Uganda Seed Traders Association</td>
</tr>
<tr>
<td>WFP</td>
<td>United Nations World Food Programme</td>
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<tr>
<td>WRS</td>
<td>Warehouse Receipt System</td>
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Improved Inputs Use, Productivity and Commercialisation in Uganda
Maize Production

By

Geofrey, Okoboi., PhD (Economics), Makerere University, 2011.
Supervisors: Dr. James Muwanga, and Dr. Tom Mwebaze.

Abstract

Productivity and commercialisation in Uganda’s agriculture is still low despite the fact that policy makers have initiated and implemented policies including the Plan for Modernisation of Agriculture (PMA) to encourage farmers to use improved inputs in production. This study examined the factors that influence farmers to use improved inputs (improved seed, fertiliser, fungicides/herbicides and traction) in maize production. The relationships between improved inputs use and productivity, and commercialisation in maize production were also examined in the study. Three econometric approaches, namely: multinomial logit model (MLM), stochastic frontiers analysis (SFA) and tobit model were used to examine these relationships; using Uganda National Household Survey (UNHS) 2005/06 data, collected by Uganda National Bureau of Statistics (UBoS).

Results revealed that majority of farmers in Uganda do not use improved inputs in maize production. Improved seed was the only major improved input used in maize production. Geographical location (for example Eastern vis-à-vis Western Uganda) of farmers was found to be the most important attribute associated with use or non-use of improved inputs in maize production. Related to geographical location were factors such as economic status of the farmer: for example the low level of improved inputs use by farmers in Northern Uganda in general and in Internally Displaced Peoples’ (IDP) camps in particular; or tradition: for example the low level of traction (oxen-plough) use in Central and Western Uganda compared to Eastern and Northern Uganda. Results
suggested that the level of fertiliser and traction use had a remarkably positive effect on yield and labour productivity but not gross profit. Marginal labour productivity value from maize production was found to be lower than the community wage rate. Finally, results indicated that the pattern of commercialisation of maize producers was not explained by the level of use of improved inputs. Instead, commercialisation was highly influenced by area cultivated, grain price and yield.

In terms of policy, results underscore the fact that in Uganda, it is not economically viable to use improved inputs in production of low-value crops such as maize, much as these inputs are yield enhancing. Thus, unless there is government intervention in form of subsidies such that use of improved inputs in production is economically viable; farmers are less likely to use these inputs in production of maize as well as other low value food crops. Results also emphasize the fact that output commercialisation of maize producers is not driven by extent of improved inputs use but more importantly by the price incentive among other factors. Therefore, government policies that assure some minimum price for maize grain and other produce appear to be important in enhancing production and commercialisation of food crops in Uganda. Otherwise household production for subsistence will remain predominant in the country, despite fast growing demand for food in urban areas.
CHAPTER 1

INTRODUCTION

1.1 Introduction

Agriculture is an important economic sector in Africa that constitutes the backbone of most African economies, provides 60 percent of all employment; accounts for about 40 percent of the continent's foreign exchange earnings; and in most countries, it is still the largest contributor to Gross Domestic Product (GDP); and the dominant provider of industrial raw materials (NEPAD, 2003). Notwithstanding the importance, agricultural productivity is low and subsistence production is dominant in Africa, partly on account of limited use of improved technologies in production (NEPAD, 2003; World Bank, 2007).

In Uganda, agriculture is the source of livelihood to about 73 percent of the country’s labour force (UBoS, 2006), contributes 48 percent of formal exports and 23 percent of the gross domestic product (GDP) (MFPED, 2010). Besides, agriculture is the major source of raw materials for industry, and food for the nation. As such, the five-year National Development Plan (NDP) identifies agriculture as the primary growth sector to transform the economy from a peasant to a modern prosperous society (GoU, 2010).

Despite the critical role, the future of Uganda’s agriculture remains uncertain. Agricultural growth rate is low and unstable, yet population growth is higher and appears to be on the rise (See Appendix 1). Growth of the agricultural sector is much
lower than the 5.6 percent annual growth envisaged in the NDP and the 6 percent annual
growth target of the African Union under the Comprehensive Africa Agriculture
Development Program (CAADP) (African Union, 2003). Low growth in agriculture is
blamed on declining productivity and commercialisation, as yield of most crops is
several times lower than potential and subsistence production that is estimated at about
70 percent of smallholder agriculture is on the rise (MAAIF, 2010).

Limited participation of farmers in the market due to subsistence production implies low
income, low saving and investment in productive assets, which is likely to perpetuate the
vicious cycle of low improved inputs use, low productivity and low commercialisation.
Furthermore, limited investment in agricultural production leads to environmental
degradation (Pender et al., 2004). All these in turn limit national employment growth,
food security, and economic growth, which further aggravate rural poverty.

Thus, enhancing agricultural productivity cannot be emphasized in a country with a
population growth rate of 3.2 percent per annum. Increased performance of agricultural
sector in Uganda has significant implications on income poverty reduction, particularly
among crop farmers where poverty is more concentrated (Senoga and Matovu, 2010).

To reverse the poor performance of agriculture, various institutional and policy reforms
have been pursued over the past decade. Key among the reforms was the restructuring
of MAAIF and the establishment of the Plan for Modernisation of Agriculture (PMA) in
2000, closely followed by the establishment of the National Agricultural Advisory
Services (NAADS) in 2001, (MAAIF and MFPED, 2000; GoU, 2001). The PMA was
designed as multi-sectoral policy framework whose main objective was to increase the
incomes of poor subsistence farmers through increased productivity and share of marketed output. On the other hand, NAADS was established with the mandate of increasing farmers’ access to information, knowledge and improved agricultural technologies through the overhaul of the extension services delivery system from supply-driven to a demand-driven service (MAAIF and MFPED, 2000). Other areas of NAADS intervention to support farmer productivity and participation in the market included support to formation of farmer groups and savings and credit cooperatives (NAADS, 2005).

Despite the establishment of PMA, NAADS and increased government funding to agricultural sector\(^1\), agricultural productivity remains constant or declined in some sub-sectors (MAAIF, 2010). The NDP and MAAIF 5-year (2010/11 -2014/15) Development Strategy and Investment Plan (DSIP) highlight a number of binding constraints to increased agricultural production and productivity in Uganda. They include among others: limited access to and use of improved inputs such as high yielding seeds and fertiliser, and limited access to markets partly due to the subsistence-oriented nature of smallholder production.

Designing appropriate intervention programs to address the continuing challenges of limited use of improved inputs, low productivity and market participation of producers requires adequate understanding the physical and economic outcomes associated with improved inputs use. Previous studies that have examined issues of agricultural productivity in Uganda have focussed more on output or revenue (Appleton and

\(^1\) According to data from various reports of Background to the Budget, MAAIF budget in 1998/99 was UGX 9.86 billion while in 2008/09 it was UGX 222.5 billion.
Balihuta, 1996; Deininger and Okidi, 2001) and not productivity (output per unit input(s)). Furthermore, these studies have paid less attention on the relationship between improved inputs use and the profit of those using the inputs. This is despite the fact that some studies inform that farmer use of improved agricultural technologies is more closely linked to economic than physical productivity (Kelly, 2006; FAO, 2006). Also, there are few studies, for example Larson and Deininger (2001), that have focussed on the relationship between improved inputs use and commercialisation of crop farmers in Uganda. Yet, government philosophy through NAADS of encouraging farmers to use improved technologies was that use of these inputs would spur commercialisation.

With the recent completion of the five-year DSIP (2010/11- 2014/15), efforts to turn-around Uganda’s agriculture continue. In the revised DSIP, MAAIF planning to strategically focus on five food-crops, namely: maize, bananas, rice, cassava and millet as the priority crops for agricultural growth (MAAIF, 2010). One of the DSIP strategies to increase agricultural productivity is to encourage farmers through the NAADS programme to use improved inputs. But owing to the fact that interventions such as PMA and NAADS have not been very effective (DANIDA, 2005; Benin et al. 2007), it would therefore be highly beneficial to policy makers, development partners as well as farmers if empirical evidence is made available on the physical and economic benefits of improved inputs use. This study attempts to provide this evidence by focussing on maize, which is one of the strategic crops in the current DSIP.

By definition, improved inputs in agricultural production are factors of production generally recognised to augment productivity than traditional inputs (MacRobert et al.,
Improved inputs can be categorised as non-labour factors of production including improved seeds (hybrid seed and open pollinated varieties -OPVs), fertiliser, traction (tractor and/or animal traction), pesticides, fungicides, herbicides and manure (UBoS, 2007). Hybrid seeds for example, are improved seed varieties and produce higher yields compared to landraces (MacRobert et al., 2007). Use of a tractor or animal power for ploughing land is labour saving and boosts labour productivity than using a hand-hoe (Curtis and Gadbois, 1996).

Agricultural productivity is defined and measured in a number of ways including land productivity or yield, which is output per unit of area cultivated; labour productivity which is output per unit of labour employed; and gross profit, which is the difference between total revenue and total costs of production (OECD, 2001; Wiebe et al., 2001). Agricultural commercialisation on the other hand is defined as the degree of participation of agricultural producers in the market; either by selling or buying agricultural output, inputs and/or services in a given period (von Braun et al., 1994; Sokoni, 2008).

In this study, the definition and measure of improved inputs as provided by UBoS (2007) was generally adopted. That is, improved inputs included improved seeds (hybrids and open pollinated varieties (OPVs)), fertiliser, traction power (tractor and/or animal), pesticides, fungicides and herbicides except manure. Manure was not included because of the ambiguity of whether or not manure is an improved input. This is because most of the materials including animal dung, chicken droppings and plant residues that are categorised as manure in Uganda are generally applied to plants with little or no
improvement in their original state. Some farmers may make composite manure, which is an improvement from original state such as cow dung, but since no differentiation is made among manure types in Uganda National Household Survey (UNHS) 2005/06 data that is used in this study, the input (manure) was considered among other inputs and not categorised as improved inputs. As for extent of use of improved inputs, the level of expenditure on these inputs, as applied by UBoS (2007) was adopted. Maize productivity was measured by crop yield, labour productivity and gross profit while commercialisation was measured by the proportion of maize output sold.

1.2 Overview of Uganda’s Maize Sub-sector

The study focussed on maize because it is an important crop in Uganda. Maize is the most highly cultivated crop with about 86 per cent of Uganda’s agricultural households (UBoS, 2007). Maize is the number-one staple food for the urban poor, in institutions such as schools, hospitals and the military. Also, the crop is the number-one source of income for most farmers in Eastern, Northern and North-Western Uganda (Ferris et al., 2006).

Other than food, maize has a wide range of other uses, including processing of livestock and poultry feeds and making of local brew. Because of the multiplicity of uses, maize is one of the highly traded food crops in Uganda. Maize grain is the most traded food crop under the Uganda Warehouse Receipt System (WRS), since the inception of WRS services in 2006 (Rural Savings Promotion and Enhancement of Enterprise Development
–SPEED, 2006) Moreover, maize is the major export food crop in Uganda, from which the country earns about US $30 million in revenue (MFPED, 2010).

There are many other industrial formulations that can be developed from maize, although this component of the value-chain is not yet fully exploited in Uganda. For example, maize is used in the manufacture of cooking oil, ethanol or bio-fuel (which is an additive in gasoline), and starch and syrup, which are used in the manufacture of medicines. But, none of these maize-based products are processed in Uganda at present.

Maize cultivation in Uganda is generally on smallholder farms with plot sizes averaging 0.28 hectares (ha) in 1999/2000 (UBoS, 2007). Area under cultivation and output have more than doubled over the past two decades but yield has declined from the peak of 1.8 tonnes per hectare (t/ha) in 2004 to about 1.5 t/ha in 2007 (Appendix 2). At Uganda’s national research station, hybrid maize seed yields as much as 8 t/ha while OPVs yield at least 5 t/ha(3). The variance in the yield at the research station compared to farm yield suggests that there are still opportunities to increase maize yield in Uganda through increased use of improved inputs such as improved seed.

The National Agricultural Research Organization (NARO) is the institution mandated with production and release of new crop varieties in Uganda. NARO has produced about 10 varieties of maize seed (Sserunkuma, 2007). Five of the varieties are OPVs and the other five are hybrid varieties. OPVs of maize seed currently on the market include (i) Longe 1, (ii) Longe 4, and (iii) Longe 5 (Nalongo or high quality protein 2 Though other crops including paddy rice, coffee and cotton, are also traded under the Uganda WRS, maize remains the dominant and most successfully traded commodity (SPEED, 2006).

(3)Technologies released at NAARI- http://www.naro.go.ug/technologies/naaritechn.htm
maize), (iv) Longe 6 (Salongo) while the hybrid varieties include (i) Longe 2H, (ii) Longe 6H, (iii) Longe 7H (iv) Longe 8H and (v) Kawanda Composite (Sserunkuma, 2007). Besides Ugandan maize varieties, there are imported varieties of maize seed on the market including DK 8057 imported by Farm Inputs Care Centre Ltd (FICA) from Zimbabwe and Kenya hybrid imported by East African Seeds from Kenya (Sserunkuma, 2007).

Before liberalization of the seed industry in 1999, Uganda Seed Project was the sole company processing maize seed in Uganda (Independent Consulting Group, 2003). Uganda Seed Project also had the responsibility for marketing and distribution of seed to farmers. At present, however, there are about six companies processing maize seed besides Uganda Seed Project, now called Uganda Seeds Ltd. These include (i) Farm Inputs Care Centre (FICA), which also represents Monsanto—a multinational seed company based in USA, (ii) East African Seeds, (iii) Harvest Farm Seeds, (iv) Victoria Seeds, (v) Nalweyo Seed Company Ltd (NASECO), and (vi) Elgon Seed Company. While Uganda’s maize seed industry appears to be organized and vibrant, information regarding the quantity of seed produced and sold by the various producers is not easy to access even at the offices of Uganda Seed Traders Association (USTA), a body that brings together seed processors and traders in country.

Following the liberalization of agricultural produce marketing in 1993, maize marketing in Uganda is in private hands (Independent Consulting Group, 2003). Both the buyers (traders) and sellers (farmers) largely participate in the market individually. As such,

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4 Information obtained through personal interview with Dr. Ruth Ssebuliba, Executive Secretary of Uganda Seed Traders Association.
maize grain price is volatile, determined by market forces such that the price is usually lowest just after harvest and highest just before harvest season (Independent Consulting Group, 2003).

With the establishment of NAADS programme, government encouraged farmers to sell their crops collectively in groups as one of the ways to improve farmers’ income as well as minimise price volatility (NAADS, 2005). Little is known however, on the effect of NAADS interventions in improving farmer participation in the market as well as profit.

Other government interventions in supporting farmer marketing include the establishment of Warehouse Receipt System (WRS) in 2006 as an alternative avenue for farmers to store and sell maize at a later date when prices are expected to be higher (SPEED, 2006). Under the WRS initiative, farmers are able to get credit from collaborating financial institutions such as Centenary Rural Development Bank while using their stored crop as collateral. Non-government agencies such as the World Food Programme (WFP) are also supporting government efforts of developing storage infrastructure by establishing warehouses of various storage capacities in rural areas such as in Parabong, Patongo, Omot, Awere and Pajule in Pader district as well as in urban centres including Gulu town and Kasese town (WFP, 2010).

In late 1980s, government identified maize among the five non-traditional agricultural export (NTAE) food crops the country was to promote (Independent Consulting Group, 2005). To date, maize is the major NTAE crop in the country, although low productivity and price volatility at farm-level remain a challenge (MFPED, 2010). In the DSIP 2010/11 – 2014/15, government is planning to invest greater resources in the maize sub-
sector including encouraging farmers to use improved inputs by giving them starter packs of improved seed and fertiliser and setting up more warehouses through the NAADS programme (MAAIF, 2010). It is hoped that this new investment initiative will increase farmer productivity and commercialisation.

1.3 Statement of the Problem

Agriculture is the primary growth sector in Uganda’s transformation from peasant to a modern prosperous society (GoU, 2010). For successful transformation of the national economy however, it is essential for agriculture to post high and sustained growth of at least 5.6 percent per annum (GoU, 2010). Unfortunately, this is not the case, as growth in the sector is low, averaging one percent per annum, between 2002 and 2008. Weak growth in agriculture is generally attributed to low productivity and commercialisation in the sector as a result of limited use of improved inputs (MAAIF, 2010).

To enhance productivity and commercialisation in agriculture, government through programmes such as NAADS is promoting use of improved inputs, particularly in the five prioritised crops including maize (MAAIF, 2010). Encouraging farmers to use improved inputs per se, however may not lead to higher adoption unless the economic productivity besides physical productivity of improved inputs use is realised (Kelly, 2006). Thus, it is imperative that evidence regarding the relationship between improved inputs use, productivity and commercialisation in maize production is provided, given the strategic nature of the crop in the country’s development in general and agricultural sector growth in particular.
1.4 Objectives of the Study

The main objective of the study was to examine the effect of improved inputs (improved seed, fertiliser, fungicides, herbicides and traction) use on maize productivity and commercialisation in Uganda. The specific objectives of the study were:

i. To examine the factors that influence use improved inputs in maize production;

ii. To determine the effect of improved inputs use (measured by expenditure) on yield, labour productivity and gross profit in maize production; and

iii. To investigate the relationship between improved inputs use (expenditure) and output commercialisation in Uganda maize production.

1.5 Research Hypotheses

The following hypotheses were tested in view of objectives stated above

i. Use of improved inputs in maize production is positively influenced by socio-economic factors such as education level and access to extension services and negatively by distance to market;

ii. A unit increase in expenditure on improved inputs in maize production has a positive effect on yield, labour productivity and gross profit; and

iii. There is a positive relationship between expenditure on improved inputs in maize production and output commercialisation.
1.6 Significance of the Study

Countries that have witnessed momentous growth in agricultural productivity to a great extent used improved agricultural inputs. The green revolution observed in Asia, for example, is a result of increased use of high yielding seeds, fertilisers and irrigation water in production (World Bank, 2007). The success story of Malawi turning around from a net importer of maize grain less than five years ago to net exporter now, is attributed to increased use of improved seed and fertilisers by smallholder farmers following the implementation of an input subsidy program (Dorward et al., 2008). Thus, in developing countries such as Uganda where national development is anchored on agriculture, the role of improved inputs in boosting agricultural productivity, household income and consequently national development cannot be overemphasized. For that reason, understanding the factors that influence farmers’ decisions to use improved inputs on the one hand and the effect of these inputs on productivity and commercialisation on the other hand, offers valuable information to promote effective use of improved inputs in agricultural production in the country.

For producers to sustainably use improved inputs, the physical and/or economic outcome from using such inputs should at least be better than when these inputs are not used in production (Kelly, 2006). Thus, understanding the physical and economic returns from use of improved inputs is crucial evidence for farmers as well as other people, particularly policymakers and extension agents who are engaged in promotion of increased use of improved inputs and other production practices.
Farmers engage in agricultural production for diverse reasons including production to satisfy home needs and/or for sale. Sale of food especially by subsistence producers is said to arise mainly from surplus production (von Braun et al., 1994). Thus, it is important to examine whether or not improved inputs use can trigger increased maize output commercialisation as a means of increasing household income due to increased productivity.

Therefore, it was hoped that the study will provide some evidence to policymakers, farmers, and extension agents, on possible ways to increase the use of improved inputs, productivity and commercialisation of maize production as well as other crops in Uganda. Besides, the study is expected to contribute to the existing literature on maize production as well as provide pointers to areas of further research.

1.7 Scope of the Study

The study was based on the Uganda National Household Survey (UNHS) 2005/06 data, collected for the period July –December 2004 (called Second Season) and January – June 2005 (called First Season). As such, the reference period was July 2004 to June 2005 and the study was national in context, covering 51 out of 53 districts of Uganda as of 2005 (UBoS, 2006). The study focused on maize producers in Uganda and was concerned with three issues: improved inputs use, productivity and commercialisation. Improved inputs use was defined to include improved seeds, fertiliser, fungicides/herbicides, and traction (tractor and animal traction). Due to ambiguity of whether or not manure is an improved input, it was not included in the definition of improved inputs in this study, although it is considered as such in UNHS 2005/06.
(UBoS, 2007). Use of improved inputs was measured in two ways. The first measure was categorical: yes for use and no for non-use. The second measure was by amount spent by the farmer on purchase of improved seed, fertiliser, fungicides/ herbicides, and traction. Crop yield, labour productivity and gross profit were used to measure productivity while the proportion of maize output sold or output commercialisation index (OCI) was the measure for commercialisation.

1.9 Organisation of the Dissertation

Chapter 1 of the study was the introduction. The remainder of the dissertation is organised into seven chapters. A review of the theoretical and empirical literature on improved inputs, productivity and commercialisation in agriculture is presented in Chapter 2, which is followed with presentation and explanation of theoretical and conceptual framework of the study in Chapter 3. Chapter 4 describes the methods and procedures of the study while the results are presented and discussed in Chapters 5, 6, and 7. Chapter 8 presents the summary, main conclusions and recommendations drawn from the analysis.
CHAPTER 2

REVIEW OF LITERATURE

2.1 Introduction

This chapter presents the theoretical and empirical literature about improved inputs use, productivity and commercialisation in agriculture. The theoretical literature deals with concepts and methods that have been advanced to explain the factors that may influence improved inputs use, productivity and commercialisation in agriculture. Specific attention is given to the farm-household theory as an entry point in the explanation of the joint production and consumption decisions of farm households. The empirical literature provides evidence from past studies related to the subject, including studies specifically carried out in Uganda. The purpose of this chapter was to support the identification and selection models best suited for analysis of the farmers’ decision to use improved inputs in maize production and the subsequent outcomes on productivity and output commercialisation. Furthermore, literature also helped to identify gaps in past studies as far as the present study is concerned.

2.2 The Theory of the Farm Household

The theory that is often used to explain the economic behaviour of agricultural households in terms of resource acquisition and allocation, production and consumption decisions is the theory of the farm-household (Ellis, 1992). According to Barnum and Squire (1997), the farm-household theory dates back to 1925 with the literally works of...
Chayanov (1966 cited in Barnum and Squire, 1979) but the empirical application of the model was pioneered in late 1970s by Lau et al. (1978) and followed Barnum and Squire (1979). Several authors including Becker (1965) and Lancaster (1966) cited in Ellis (1992); Sen (1966) and Nakajima (1969), cited in Barnum and Squire (1979) are credited for refining the original theory of the farm-household by Chayanov.

In the farm-household model, agricultural households are assumed to maximize utility subject to the production function and time and income constraints (Barnum and Squire, 1979). In application of the farm-household model, Barnum and Squire (1979) assumed that: (i) land available to the household is fixed, at least for a given production cycle; (ii) there exists a market for labour such that farm households are able to hire in and hire out labour at a given market wage; (iii) households have to choose from own consumption of output and sale of output in order to purchase non-farm consumption goods; and (iv) food surplus farm households who hire in more labour than hire out.

Without altering the model structure, Low (1986 cited in Ellis, 1992) revised the assumptions of Barnum and Squire (1979) to incorporate realities of peasant agriculture in Sub-Saharan Africa (SSA). The revisions in the assumptions that Low (1986) suggested are: (i) flexible access to land by farm households based on their family size and given the nature of the land tenure systems in SSA; (ii) differential wage rates and wage income to household members, which contrasts with single market wage in Barnum and Square (1979); (iii) different prices at which farm households sell and buy commodities such as food; and (iv) widespread occurrence of food deficit farm households who hire out family labour. In essence, farm household models of Barnum
and Squire (1979) and Low (1986) are similar, but only differ in assumptions and emphasis.

The structure of the farm household model allows the separation of a household into a producer and a consumer (Ellis, 1992). As a producer the household converts purchased goods and services, as well as domestic resources into a set of final goods yielding utility and as a consumer, he/she maximises utility from domestic and market supply. Other than production and consumption, the household also supplies resources for domestic and external production (Ellis, 1992).

A number of studies have applied the farm-household model to examine the joint decisions and outcomes regarding household production and consumption. Singh et al. (1986) conducted a comprehensive survey of studies from 1978 to 1986 that applied the farm-household model. A summary of some of the studies is given in Table 3.1.

Other uses of farm household models include applications to topics such as technology policy (Taffesse, 1998); non-farm income and food security (Abdulai and Delgado, 1999); off-farm labour supply (Huffman, 2001). Application of farm-household models has extended beyond agricultural production and consumption to model other socio-economic aspects of household decision making such as on engagement in financial markets (Sial and Carter, 1996); migration (Rozelle et al., 1999) and nutrition (Sahn et al., 1994).
Table 3.1. Some of the Studies that have utilised the Farm-Household Model Framework

<table>
<thead>
<tr>
<th>Study</th>
<th>Economy</th>
<th>Type of data</th>
<th>Type of analysis</th>
<th>Policy problems addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lau et al. (1978)</td>
<td>Taiwan</td>
<td>Average by farm size and region for each of two years</td>
<td>LLES and Cobb-Douglas profit function estimated for three commodities</td>
<td>Consumption of agricultural commodity, marketed surplus, and labour supply</td>
</tr>
<tr>
<td>Barnum and Squire (1979)</td>
<td>Malaysia</td>
<td>Cross-section household level</td>
<td>LES and LLES estimates for three commodities along with Cobb-Douglas profit function</td>
<td>Rice consumption, labour supply, and marketed surplus</td>
</tr>
<tr>
<td>Kuroda and Yotopoulos (1980)</td>
<td>Japan</td>
<td>Cross-section averaged by farm size and region</td>
<td>LLES and Cobb-Douglas profit function for four commodities. Leisure disaggregated by farm workers and off-farm workers</td>
<td>Consumption of agricultural commodity, marketed surplus, and labour supply</td>
</tr>
<tr>
<td>Rosenweig (1980)</td>
<td>India</td>
<td>Cross-section household level for all India</td>
<td>Reduced-form estimates of male and female off-farm labour supply</td>
<td>Off-farm labour supply by sex</td>
</tr>
<tr>
<td>Ahn et al. (1981)</td>
<td>Korea</td>
<td>Cross-section household level</td>
<td>Multiple (six) commodities analysed, linear programming used for production side and LES estimated for demand side</td>
<td>Effects of technological change on consumption of agricultural commodity</td>
</tr>
<tr>
<td>Adilavidhaya et al. (1984)</td>
<td>Thailand</td>
<td>Separate household cross-section data for input and output demand system</td>
<td>LLES and Cobb-Douglas profit function for three commodities.</td>
<td>Consumption of agricultural commodity, marketed surplus, and labour supply</td>
</tr>
<tr>
<td>Strauss (1986a)</td>
<td>Sierra Leone</td>
<td>Cross-section household level</td>
<td>Multiple commodities analysed, QES estimated on demand side with Cobb-Douglas output supply equation</td>
<td>Price and income responsiveness of calorific availability</td>
</tr>
<tr>
<td>Singh and Janakiram (1986)</td>
<td>Northern Nigeria</td>
<td>Cross-section household level</td>
<td>Multiple commodities analysed (intercropping), linear programming used for production side and LES for demand equations</td>
<td>Production choice among alternative crops. Substitutability of certain crops in consumption</td>
</tr>
</tbody>
</table>

Note: Abbreviations LLES, Linear Logarithmic Expenditure System; LES, Linear Expenditure System; QES, Quadratic Expenditure System. All models are separable.

Source: Singh et al. (1986).
Although in the theory of farm-household, production and consumption decisions are assumed simultaneous, the partial equilibrium approach which is commonly used in the analysis treats the decisions as separable, and as such, studies that use partial equilibrium approach indirectly apply the farm household modelling methodology (Lopez, 1986).

2.2 Determinants of Improved Inputs Use in Agriculture

Improved inputs are factors of production which have undergone some form of amendment from their original state with the intent of enhancing their performance. According to Knight et al. (1972), improved agricultural inputs may be divided into four principal types including biological, chemical, mechanical and management. Knight et al. (1972) categorise biologically improved inputs to include new crop varieties such as high yielding varieties, disease resistant varieties and drought resistant varieties. Chemically improved inputs include chemical fertiliser, pesticides, fungicides, insecticides and herbicides while mechanical inputs include farm machinery and equipment used in tilling, weeding, irrigation, spraying and transportation. Knight et al. (1972) define management as knowledge acquired concerning decision-making and management of farming activities without directly involving the use of new materials, and, argue that it should be classified as an improved production input, yet they caution that it may be difficult to measure and attribute as it is accumulated over time.

Although use of improved inputs in production is desirable, not all farmers use these inputs due to various reasons. Langyintuo and Mekuria (2005) broadly categorise the factors that influence farmer use of improved inputs as: farmer characteristics, institutional factors and characteristics of the input. Farmer characteristics among others
include gender, age, education, and household size while institutional factors include farm size, membership to association, access to information, access to credit, and access to infrastructure such as roads or storage. Characteristics of the production input relate to the subjective attributes of the input as perceived by the farmer (Adesina and Zinnah, 1993).

2.2.1 Farmer Characteristics

Gender plays an important role in farmer use of agricultural technologies such as improved seeds or animal traction, in production. Appleton and Scott (1994) observe that the socio-economic conditions such as land access restrictions and poverty, in which women live affect their pattern of production and their use of technology in agriculture. Furthermore, women’s perception and use of agricultural technology is shaped by their evaluation of the level of risk, such that if the risk is perceived to be high then use of agricultural technology will be low (Appleton and Scott, 1994). Langyintuo and Mekuria (2005) urge for inclusion of gender in analysis of adoption studies by observing that extension services provision which is important in use of improved inputs is mainly conducted by men who are biased towards fellow men yet women are dominant in African agriculture. Inclusion of a gender variable in this case is important given that in Uganda women-headed households are relatively poor compared to male-headed households (UBoS 2010), yet 72 percent of all employed women and 90 percent of all rural women work in agriculture (IFAD, 2000).

Studies that have examined the relationship between age and use of improved inputs in production have reported mixed results. Adesina and Baido-Forson (1995) report a
positive relationship between age and adoption of new sorghum and rice varieties in Burkina Faso and Guinea respectively while Kassie et al. (2010) report a negative relationship between age and use of compost manure and stubble tillage technologies in Ethiopia. In Nigeria, Akramov (2009), Lawal and Oluyole (2008), and Tabi et al. (2010) also report a negative relationship between age and improved inputs use. Explanations offered for the mixed results regarding age and improved inputs use are that on the one hand, young farmers may have lower income and wealth, limited access to credit and extension services, and face labour constraints, all of which may make them less prepared to adopt and use improved agricultural technologies than older farmers, hence age having a positive relationship with adoption (Langyintuo and Mekuria, 2005). On the other hand, young farmers are sometimes thought to be more open to change and hence eager to try out new ways of doing things, thus a negative relationship between age and improved inputs use (Langyintuo and Mekuria, 2005).

The role of education in farmer use of improved inputs is widely discussed in literature. Educated farmers are believed to have higher ability to perceive, interpret and respond to new information about improved technologies than their peers with little or no education (Langyintuo and Mekuria, 2005; Tabi et al., 2010). More educated farmers are thus more likely to access information and advice from extension workers, which influence their adoption and use of improved inputs. Moreover, education and the economic status of the farmer, which affects ability to buy and use of production inputs, are to a great extent positively correlated especially in developing countries including Uganda (UBoS, 2010).
Studies such as Akinola (1987), and Igodan et al. (1988), examining the effect of household size on the intensity of farmers’ use of improved inputs report a negative relationship while other studies, for example Perz (2003) and Tabi et al. (2010) report a positive relationship. The explanation offered for the negative relationship is that farmers with large households especially in rural areas are very poor and the limited financial resources are mostly spent on basic needs, leaving little or nothing for purchase of farm inputs. On the other hand, a large household may encourage adoption of improved inputs such as fertiliser and pesticides whose application is labour-intensive Perz (2003).

2.2.2 Institutional Factors

The effect of institutional factors such as farm size, access to credit, access to information, access to infrastructure and membership to association on farmers’ use of improved inputs has received great attention in the literature. Langyintuo and Mekuria (2005) observe that for lumpy inputs such as tractor or animal traction to plough land, farmers with large farms are more likely to use as compared to farmers with small farms. For example, Mwinjilo (1994) found that fewer farmers in Malawi used a tractor for ploughing as it required a minimum of 3 ha in order to realize a good profit margin, yet most farmers cultivated less than 3 ha. For other inputs such as fertiliser, however, some studies for example Zhou et al. (2010) found an inverse relationship between use and farm size. This suggests that the relationship between farm size and improved inputs use may not be straight forward.
The role of credit in financing farmer investments in improved technologies such as high yielding seeds, fertiliser and machinery particularly in developing countries where smallholder farmers are generally financially constrained cannot be overstated. Constraints to credit access have been identified as some of the barriers to adoption and use of improved agricultural inputs in developing countries (Feder et al., 1985). A survey of literature by Feder et al. (1985) found that most studies report a positive relationship between farmers’ access to credit and use of improved technologies. In developing countries including Uganda, access to credit however remains a challenge (UBoS, 2010).

Extension agents are some of the most important sources of agricultural information in any country. Farmer access to information on agricultural technologies through increased government investment in extension services is crucial in revealing the opportunities of using such technologies, thereby reducing the subjective uncertainty on one hand and fostering increased adoption on the other (Strauss et al., 1991; Langyintuo and Mekuria, 2005). Studies in this area including Feder and Slade (1984); Igodan et al. (1988); Strauss et al. (1991); and Akromov (2010) report a positive relationship between extension services access and use of improved technologies.

Infrastructures such as roads, storage and irrigation are critical in agricultural production process. Roads are important in access to input and output markets while storage is important for storage to maintain the quality of crops to postpone immediate sale to a future date. A number of studies including Jansen et al. (1990), and Ransom et al. (2003) show that availability and access to these infrastructures increases the likelihood
of use of improved technologies. In Bangladeshi, Ahmed and Hossain (1990) found that improved rural infrastructure tremendously increased the intensity of use of modern agricultural technologies such as irrigation, high yielding varieties and fertilizer, in villages with developed infrastructure than in underdeveloped villages.

2.2.3 Factor Input Characteristics

The characteristics of factor inputs on their own have an influence on farmers’ perception and ultimately the decision to utilize these inputs in production. Four related explanations have been put forward including: safety-risk attributes, consumptive traits, farmer experimentation; and farmer resource endowment and/or access (Smale et al. (1995). Smale et al. (1995), found that farmers in Malawi, favoured cultivation of local maize varieties to hybrids due to their better food processing and on-farm storage characteristics compared to most hybrid maize varieties. The yield risk associated with use of some seeds, for example, their tolerance to agro-climatic conditions, pest and diseases, has been shown to have a strong influence on the farmers’ choice of seed varieties (Zeller et al., 1998). Furthermore, the income risk associated with market preferences for certain attributes can also influence input use. Adesina and Baidu-Forson (1995) and Adesina and Zinnah (1993) found that in addition to yield, farmer’s subjective perceptions of the grain milling and cooking attributes of new rice varieties played a significant effect on their level of adoption.
2.2.4 Analysis of Improved Inputs Use Determinants

Studies examining the determinants of improved inputs use in production usually employ the ordinary least squares (OLS), logit, probit or tobit regression techniques. The technique of estimation largely depends on the type of data (categorical or continuous) for the dependent variable. When the data for the dependent variable is continuous, OLS regression is preferred while logit, probit or tobit regression are widely applied when the data are categorical (Gujarati, 2003). Furthermore, when data for the dependent variable are jointly considered in the utilisation decisions of the consumers, the multinominal probit or multinominal logit models are mostly used (Wu and Babcock, 1998; Bekele and Drake, 2003).

Kamara (2004) used the least squares regression to analyse the determinants of farmers’ use of chemical fertiliser, pesticide and high yielding seeds in maize production in Kenya’s Machakos district. Kamara found a positive and significant relationship between farmer use of high yielding seeds and market access as well as access to credit.

Using a probit model, Nkamleu and Adesina (2000) examined the effect of socio-economic factors on the likelihood of farmer use of chemical fertiliser and pesticide in peri-urban lowland agricultural systems in Cameroon. Farmers who were more educated or had access to extension services were found to have higher chances of using fertiliser and pesticides. Nzomoi et al. (2007) utilised a logit model to investigate the determinants of technology adoption in the production of horticultural export crops in Kenya. Regression results showed that farmers with higher levels of education, access
to credit and membership to farmer groups, were more likely to adopt post-harvest handling technologies in production of horticultural export crops.

Strasberg et al. (1999) used the tobit model, to analyse factors that influence smallholder food producers in Kenya to fertiliser use. Results of the study revealed that education and wealth had a positive and significant effect on the intensity of fertiliser use. Factors that were found to have a negative correlation with the quantity of fertiliser use were the price of fertiliser, distance to road and farmer engagement in production of high-value crop such as French-beans and coffee.

Using the multinomial logit model, Kassie et al (2010) examined the factors affecting adoption of organic farming techniques in a semi-arid region in Ethiopia. Results of their study underscored the importance of household characteristics such as age, gender, membership in farmer group, farm size and livestock value on adoption decisions. Plot-level characteristics such as tenure and topography were also found to have a significant effect on adoption of organic farming techniques.

### 2.2.5 Studies on Improved Inputs Use in Uganda

In Uganda, national level studies on improved inputs use are few. Deininger and Okidi (2001) is the only previous study that used the Uganda national household survey data of 1992/93 and 1993/94 to estimate household demand functions for fertiliser, seed and hired labour. The fertiliser equation was estimated using the probit model, seed equation using OLS technique, and hired labour function using the tobit model. Deininger and Okidi (2001) reported a positive but not significant relationship between the farmers’
level of education and expenditure on seed, negative and not significant relationship between education level and expenditure on fertilisers. Farmer expenditure on seed was also found to be positive but not significant in relation to access to extension services. It was only the level of expenditure on fertiliser that was found to be positive and significant in relation to extension services access. The value of assets owned by farmer, quantity of land owned and household size are the other factors that were found to be positive and significantly associated with expenditure on fertiliser. Working capital constraints and road distance to infrastructure were negatively correlated with expenditure on fertiliser.

In 2000/01, Sserunkuma (2005) conducted a survey in 32 districts of Uganda to examine the level of adoption and impact of improved maize and land management technologies in the country. The logit model was used to estimate the adoption model. Results of his study indicated a positive relationship between farmer use of fertiliser and their level of education, access to extension services. Use of fertiliser and improved maize seed was found to be negatively related with distance to market. In a related study based on three districts of Iganga, Kapchorwa and Masindi, Sserunkuma (2007) analysed the determinants of farmer use of chemical fertiliser and improved seeds in maize production using the probit model. A positive correlation between improved seed use and chemical fertiliser use was found. Wealthier and/or more educated farmers were observed to use higher quantities of chemical fertiliser and improved seeds.
2.3 Agricultural Productivity

2.3.1 Definition and Measurement

Productivity is generally defined as a ratio of a volume measure of output to a volume measure of input use (OECD, 2001). The measure of output and input is usually in a standard unit such as money value. In the case of agricultural productivity, it is the quantity (value) of agricultural output per unit quantity (value) of input(s) used in production (OECD, 2001).

Measures of agricultural productivity can be classified broadly, either as single factor productivity (SFP) or total factor (multifactor) productivity (TFP) measures (Wiebe et al., 2001; OECD, 2001). According to Wiebe et al. (2001), SFP relates a measure of output to a single measure of input while TFP relates a measure of output(s) to a bundle of inputs. Within these two broad categories (SFP and TFP), there are many different measures; for example, at farm level, SFP measures may include yield, labour productivity and capital productivity while TFP measures may include an index of a ratio of the value of output(s) to the value of a combination of two or more factors such as land and labour or labour and capital, or the value of all factors of production utilised in the production process (Wiebe et al., 2001).

Yield, which is commonly expressed in tonnes per hectare (t/ha) is the most frequent measure of agricultural productivity and is defined as amount of agricultural output per unit of land used in production (Wiebe et al., 2001). Labour productivity on the other hand is the amount of agricultural output per unit of labour employed in production.
Gross profit is another measure of agricultural productivity that is important although not much used in the literature due to some difficulties of access of data on price, value or costs of inputs and/or output (Kelly and Murekezi, 2000).

### 2.3.2 Agricultural Productivity Determinants

Factors that influence productivity of a particular producer may be classified into three, as: the quantity and quality of physical inputs used including land, labour and capital; farm and farmer characteristics and external factors such as government policy and agro-climatic conditions (Wiebe et al., 2001). Capital inputs among others include seed, fertiliser, and farm equipment. Farm and farmer characteristics on the other hand include factors such as size and topography of area cultivated, location of the farm with respect to input and output markets, age, gender, education level, household size, access to extension services, and access credit. Agro-climatic conditions mainly imply soil conditions and weather factors including rainfall, temperature and humidity (Michele, 2001).

Most studies in developing countries are unanimous about the positive role of fertiliser in increasing crop yield (World Bank, 2007), but there is contention on the effect of fertiliser on gross profit (Kelly, 2006). For example, a synthesis report by Reardon et al. (1997), of studies conducted in Burkina Faso, Rwanda, Senegal and Zimbabwe shows that fertiliser had a positive effect of on crop yield. Studies by Evenson and Mwabu (1998), Strasberg et al. (1999), and Tittonell (2007) also concluded that fertiliser use leads to higher crop yields. Regarding the economic returns from fertiliser use, however, Kelly and Murekezi (2000) found that on one hand fertiliser use in some areas
of Rwanda was not profitable for some crops including sorghum and beans while on the other hand profitable for other crops such as maize and potatoes. In the case of labour productivity, Fan and Chan-Kang (2005) and Bonvin (1986) reported a positive relationship with respect to fertiliser use.

The role of improved seed varieties on increasing crop yield in Asia and even in Sub-Saharan Africa is well documented in the World Development Report of 2008 on Agriculture (World Bank 2007). There isn’t much literature, however, on the impact of improved seeds varieties on profit and labour productivity, especially for smallholder farmers. Japhether et al. (2006) compared the yield, profit and labour inputs of farmers using certified hybrid seeds to those using recycled hybrid seeds in Kenya. Results of their study indicate significantly higher yield for farmers using certified hybrids but lower labour productivity due to more intensive use of labour in fertiliser application in certified hybrid seeds farming system. Moreover, Japhether et al. (2006) did not find a significant difference in gross profit of farmers who recycled hybrid seed up to generation two vis-à-vis farmers who planted fresh (certified) hybrid seeds.

Herbicides use to control weed minimises tillage and releases farmers from hours of back-breaking labour (Bray, 1986). On-farm trials of weed management using herbicides and fungicides in Kenya showed that their use resulted in higher yield of maize and beans compared to hand-hoe weeding (Muthamia et al., 2001). The study however did not give the cost of weed management using herbicides compared to hand-hoe weeding. Stemmeroff et al. (1988) found that use of herbicides in corn and soybean production in Canada had a positive effective on yield and income. Forestry studies in
North America among others examined the effect of herbicides use on increasing forest productivity (Wagner et al., 2004). Results from these studies indicated 30–300 percent increases in wood yield for major commercial tree species and that gains were relatively consistent for a wide range of site conditions.

Use of traction (tractor or animal traction) directly reduces on labour input, easily increases on area cultivated and thus increases labour productivity (Bray, 1986). Reardon et al. (1997) report that cotton and maize farming households in Burkina Faso who used animal traction had significantly higher land and labour productivity compared to non-traction households. In Mali and Zambia, where animal traction is widely used in cultivation, Curtis and Gadbois (1996) and Smith (2008) respectively, reported higher labour productivity for farmers using animal traction.

The relationship between area cultivated and productivity has received much attention in the literature. In almost studies, the relationship between crop yield and area cultivated is negative (Barrett, 1996; Pender et al., 2004; Stifel and Minten, 2008; Okoye et al., 2008). Literature on the relationship between labour productivity and area cultivated is mixed however. Some studies including Fan and Chan-Kang (2005) and Bonvin (1986) report a positive relationship between labour productivity and area cultivated while other studies including Masterson (2007) and Byiringiro and Reardon (1996) report an inverse relationship.

The influence of farmer characteristics and farm attributes on productivity has received great attention in productivity analysis. For example, studies including Kalirajan (1981), Bravo-Ureta and Evenson (1994), and Evenson and Mwabu (1998), report a positive and
significant relationship between farm-level yield and access to extension services. In the case of the relationship between education level and yield, results are mixed. Some studies report a positive and significant relationship between the level of education and yield (Evenson and Mwabu, 1998), others report an inverse relationship (Aguilar, 1988 as cited in Evenson and Mwabu, 1998) and yet other studies have reported no statistical significance (Bravo-Ureta and Evenson, 1994).

The issue of family size and gender in productivity has received a fair share of research attention. Bravo-Ureta and Pinheiro (1997) and Iheke (2008) show that household production is positively influenced by family size. A study of gender efficiency in agricultural production by Udry (1996) in Burkina Faso found that that plots controlled by women had notably lower yields than similar plots controlled by men within the same household planted with the same crop in the same year. Udry (1996) noted however, that yield differentials were due to allocative rather than technical inefficiency of women managed farms given the significantly higher labour and fertiliser inputs per acre on plots controlled by men. Saito et al. (1994) also reported a positive but statistically insignificant coefficient of gender (male plot manager) effect on yield in a study in Kenya.

2.3.4 Analysis of Agricultural Productivity

There are two approaches to the estimation of a production function; that is the parametric approach and the non-parametric approach (Kumbhakar and Lovell, 2002; Coelli and Prasda, 2003; Coelli et al., 2005). The parametric approach, which uses the econometric estimation methods, is normally used in estimation of the production
function formulated parametrically, while the mathematical programming methods such as the Data Envelop Analysis (DEA) are normally used in the estimation of a production function stated in a non-parametric form (Kumbhakar and Lovell, 2002).

In the literature, parametric functional forms including Cobb-Douglas, translog, quadratic, and the stochastic frontier have been applied in productivity analysis. Before 1980s, the Cobb-Douglas production function was the main technique of estimation and to some extent is still popular despite its weakness regarding the restrictions of fixed returns to scale and elasticity of substitution always equated to unity (Coelli et al., 2005). The translog and quadratic production function were formulated as part of the solution to the restriction imposed by the Cobb-Douglas function. The main weaknesses of the translog and quadratic models however, are that they are vulnerable to multicollinearity and possible lack of sufficient degrees of freedom due to presence on interaction terms (Coelli et al., 2005). In the case of the translog function, according to Abdulai and Huffman (2000), the interaction terms in the model do not have economic meaning.

Following the observed weaknesses in the Cobb-Douglas as well as successor models, the stochastic frontier production function was pioneered by Aigner et al. (1977) and Meeusen and van den Broeck (1977) as another alternative to productivity analysis. The stochastic frontier function is partitioned into two parts: one representing the stochastic component and the other representing the inefficiency component. This methodology has taken centre-stage in productivity studies since the late 1980s and is estimated using the one step procedure under the maximum likelihood (ML) technique (Wang and Schmidt, 2002; Kumbhakar and Lovell, 2002).
The ML technique of estimation of the stochastic frontier model has become popular because of the one-step method that incorporates both stochastic and inefficiency disturbance terms in one estimation (Kumbhakar and Lovell, 2002). Before, a two-step least squares method was used to estimate the stochastic variables separately and also the inefficiency disturbance terms separately. For example, Bravo-Ureta and Pinheiro (1997) used the ordinary least squares method to estimate the stochastic component and the tobit model to estimate the inefficiency component of the stochastic frontier function.

There is a large stock of studies on agricultural productivity that have used the stochastic frontier analysis (SFA) method and the ML technique in particular. Some of these studies include Rahman (2003); Kolawole (2006); Oladeebo and Fajuyigbe (2007); and Hyuha et al. (2007) among others.

2.3.5 Agricultural Productivity Studies in Uganda

Analysis of agricultural productivity in Uganda has attracted a reasonable number of studies. Appleton and Balihuta (1996) were the first to use the Uganda Integrated Household Survey data of 1992/3 to examine the relationship between education level and agricultural productivity in Uganda. Agricultural productivity was measured as the value of farm household crop output and the least squares method was used to estimate the relationship, which showed a positive relationship between the level of education and output of the producers.

Deininger and Okidi (2001) examined the agricultural productivity of rural households in Uganda using a panel data set derived by combining the Uganda Integrated Household
survey data of 1992/3 and 1993/94. In line with Appleton and Balihuta (1996), Deininger and Okidi (2001) measured agricultural productivity as the annual value of farm household crop output and used the generalised least squares estimation method and found that increase in output value was positively associated with the value of land, labour and fertiliser used in production. The level of output of the farmer was also found to be positive in relation with level of education and access to extension services.

Using the least squares method, Okello and Laker-Ojok (2005) examined the determinants of crop productivity among farmers in Lake Kyoga basin. The authors established that farmer productivity measured by revenue per acre was significantly influenced by land topography, season (as a proxy for good weather), incidence of pests and diseases, and infrastructural developments. Other factors found to significantly affect farmer productivity included the value of investment in agricultural production inputs such as seeds and fertiliser.

Hyuha et al. (2007) is one the few studies that analysed the productivity (measured by profit) of rice farmers in Tororo, Pallisa and Lira districts in Uganda using the SFA method. Lack of extension services and low educational levels were found as the major factors that amplified the profit inefficiency of rice farmers in the areas where the study was conducted.
2.4 Agricultural Commercialisation

Agricultural commercialisation is the degree of participation of agricultural producers in the market; either by selling or buying agricultural output, inputs and/or services in a given period (von Braun et al., 1994; Sokoni, 2008). That is, producers can participate in the input and/or output market. In this study, we focus on the participation of maize producers in the output market to sale their crop.

The level of commercialisation is measured as a proportion, which ranges from zero to one. Zero if the farmer does not buy/sale any input/output in the market and one if the farmer buys/sells all inputs/output in the market (von Braun et al., 1994). The proportion is turned into an index when multiplied by 100. According to the 2008 World Development Report, if producers sell more than 50 per cent of their agricultural production on the market, they are market-oriented; otherwise they are considered subsistence farmers (World Bank, 2007). Furthermore, on the one hand agricultural producers are regarded as pure subsistence farmers if they do not at all participate in the market. On the other hand they are considered pure or fully commercialised if they buy/sell all agricultural inputs/outputs in the market.

Commercialisation is generally advocated for its integration of producers with the market or global economy and lowering of subsistence production. Greater dependence of the producer on the input market as the source of production inputs has been associated with increased productivity; while on the output side, commercialisation has been linked with improvement in people’s income and welfare (von Braun et al., 1994).
2.4.1 Agricultural Commercialisation Determinants

The factors that influence farmer commercialisation may be categorized as household specific and external factors. Household specific factors include the quality and quantity of household resource assets such as land, labour and capital while external factors are factors beyond the control of the farmer including technological change and introduction of new commodities, the state of infrastructure, marketing facilitation institutions, policies affecting credit access, and prices (Pingali and Rosegrant, 1995; Jaleta, et al., 2009).

At household level, change in household size and structure is one the driving forces of commercialisation (von Braun et al., 1994). According to von Braun et al. (1994), large households may be able to increase the marketable surplus if expansion of the cultivated area is possible. On the other hand, however, large families might lead to a reduced volume of marketed surplus in relative or even absolute terms in order to meet household food requirements. This argument is shared by Chattopadhyay and Sen (1988) who found that in India, households with big family size had relatively lower marketable surplus.

Pingali and Rosegrant (1995) point out that agricultural commercialisation is a transformation process from subsistence to semi-commercial and then to a fully commercialised agriculture. In the transformation process, the level of output commercialisation of producers is said to be greatly associated with the level of inputs use. For example, in subsistence production farmers use mainly non-traded and
household generated inputs while in a fully commercialised agriculture, inputs are predominantly obtained from markets (Pingali and Rosegrant, 1995)

Transaction costs, which include transport and communication costs as well as market levies to a large extent influence commercialisation. Prevalence of high market transaction costs for example due to poor road network limit household participation in crop markets, prompting them to give priority to subsistence food production (Key et al. 2000; Pingali et al. 2005). In Tanzania, Manda (2003) found out that increased agricultural production and commercialisation was highly influenced by improved and timely availability of agricultural inputs to farmers due to reduction in transport costs as a result of improvements in rural roads by gravelling.

Increased commercialisation can be enforced by direct government action, such as execution of certain management practices for example contract farming arrangements, and voluntary or forced procurement of produce (Braun et al., 1994). When farmers are in contract farming arrangement for example, they are assured of the market, which is an incentive to produce and sell more. Other production and marketing arrangements such as farmer groups or cooperatives also have a significant impact on the group members’ decision to participate in the market. For example, a study by Okoboi (2008) reveals that potato farmers in Kabale district, organized under Nyabyumba Farmers’ Group became increasingly market-oriented in production after getting a contract to supply potatoes to Nandos, a fast-food restaurant in Kampala.

One of the constraints on smallholder farmers’ access to markets is lack of market information (Barret, 2008). Lack of information about prices of production inputs and
outputs, about places and best periods for selling their products, about potential buyers as well as quality requirements, frustrates producers to the extent that they may resort to production for subsistence (Robbins, et al., 2004; Klieh, 2004). A survey conducted by Ferris et al. (2006) to evaluate the impact of market information services in Uganda found out that farmers with access to market information sold a larger quantity of their crops and moreover at higher prices than their counterparts with limited access to information.

2.4.2 Analysis of Agricultural Commercialisation

In the analysis of factors affecting agricultural commercialisation, a number of methods including the logit, probit, double hurdle and the OLS models have been applied. The model applied depends mainly on the type of data considered in the analysis of the dependent variable. For instance, when the dependent variable data is continuous, the OLS method is widely applied, when the data is categorical, the logit or probit models take precedence while when the data is categorical and censored, the tobit model is the prime choice model of estimation and when data is truncated the double hurdle is applied in a number of instances (Greene, 1997; Wooldridge, 2002).

Gebreselassie and Ludi (2008) applied the logit and OLS regression methods on survey data to assess the determinants of the likelihood and extent of market participation among smallholders in major coffee growing areas in Ethiopia. The logit model was applied to categorical dependent variable data while OLS regression was applied to continuous sales data for the dependent variable. Results of the study showed that the value of total farm output was critical in explaining the intensity of household
participation in the market. Socio-economic variables such as wealth, total farm size, household size, age and education level of the farmer were found to have no effect on the degree of commercialisation among sampled households.

Eskola (2005) examined the determinants of farmer participation in the output market in Tanzania using the generalised linear model. Increase in the distance to the market was found to negatively affect the level of commercialisation. Also, access to information was observed to affect the farmers’ level of commercialisation but to a limited extent.

Gibreel and Bauer (2007) used the OLS model to assess the effect of socio-economic variables on producer commercialisation decision in Western Sudan. The level of output commercialisation was found to be negatively correlated with the number children in the family, cost of inputs (pesticide), and transportation cost. On the other hand, output commercialisation was found to be positively correlated with the level of education and off-farm income of the producer.

Asfaw et al. (2010) utilised the propensity score regression model to examine the causal relationship between improved inputs use and commercialisation in Ethiopia. Results of their study revealed that the use of improved agricultural technologies, wealth and availability of active family labour force have a positive impact on marketed surplus while age of household head and distance to main market have a negative impact on marketed surplus.
2.4.3 Agricultural Commercialisation Studies in Uganda

As compared to literature on productivity, studies on agricultural commercialisation in Uganda are few. Based on UNHS 1992/93 data, Larson and Deininger (2001) used the tobit model to examine the determinants of farmer participation in crop markets in Uganda. A higher level of participation of farmers in the market was observed for crops with higher prices while access to transport infrastructure was found to be of limited influence on the level of participation in the market. Notable in this study however is that the level of farmer commercialisation was averaged from over 20 crops including cash crops and food crops that were cultivated by the farmer. Since total sale of cash crops such as coffee and cotton is almost certain, this is likely to mask the proportion of food crops sold in the market and falsely suggest that a higher level of farmers in the food crop market.

Komarek (2010) used a tobit model and a double hurdle model to examine the determinants of banana market commercialisation in Western Uganda. Farmers with higher crop yield and access to information were found to sale more output while farmers who were distant to the market were found to participate less in the market. Increase in the price of produce was also found to attract more participation in the market.

2.5 Summary

This chapter reviewed both the theoretical and empirical literature on improved inputs use, productivity and commercialisation in agriculture. The literature suggests that the
theory of farm-household is that standard framework for modelling simultaneous production and consumption decisions of agricultural households. Furthermore, literature indicates a diverse range of factors that influence the farmer’s decision to use and hence spend on improved inputs, as well as their productivity and participation in the market. These diverse factors may be grouped generally as farm/farmer specific characteristics, and external factors that include government policies and agro-climatic factors.

In the empirical literature, improved inputs use determinants are generally estimated using the logit and probit models. Regarding productivity analysis, literature shows that the SFA method, which is somewhat recent, has gained more prominence in agricultural productivity estimation over other methods such as the Cobb-Douglas or translog models due to SFA model’s effort to overcome some of the weaknesses observed in Cobb-Douglas or translog models. As for analysis of commercialisation, the tobit model is widely applied, especially when commercialisation is measured as the proportion of sales to total output.

A review of studies in Uganda addressing issues related to improved inputs use, productivity and commercialisation in agriculture suggest that studies in this area are generally few and/or fairly old. For instance, national level studies reviewed use data of 1992 -1994. Also, most of the studies reviewed generally address production and not productivity, and are general in focus and not crop specific.
CHAPTER 3

CONCEPTUAL AND THEORETICAL FRAMEWORK

3.1 Introduction

This chapter describes the conceptual framework and theoretical model for analysis of the factors that are likely to influence improved inputs use, productivity and output commercialisation in maize production. The conceptual and theoretical models are based on the literature review presented in Chapter 2. The theoretical model in particular is based on the standard farm-household model of Barnum and Squire (1979), and incorporates the assumptions of Low (1986). The model provides the framework for the research methodology that follows in the next chapter.

3.2 The Conceptual Framework

Factors that influence the household decisions to use improved inputs can be grouped into internal factors or farmer characteristics (I) and external factors (II) (Langyintuo and Mekuria, 2005). On the one hand, factors that influence maize productivity (B) and the level of output commercialisation (C) can be group into: improved inputs (A) and other factor inputs including land and labour; and internal factors (farmer characteristics); and external factors (Pingali and Rosegrant, 1995). These relationships are illustrated diagrammatically in Figure 3.1. The direction of the arrows in Figure 3.1, illustrates the cause-effect or explanatory variable – dependent variable relationship.
Figure 3.1: A conceptual framework of the linkage between improved inputs use and productivity and output commercialisation in maize production

Source: Author’s illustration based on theory.
Studies such as Chattopadhyay and Sen (1988) and Gebreselassie and Ludi (2008) found a positive relationship between productivity and output commercialisation. This relationship is captured in Figure 3.1, by the arrow from productivity to output commercialisation.

Overall, positive changes in productivity and output commercialisation in the maize sub-sector contribute to the achievement of the vision of the Ministry of Agriculture Animal Industry and Fisheries (MAAIF), as stated in the DSIP 2010/11 – 2014/15 (MAAIF, 2010). Bold dashed lines from maize productivity (B) and maize output commercialisation (C) to MAAIF vision (D) illustrate this relationship.

### 3.3 The Theoretical Model

The farm-household model formulated by Barnum and Squire (1979) is adopted and modified to suite this study. The modified model is stated as follows:

\[
U = U(L, C, M; \alpha_i), \quad i = 1, \ldots, \tag{1}
\]

\[
Q = Q(D, d_j; A), \quad j = 1, \ldots, \tag{2}
\]

\[
T = H + L + D, \tag{3}
\]

and

\[
qM + pC = wH + R + pQ - \sum w_j d_j, \tag{4}
\]

Where

- \(L\) = leisure;
- \(C\) = own consumption of maize output;
- \(M\) = consumption of market-purchased goods such as fertilisers;
$a_i$ = household characteristics (for example, household size);

$Q$ = Total output of maize;

$D$ = total labour input (both family and hired labour) used in $Q$ production;

$d_j$ = other variable inputs used in $Q$ production;

$A$ = area of land used in $Q$ production;

$T$ = total household time available for labour;

$H$ = net quantity of labour time sold if $H > 0$, net quantity of labour time purchased if $H < 0$, and net quantity of labour time neither sold nor purchased if $H = 0$;

$R$ = non-wage, non-crop net other income such as rental income;

$q$ = price of $M$;

$p$ = price of $C$;

$w$ = wage rate;

$w_j$ = price of other variable inputs.

In line with Low (1986), the following assumptions are made for this study:

(i) the household is assumed to maximise its utility function [equation (1)]
subject to the production function [equation (2)] and the time and income
constraints [equations (3) and (4)];

(ii) flexible access to land by farm households based due the nature of the land
tenure systems in Uganda that allow renting of land;

(iii) differential wage rates and wage income to household members;

(iv) different prices at which farm households sell and buy commodities such as
food; and

(iv) occurrence of food deficit farm households who hire out family labour.
According to Barnum and Squire (1979), maximising equation (1) subject to equations (2) to (4) and eliminating the Lagrangian multipliers, gives the following first-order equations:

\[ U_c = p, \quad (5) \]
\[ U_M = q, \quad (6) \]
\[ U_L = w, \quad (7) \]
\[ pQ_D = w, \quad (8) \]
\[ pQ_{dj} = w_j, \quad j = 1, \ldots, \quad (9) \]

and

\[ qM + pC + wL = \Pi + R + wT \quad (10) \]

where

\[ \Pi = pQ(D) - wQ - \sum w_j d_j, \quad (11) \]

Equations (5) to (7) express the first-order conditions of utility maximisation: that is, the marginal utilities from consumption of own consumption of maize output, consumption of market-purchased goods, and leisure must equal their respective prices. Equations (8) and (9) are the profit maximising conditions for the allocation of labour and other variable inputs. Equation (10) includes the income and time constraints in addition to the technological constraints expressed by the production function. The right-hand side of equation (10) is the “full income” which includes the gross profit from maize production; non-wage, non-crop net other income; and actual and foregone wage income. The left-hand side of equation (10) includes “expenditure” on home
consumption maize output \((C)\) and leisure \((L)\) besides expenditure on consumption of market-purchased goods \((M)\).

Assuming the second order conditions are satisfied, equations (5) to (7) and (10) can be solved for consumption goods, \(C\), \(M\), and \(L\), in terms of the prices, \(q\), \(p\) and \(w\); the household characteristics, \(a_i\); and the total household expenditure, \(E\), which is the sum of \(\Pi, R\) and \(wT\) (Barnum and Squire, 1979) as indicated in equations (12) to (14).

\[
C = C(q, p, w, a_i, E) \quad (12)
\]

\[
M = M(q, p, w, a_i, E) \quad (13)
\]

\[
L = L(q, p, w, a_i, E) \quad (14)
\]

Optimisation of \(C\), \(M\), and \(L\), suggests the maximisation of production \((Q)\) side equations (8) and (9), profit, \(\Pi\) from sale of the proportion of \(Q\) not consumed at home, \((Q - C)\) or minimisation of the total cost of variable inputs, \(\sum w_j d_j\).

Assuming the total cost function is differentiable, following Shephards Lemma, the cost-minimising input vector \((x)\) is given by the vector of derivatives of the cost function with respect to the prices \((w_i)\), (Varian, 1992). That is:

\[
\frac{\partial (\sum w_j d_j)}{\partial w_j} = d_j, \quad j = 1, \ldots \quad (15)
\]

Equation (15) can also be solved for \(d_j\), in terms of the prices, \(q\), \(p\) and \(w\); the household characteristics, \(a_i\); and the total household expenditure, \(E\), as indicated in equation (16).

\[
d_j = d_j(q, p, w, a_i, E), \quad j = 1, \ldots \quad (16)
\]
To implement this model econometrically in line with the conceptual framework, the reduced form equations for improved inputs use, productivity (yield, labour productivity, gross profit), and output commercialisation are stated as in equations (17) to (19).

\[ d_j = d_j(I,II), \quad j = 1, \ldots 4, \]  
\[ y_k = y_k(A,I,II), \quad k = 1, 2, 3\ldots, \]  
\[ s = s(A,B,I,II), \]

Where \( j = 1 \) is improved seed, \( j = 2 \) is fertiliser, \( j = 3 \) is fungicides/herbicides, \( j = 4 \) is traction

\( k = 1 \) is yield, \( k = 2 \) is labour productivity and \( k = 3 \) is gross profit

\( s \) = output commercialisation (proportion of output sold).
CHAPTER 4

METHODOLOGY

4.1 Introduction

This chapter describes the data and estimation methods used in the study. In section 4.2, the data, including the source and type of data and area of study are presented while in section 4.3, the econometric models are specified and explained including the variables used in the analysis. The approaches that were employed during estimation to obtain reliable estimates are discussed in section 4.4.

4.2 The data

Data used in this study are from the Uganda National Household Survey 2005/06 (UNHS 2005/6), collected by Uganda Bureau of Statistics (UBoS). The UNHS 2005/06 was nationally representative. The survey was conducted in two intervals: the Second Season (July-December) of 2004 and the First Season (January – June) of 2005 (UBoS, 2007).

Five modules were administered in the UNHS 2005/6, including Agriculture as the core module, Socioeconomic, Community, Price, Crop cards and Qualitative modules (UBoS, 2006). The Agricultural module included components such as: investments on land, crop areas, labour and non-labour inputs and crop disposition for the two season; livestock numbers; small animals and poultry numbers; agricultural extension services and technologies.
The Socioeconomic module covered demographic characteristics (age, sex, household size and membership), education, health, economic activities, asset ownership, housing conditions, credit access, distance to market, and other welfare indicators such as household experience of shocks from drought, pests and diseases). The Price module mainly covered market prices for agricultural inputs and outputs while the Community module included data on community access to facilities and services such as health facilities, education facilities, transport infrastructure; agricultural extension; and markets both for inputs and output. Though the Qualitative Module was developed to complement the quantitative data from household surveys, data were not included in the UNHS 2005/06 database.

The UNHS 2005/06 data on agriculture was collected at household level and plot level. At household level, UNHS 2005/06 covered 7426 households; of whom, about 5850 or 78.8 percent were agricultural households (UBoS, 2006; 2007). In this study however, the focus was on households who had complete information pertaining to the variables of interest in maize production at plot level in the two seasons. On this basis, a total of 1888 plot level observations were derived by merging several pieces of data from the Socio-economic, Agriculture, Community, and Price Modules. However, before merging data from one module with that in another module, various sections of data within the same module were merged first. For example, the Agricultural Module contained 12 sections, and each section contained several columns of data that were relevant for the study. Different datasets within the same module were merged using unique identifiers. For instance, in Agricultural module, the household and plot identities were the unique identifiers and hence merging variables. To merge data from
different modules, the household and/or community identification codes were the unique merging variables.

The sample size of plot-level data relating to maize production that was finally generated from UNHS 2005/06 data is regionally distributed as in Appendix 3. That is, 20 percent of maize producers were from Central, 45 percent from Eastern, 19 percent from Northern, and 17 percent from Western Uganda. Details regarding sample distribution according to the season are also given in Appendix 3.

4.3 Estimation Methods.

This study had three specific objectives to address. In the sub-sections that follow, the models to address each of the objectives are presented including the definition of the variables. The measurement and expected sign of the variables are also given.

4.3.1 Analytical Model for Improved Inputs Use

A number of studies have modelled farmer decisions on whether or not to use improved inputs as a binary choice, estimated by logit or probit regressions (Akinola, 1987; Adesina and Zinnah, 1993; Smale et al., 1995; Nkamleu and Adesina, 2000; Deininger and Okidi, 2001; Langyintuo and Mekuria, 2005; Sserunkuma, 2005; 2007). It is however known that farmer decisions to use improved inputs such as fertiliser are at times contingent upon use of other complementary inputs such as improved seed. That is, the decision to use multiple improved inputs is mutually dependent (Wu and Babcock, 1998; Bekele and Drake, 2003). In this study, farmer use of improved seeds,
fertiliser, fungicides/herbicides and traction is treated and modelled as mutually
dependent decisions.

Mutually dependent unordered choice models are typically estimated by either
multinomial logit model (MLM) or multinomial probit model (MPM), which give
similar results (Greene, 1993; Gujarati, 2003). Studies including Wu and Babcock
(1998), Bekele and Drake (2003) and Kassie et al. (2010) have used the MLM regression
analysis. The MLM is usually preferred to the MPM due to its simplicity in computation
of the probabilities (Greene, 1993; Gujarati, 2003). In this study, the MLM is adopted to
estimate the determinants of farmer use of improved seeds, fertiliser, fungicides/
herbicides and traction.

4.3.1.1 Multinomial Logit Model Specification

According to Greene (1993), the MLM of the multiple choices regarding improved
inputs can be stated as follows: assume $Y_i$ as a random variable that indicates the choice
of improved input by farmer $i$, then;

$$P_{ij} = E(Y_i = j/x_i) = F(\alpha + \beta X_i), j = 0, 1, \ldots, 4$$  \hspace{1cm} (20a)

$$= \frac{1}{1+\sum_{j=0}^{4}e^{-z_i}}, \text{ where } z_i = \alpha + \beta X_i$$ \hspace{1cm} (20b)

$$= \frac{e^{zi}}{1+\sum_{j=0}^{4}e^{zi}}$$ \hspace{1cm} (20c)

Where $P_{ij} = E(Y_i = j/x_i)$ is the probability that maize farmer $i$ uses improved input $j$:
$j = 0$ is the reference category of non-use of the improved input, $j = 1$ is improved seed, $j$
= 2 is fertiliser, \( j = 3 \) is fungicides/herbicides, and \( j = 4 \) is traction. The coefficients of the parameters to be estimated are \( \beta \)'s while \( \alpha \) is the constant term. The choice of \( j \) is affected by different factors \( x_i \), which include farmer characteristics (also called internal factors in Figure 3.1) and external factors.

From equation (20), the probability of non-use of improved input \( j \) is given by:

\[
1 - P_{ij} = E(Y_i = 0 / x_i) = \frac{1}{1 + \sum_{j=1}^{4} e^{x_i}} \tag{21}
\]

The odds ratio, which is the ratio of the probability that the farmer will use the improved input to the probability that he/she will not use the improved input is written as:

\[
\frac{P_{ij}}{1-P_{ij}} = \frac{e^{Z_i}}{1 + \sum_{j=1}^{4} e^{Z_i}} = e^{Z_i} \tag{22}
\]

Normalising the probabilities and including the error term (\( \varepsilon \)) leads to the following log-odds ratio.

\[
\ln \left[ \frac{P_{ij}}{1-P_{ij}} \right] = z_i = \alpha + \beta x_i + \varepsilon_i \tag{23}
\]

In equation (23), the dependent variable is the log of use of a particular improved input to the reference (non-use) alternative. For better explanation of the coefficients of the multinomial logit, the marginal effect of the explanatory variables is derived (Greene, 1993; Gujarati, 2003).
Following the conceptual framework (Figure 3.1) highlighting the relationship between improved inputs and internal and external factors, equation (23) can be written as:

\[
\ln \left[ \frac{P_{ij}}{1-P_{ij}} \right] = \alpha + \beta_1 Urban_i + \beta_2 IDPcamp_i + \beta_3 HHsize_i + \beta_4 Sex_i + \beta_5 Age + \beta_6 Educ_i + \beta_7 Ext_i + \beta_8 Group_i + \beta_9 NAADS_i + \beta_{10} Credit_i + \\
\beta_{11} Road dist_i + \beta_{12} Central_i + \beta_{13} Northern_i + \\
\beta_{14} Western_i + \beta_{15} Ln(Plot size_i) + \beta_{16} Ln(Lvstk_i) + \\
\beta_{17} Ln(hiredlbr) + \beta_{18} Ln(manure) + \epsilon_i
\]

(24)

4.3.1.2 Definition and Measurement of the Variables in the Model

Dependent variable in equation (24) included four improved inputs, namely: improved seeds, fertiliser, pesticide/herbicide and traction. If the farmer had used improved seed procured from market (input shop), then \( j = 1 \), 0 otherwise; \( j = 2 \) if the farmer used fertiliser, 0 otherwise; \( j = 3 \) if the farmer used fungicides/herbicides, 0 otherwise; and \( j = 4 \) if the farmer used traction, 0 otherwise.

Definition, measurement and expected signs of the explanatory variables in equation (24) are presented in Table 4.1. Explanations for the expected sign are also given in Table 4.1.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
<th>Measurement / value</th>
<th>Expected sign and explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>Location in urban area.</td>
<td>1 = urban, 0 = rural</td>
<td>+ Farmers in urban centres are close to input markets and more likely to buy and use improved inputs</td>
</tr>
<tr>
<td>IDP camp</td>
<td>Live in internally displaced people’s (IDP) camp</td>
<td>1 = IDP, 0 = non-IDP</td>
<td>- Most of farmers in IDP particularly in Northern Uganda were deprived of their assets due to civil insecurity, hence are less likely to buy and use improved inputs</td>
</tr>
<tr>
<td>HHsize</td>
<td>Size of household</td>
<td>Number of household members</td>
<td>+/- Both large and small households may use improved inputs</td>
</tr>
<tr>
<td>Gender</td>
<td>Sex of maize farmer</td>
<td>1 = male, 2 = female</td>
<td>+ Male persons in Uganda are less poor than female persons (UBoS, 2006), thus more likely to buy and use improved inputs</td>
</tr>
<tr>
<td>Age</td>
<td>Age of maize farmer</td>
<td>Years</td>
<td>+/- Older farmers are wealthier hence more likely to use improved inputs. On the other hand, though wealthier, older farmers may not be keen to use improved inputs due to various reasons such as lack of knowledge (Langyintuo and Mekuria, 2005)</td>
</tr>
<tr>
<td>Educ</td>
<td>Education level of maize farmer</td>
<td>10 = no formal schooling; 11 - 17 = P1 – p7; 21 – 23 = J1 – J3; 31 – 36 = S1 - S6; 41 = Post primary; 51 = post secondary; 61 = degree and above</td>
<td>+ More educated persons in Uganda are less poor (UBoS, 2006), hence more likely to buy and use improved inputs</td>
</tr>
<tr>
<td>Ext</td>
<td>Maize farmer access to extension services</td>
<td>1 = yes, 0 = no</td>
<td>+ Farmers who receive extension visits and/or training are more likely to purchase and use improved inputs</td>
</tr>
<tr>
<td>NAADS</td>
<td>Maize farmer membership to NAADS programme</td>
<td>1 = yes, 0 = no</td>
<td>+ Farmers in NAADS are provided with improved inputs (NAADS, 2005), hence more likely to use improved inputs</td>
</tr>
<tr>
<td>Group</td>
<td>Maize farmer membership to farmer association</td>
<td>1 = yes, 0 = no</td>
<td>+ Farmers in production associations have more access to extension services (NAADS, 2005), hence more likely to use improved inputs</td>
</tr>
<tr>
<td>Credit</td>
<td>Maize farmer obtained credit</td>
<td>1 = yes, 0 = no</td>
<td>+ Farmers who get agriculture-related credit are more likely to purchase and use improved inputs</td>
</tr>
</tbody>
</table>
Table 4.1 Continued

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
<th>Measurement /value</th>
<th>Expected sign and explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roaddist</td>
<td>Household distance to the gravel road</td>
<td>Kilometers (Km)</td>
<td>- Farmers further away from the road are less likely to purchase and use improved inputs</td>
</tr>
<tr>
<td>Central</td>
<td>Central Uganda</td>
<td>1 = if maize farmer from Central Uganda, 0 otherwise</td>
<td>+/- due to diverse characteristics of farmers in Central Uganda, it is not possible to ascertain the expected sign of coefficient</td>
</tr>
<tr>
<td>Northern</td>
<td>Northern Uganda</td>
<td>1 = if maize farmer from Northern Uganda, 0 otherwise</td>
<td>+/- due to diverse characteristics of farmers in Northern Uganda, it is not possible to ascertain the expected sign of coefficient</td>
</tr>
<tr>
<td>Western</td>
<td>Western Uganda</td>
<td>1 = if maize farmer from Western Uganda, 0 otherwise</td>
<td>+/- due to diverse characteristics of farmers in Western Uganda, it is not possible to ascertain the expected sign of coefficient</td>
</tr>
<tr>
<td>Ln(Plotsize)</td>
<td>Size of area cultivated with maize</td>
<td>Hectares (ha), expressed in natural logarithm (Ln)</td>
<td>+ Farmers who cultivate more area are expected to use more improved inputs.</td>
</tr>
<tr>
<td>Ln(Lvstk)</td>
<td>Value of household livestock and poultry</td>
<td>Uganda shillings (Ugx), expressed in natural logarithm (Ln)</td>
<td>+ Farmers with more livestock are more wealthier and thus more likely to buy and use improved inputs</td>
</tr>
<tr>
<td>Ln(manure)</td>
<td>Quantity of manure used</td>
<td>Kilograms (Kg), expressed in natural logarithm (Ln)</td>
<td>+/- Farmers may use manure either as soil nutrient complement to improved inputs or substitute for fertiliser</td>
</tr>
<tr>
<td>Ln(hiredlbr)</td>
<td>Expenditure on hired labour</td>
<td>Uganda shillings (Ugx), expressed in natural logarithm (Ln)</td>
<td>+ Farmers spending more on hired labour are likely to be better off income-wise, hence more likely to buy and use improved inputs</td>
</tr>
</tbody>
</table>

Note: Educ: P = primary education J = Junior secondary education and S = Senior secondary education

Eastern is the base case region for comparison with Central, Northern and Western regions
4.3.2 Analytical Model for Agricultural Productivity

Recent studies in agricultural production have modelled agricultural productivity as a stochastic frontier production function (Ali and Flinn, 1989; Rahman, 2003; Kolawole 2006; Hyuha et al. 2007). The stochastic frontier analysis (SFA) method of agricultural productivity is considered in this study.

Following Kumbhakar and Lovell (2002), the SFA model can be stated as follows:

\[
y_i = f(x_i; \lambda) e^{\varepsilon_i}, i = 1, \ldots, N
\]

(25a)

\[
\varepsilon_i = v_i - u_i
\]

(25b)

Where \( Y_i \) is maize productivity represented by yield, labour productivity and gross profit of farmer \( i \); \( x_j \) is a vector of inputs including land, labour and improved inputs used in maize production while \( \lambda \) is a vector of coefficients to be estimated. The exponential (e) is to power \( \varepsilon \), error term, which consists of two components: the stochastic term, \( v_i \), assumed to be independently and identically distributed as \( N(0, \delta_v^2) \) and the inefficiency component representing farmer characteristics, \( u_i \), assumed to be non-negative random variables distributed independently of \( v_i \).

Normalising equation (25) and adding a constant term \( (\alpha) \) leads to equation (26)

\[
\ln(y_i) = \alpha + \lambda [\ln(x_i)] + v_i - u_i
\]

(26)
4.3.2.1 Model for Estimation of Maize Productivity

From equation (26), a detailed equation for estimation of the determinants of maize productivity, represented by yield, labour productivity and gross profit was written as follows:

\[
\ln(y_{ik}) = \alpha + \lambda_1 \ln(x_{i1}) + \lambda_2 \ln(x_{i2}) + \lambda_3 \ln(x_{i3}) + \lambda_4 \ln(x_{i4}) + \lambda_5 \ln(x_{i5}) + \lambda_6 \ln(x_{i6}) + \lambda_7 \ln(x_{i7}) + v_i - (\beta_1 Urban_i + \beta_2 1DP camp_i + \beta_3 HH size_i + \beta_4 Sex_i + \beta_5 Age_i + \beta_6 Educi + \beta_7 Exti + \beta_8 NAADS + i + \beta_9 Group_i + \beta_10 Ln Lvstki + \beta_11 Crediti + \beta_12 Roaddisti + \beta_13 Central_i + \beta_14 Northern_i + \beta_15 Western_i, \ k = 1, 2, 3
\]

(27)

Where \(y_{ik}\) = maize productivity of farmer \(i\); \(k = 1\) is yield, \(k = 2\) is labour productivity and \(k = 3\) is gross profit; \(x_{ij}\), . . . , \(x_{i7}\) are factor inputs namely improved seed, fertiliser, fungicide/herbicide, traction, manure, plot size cultivated, and labour hired.

In the estimation of SFA model, the half-normal distribution of the inefficiency variables is assumed particularly when data are cross-sectional (Bauer, 1990). Since data use in this study was cross-sectional, the inefficiency variables were assumed to be halfnormally distributed. In the interpretation of the coefficients (\(\beta\)) of the inefficiency variables, positive coefficients imply the variable leads to productivity inefficiency while negative coefficients imply the variable leads to productivity efficiency.
4.3.2.2 Definitions and Measurements of Variables Used in the Model

The dependent variable in equation (27) included three measures of agricultural productivity, namely: yield, labour productivity and gross profit. Yield was measured in tonnes per hectare (t/ha), labour productivity measured in kilograms per man day (kg/man-day) while gross profit measured in millions of Uganda shillings per hectare (Ugx/ha, millions).

Table 4.2 presents the definition, measurement and expected signs of the explanatory variables in equation (27). In line with literature on agricultural production including the World Bank (2007), farmer use of improved inputs $x_1, \ldots, x_4$ is expected to have a positive effect on maize yield, labour productivity and gross profit. For other factor inputs, use of larger quantities of manure per area of maize cultivated is expected to have a positive effect on yield (Tittonell, 2007), but a mixed effect (positive or negative) on labour productivity and gross profit (Reardon et al., 1997). Increase in area cultivated is expected to affect yield negatively (Pender et al., 1994; Stifel and Minten, 2008) while labour productivity positively (Bonvin, 1986; Fan and Chang-Kang, 2005). The effect of increased area cultivated on gross profit is also expected to be positive due to expected economies of scale from increased acreage. Increased use of hired labour is expected to increase yield (Tittonell, 2007), but the effect on gross profit is mixed since it increases the cost of production.
The inefficiency variables ($u_i$) in Table 4.2 are defined and measured as in Table 4.1. The expected signs of these variables are based on their expected relationship with improved inputs use, which was explained in Table 4.1. Signs for these variables as presented in Table 4.2 are however a bit unique, in that they carry an inverse sign to that of the interpretation based on the SFA models formulation (equation 26). For example, whereas the expected relationship between a farmer being in an urban area and yield is positive, the sign for “urban” variable with respect to yield in Table 4.2 is negative (-). The interpretation however is that a farmer being in an urban area would be associated with higher yield. Thus inefficiency variables with negative signs in the estimated model will be interpreted as having positive effect on the dependent variable while inefficiency variables with positive signs will be interpreted as having a negative effect on the dependent variable.
Table 4.2. Definition and Measurement of Variables Used in the SFA Models of Productivity

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
<th>Measurement /value</th>
<th>Expected sign of SFA models</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Improved inputs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\ln(x_1)$</td>
<td>Improved seed</td>
<td>Uganda shillings per hectare (Ugx/ha)</td>
<td>+</td>
</tr>
<tr>
<td>$\ln(x_2)$</td>
<td>Fertiliser</td>
<td>Ugx/ha, expressed in natural logarithm (Ln)</td>
<td>+</td>
</tr>
<tr>
<td>$\ln(x_3)$</td>
<td>Fungicides/herbicides</td>
<td>Ugx/ha, expressed in natural logarithm (Ln)</td>
<td>+</td>
</tr>
<tr>
<td>$\ln(x_4)$</td>
<td>Traction (tractor/animal)</td>
<td>Ugx/ha, expressed in natural logarithm (Ln)</td>
<td>+</td>
</tr>
<tr>
<td><strong>Other factor inputs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\ln(x_5)$</td>
<td>Manure</td>
<td>Quantity in Kilograms per hectare (Kg/ha), expressed in natural logarithm (Ln)</td>
<td>+</td>
</tr>
<tr>
<td>$\ln(x_6)$</td>
<td>Size of area cultivated with maize</td>
<td>Hectares (ha) expressed in natural logarithm (Ln)</td>
<td>-</td>
</tr>
<tr>
<td>$\ln(x_7)$</td>
<td>Hired labour</td>
<td>Ugx/ha, expressed in natural logarithm (Ln)</td>
<td>+</td>
</tr>
<tr>
<td><strong>Inefficiency variables</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>Location in urban area.</td>
<td>1 = urban, 0 = rural</td>
<td>-</td>
</tr>
<tr>
<td>IDPcamp</td>
<td>Live in internally displaced people’s (IDP) camp</td>
<td>1 = IDP, 0 = non-IDP</td>
<td>+</td>
</tr>
<tr>
<td>HHsize</td>
<td>Size of household of farmer</td>
<td>Number of household members</td>
<td>-</td>
</tr>
<tr>
<td>Gender</td>
<td>Sex of maize farmer</td>
<td>1 = male, 2 = female</td>
<td>-</td>
</tr>
<tr>
<td>Age</td>
<td>Age of maize farmer</td>
<td>Years</td>
<td>-/+</td>
</tr>
<tr>
<td>Educ</td>
<td>Education of maize farmer</td>
<td>10 = no formal schooling; 11 - 17 = P1 – p7; 21 – 23 = J1 – J3; 31 – 36 = S1 - S6; 41 = Post primary; 51 = post secondary; 61 = degree and above</td>
<td>-</td>
</tr>
<tr>
<td>Ext</td>
<td>Maize farmer access to extension services</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-------------</td>
<td>------------------------------------------</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>NAADS</td>
<td>Maize farmer membership to NAADS programme</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Group</td>
<td>Maize farmer membership to farmer association</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Credit</td>
<td>Maize farmer obtained credit</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Roaddist</td>
<td>Maize farmer distance to the gravel road</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Ln(Lvstk)</td>
<td>Value of household livestock and poultry</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Central</td>
<td>Central Uganda</td>
<td>-/+</td>
<td>-/+</td>
</tr>
<tr>
<td>Northern</td>
<td>Northern Uganda</td>
<td>-/+</td>
<td>-/+</td>
</tr>
<tr>
<td>Western</td>
<td>Western Uganda</td>
<td>-/+</td>
<td>-/+</td>
</tr>
</tbody>
</table>

Note: Educ: P = primary education J = Junior secondary education and S = Senior secondary education

Eastern is the base case region for comparison with Central, Northern and Western regions
4.3.3 Analytical Model for Maize Output Commercialisation

Farmer participation in the output or input market (commercialisation) is to great extent estimated by the tobit regression method (Strasberg, 1999; Deininger and Larson, 2001). The tobit model is used in analysis when data for the dependent variable is censored (Greene, 1993; Gujarati 2003). In this study, the tobit model is adopted since maize output commercialisation is measured as an index, leading to the censoring of data at 0 (pure subsistence production) and 1 (pure commercialisation). According to Greene (1993), the tobit model is specified as follows.

$$m_i = x_i' \beta + \varepsilon_i$$  \hspace{1cm} (28)

Household $i$ decision to participate in the market ($m$) is based on underlying internal and external factors ($x$). The vector of unknown parameters to be estimated is $\beta$, and $\varepsilon$ is the random term.

Since decisions are unobservable, they are represented by the share of the output sold on the market ($m^*$). Hence, the left part of equation (28) can be stated as follows:

$$m_i = \begin{cases} c_i & \text{if } m_i^* \leq c_i \\ m_i^* & \text{if } c_i < m_i^* < c_i \\ \bar{c}_i & \text{if } m_i^* \geq \bar{c}_i \end{cases}$$  \hspace{1cm} (29)

Where $\bar{c}$ and $c$ are fixed numbers representing the left and right censoring points. In this study, the left censoring point is 0 and the right censoring point is 1.
4.3.3.1 Model for Estimation of Maize Output Commercialisation

From equations (28) and (29), the specific model for estimation of maize output commercialisation is stated as follows:

\[
m_i = \alpha + \lambda_1 \ln(x_{i1}) + \lambda_2 \ln(x_{i2}) + \lambda_3 \ln(x_{i3}) + \lambda_4 \ln(x_{i4}) + \lambda_5 \ln(x_{i5}) + \lambda_6 \ln(x_{i6}) + \lambda_7 \ln(x_{i7}) + \lambda_8 \ln(x_{i8}) + \lambda_9 \ln(x_{i9}) + \beta_1 Urban_i + \beta_2 IDPCamp_i + \beta_3 HHsize_i + \\
\beta_4 Gender_i + \beta_5 Age_i + \beta_6 Educ_i + \beta_7 Ext_i + \beta_8 NAADS_i + \beta_9 Group_i + \\
\beta_{10} \ln(Lvstk_i) + \beta_{11} Credit_i + \beta_{12} Roaddist_i + \beta_{13} Central_i + \beta_{14} Notherrn_i + \\
\beta_{15} Western_i
\]  

(30)

The dependent variable in equation (30) is the output commercialisation index, which ranges between 0 and 1. All the explanatory variables in equation (30), except \( x_8 \) and \( x_9 \) are as in equation (27), hence defined and measured as in Table 4.2. The new variables \( x_8 \) and \( x_9 \) are price of maize grain and yield respectively. Furthermore, the signs of the coefficients of the explanatory variables \( x_1, \ldots, x_7 \) in equation (30) are also expected to take the same direction as those in Table 4.2. Both \( x_8 \) and \( x_9 \) are expected to take positive signs since increase in price and yield may act as incentives for increased participation in the market (Tefera et al., 2003; Gebreselassie and Ludi, 2007). With regard to variables relating to farmer characteristics in equation (30), the explanation of effect of these variables on output commercialisation is similar to the explanation made with respect to their effect on productivity. However, sign of the coefficients of these variables are expected to take the opposite to those in Table 4.2. A summary of definitions, measurements and expected signs of the explanatory variables in equation (30) are presented in Table 4.3.
Table 4.3. Definition, Measurement and expected signs of Output Commercialisation Model Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
<th>Measurement /value</th>
<th>Expected sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ln(x1)</td>
<td>Improved seed</td>
<td>Uganda shillings per hectare (Ugx/ha), expressed in natural logarithm (Ln)</td>
<td>+</td>
</tr>
<tr>
<td>Ln(x2)</td>
<td>Fertiliser</td>
<td>Ugx/ha, expressed in natural logarithm (Ln)</td>
<td>+</td>
</tr>
<tr>
<td>Ln(x3)</td>
<td>Fungicides/herbicides</td>
<td>Ugx/ha, expressed in natural logarithm (Ln)</td>
<td>+</td>
</tr>
<tr>
<td>Ln(x4)</td>
<td>Traction (tractor/animal)</td>
<td>Ugx/ha, expressed in natural logarithm (Ln)</td>
<td>+</td>
</tr>
<tr>
<td>Ln(x5)</td>
<td>Manure</td>
<td>Quantity in Kilograms per hectare (Kg/ha), expressed in natural logarithm (Ln)</td>
<td>+</td>
</tr>
<tr>
<td>Ln(x6)</td>
<td>Size of area cultivated with maize</td>
<td>Hectares (ha) expressed in natural logarithm (Ln)</td>
<td>-</td>
</tr>
<tr>
<td>Ln(x7)</td>
<td>Hired labour</td>
<td>Ugx/ha, expressed in natural logarithm (Ln)</td>
<td>+</td>
</tr>
<tr>
<td>Ln(x8)</td>
<td>Maize grain price</td>
<td>Ugx/kg, expressed in natural logarithm (Ln)</td>
<td>+</td>
</tr>
<tr>
<td>Ln(x9)</td>
<td>Yield</td>
<td>t/ha</td>
<td>-</td>
</tr>
<tr>
<td>Urban</td>
<td>Location in urban area</td>
<td>1 = urban, 0 = rural</td>
<td>+</td>
</tr>
<tr>
<td>IDPcamp</td>
<td>Live in internally displaced people’s (IDP).camp</td>
<td>1 = IDP, 0 = non-IDP</td>
<td>-</td>
</tr>
<tr>
<td>HHsize</td>
<td>Size of household of farmer</td>
<td>Number of household members</td>
<td>+/-</td>
</tr>
<tr>
<td>Gender</td>
<td>Sex of maize farmer</td>
<td>1 = male, 2 = female</td>
<td>+</td>
</tr>
<tr>
<td>Age</td>
<td>Age of maize farmer</td>
<td>Years</td>
<td>+/-</td>
</tr>
<tr>
<td>Educ</td>
<td>Education of maize farmer</td>
<td>10 = no formal schooling; 11 - 17 = P1 – p7; 21 – 23 = J1 – J3; 31 – 36 = S1 - S6; 41 = Post primary; 51 = post secondary; 61 = degree and above</td>
<td>+/-</td>
</tr>
<tr>
<td>Ext</td>
<td>Farmer access to extension services</td>
<td>1 = yes, 0 = no</td>
<td>+</td>
</tr>
<tr>
<td>NAADS</td>
<td>Farmer membership to NAADS programme</td>
<td>1 = yes, 0 = no</td>
<td>+</td>
</tr>
<tr>
<td>Group</td>
<td>Farmer membership to farmer association</td>
<td>1 = yes, 0 = no</td>
<td>+</td>
</tr>
<tr>
<td>Credit</td>
<td>Farmer obtained credit</td>
<td>1 = yes, 0 = no</td>
<td>+</td>
</tr>
<tr>
<td>Roaddist</td>
<td>Farmer distance to the gravel road</td>
<td>Kilometres (Km)</td>
<td>-</td>
</tr>
<tr>
<td>Ln(Lvstk)</td>
<td>Value of household livestock and poultry</td>
<td>Uganda shillings (Ugx), expressed in natural logarithm (Ln)</td>
<td>+/-</td>
</tr>
<tr>
<td>Central</td>
<td>Central Uganda</td>
<td>1 = if maize producer from Central Uganda, 0 otherwise</td>
<td>-/+</td>
</tr>
<tr>
<td>Northern</td>
<td>Northern Uganda</td>
<td>1 = if maize producer from Northern Uganda, 0 otherwise</td>
<td>-/+</td>
</tr>
<tr>
<td>Western</td>
<td>Western Uganda</td>
<td>1 = if maize producer from Western Uganda, 0 otherwise</td>
<td>-/+</td>
</tr>
</tbody>
</table>

Note: Educ: P = primary education J = Junior secondary education and S = Senior secondary education; Eastern is the base case region for comparison with Central, Northern and Western regions
4.4 Reliability of the Estimates

Data used in this study were cross-sectional, which may not be normally distributed across the sample (Deaton, 1997). Use of irregularly distributed data in a regression analysis may result into inefficient estimates (Greene, 1993). Hence, data for continuous variables were tested for normality using the normality distribution graph procedure. Variables that were found not to be normally distributed were normalised by transforming the values into natural logarithm. In Appendix 4, some of the normal distribution graphs are shown. During the analysis, data were weighted using inflation factors to improve the efficiency of the estimates as well as to make the analysis nationally representative (Deaton, 1997). The UNHS 2005/06 data include weights or inflation factors. Possible multicollinearity of variables representing farmer characteristics were tested using the pair-wise correlation analysis method, which indicated no significant correlation among variables (Appendix 5).

When inflation factors are included in the analysis, model specification problems are minimised, efficiency of estimates improved and as such post-estimation statistics such as the Breusch-Pagan/Cook-Weisberg test for heteroskedasticity are not necessary (Deaton, 1997). Thus, in this study, besides the marginal effect statistics estimated for improved inputs use and output commercialisation models, no other post-estimation statistics were estimated. All the results presented in this study were performed in STATA/SE 10.0.
5.1 Introduction

This chapter addressed objective one of the study. In section 5.2, the descriptive analysis of the characteristics of households engaged in maize production is presented, followed by the econometric analysis of the determinants of improved inputs (improved seed, fertiliser, fungicide/herbicide and traction) use in section 5.3. A summary of the results in the chapter is presented in section 5.4.

5.1 Descriptive Results

5.1.1 Socioeconomic Characteristics of Maize Producers

Table 5.1 gives the mean values of the characteristics of maize farmers in Uganda, based on a sample of 1888 plots-level observations. The mean values of the variables across region are given in three parts, namely for improved inputs, other inputs and farmer characteristics. At national level, Table 5.1 indicates that 11.5 percent of maize farmers used improved seed, 1.5 percent used fertiliser, 3.3 percent used fungicides/herbicides and 11.9 percent used traction. These figures compare well with those reported by UBoS (2007) for household use of these inputs on various crops.
Table 5.1: Selected socio-economic characteristics of maize producers by region

<table>
<thead>
<tr>
<th>Variable</th>
<th>Central</th>
<th>Eastern</th>
<th>Northern</th>
<th>Western</th>
<th>Uganda</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Improved inputs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved seed use (dummy)</td>
<td>9.76</td>
<td>15.88</td>
<td>5.82</td>
<td>5.73</td>
<td>11.07</td>
</tr>
<tr>
<td>Fertiliser use (dummy)</td>
<td>0.54</td>
<td>2.49</td>
<td>0.55</td>
<td>0.96</td>
<td>1.48</td>
</tr>
<tr>
<td>Fungicide/herbicide use (dummy)</td>
<td>7.32</td>
<td>2.84</td>
<td>1.39</td>
<td>1.91</td>
<td>3.28</td>
</tr>
<tr>
<td>Traction use (dummy)</td>
<td>3.52</td>
<td>18.36</td>
<td>13.02</td>
<td>2.87</td>
<td>11.86</td>
</tr>
<tr>
<td><strong>Other inputs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manure (kg)</td>
<td>21.33</td>
<td>2.55</td>
<td>0.00</td>
<td>15.75</td>
<td>7.93</td>
</tr>
<tr>
<td>Plot size (ha)</td>
<td>0.25</td>
<td>0.30</td>
<td>0.27</td>
<td>0.41</td>
<td>0.31</td>
</tr>
<tr>
<td>Hired labour (man-days)</td>
<td>19.23</td>
<td>9.06</td>
<td>19.20</td>
<td>35.26</td>
<td>17.93</td>
</tr>
<tr>
<td>Hired labour (Ugx, millions)</td>
<td>0.035</td>
<td>0.014</td>
<td>0.015</td>
<td>0.042</td>
<td>0.024</td>
</tr>
<tr>
<td>Family labour (man-days)</td>
<td>296.51</td>
<td>256.24</td>
<td>201.91</td>
<td>259.96</td>
<td>255.87</td>
</tr>
<tr>
<td><strong>Farmer characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban (dummy)</td>
<td>7.05</td>
<td>9.36</td>
<td>19.67</td>
<td>15.29</td>
<td>11.86</td>
</tr>
<tr>
<td>IDP camp (dummy)</td>
<td>0.00</td>
<td>0.00</td>
<td>5.82</td>
<td>0.00</td>
<td>1.11</td>
</tr>
<tr>
<td>Sex (dummy)</td>
<td>76.69</td>
<td>76.66</td>
<td>78.39</td>
<td>82.48</td>
<td>77.97</td>
</tr>
<tr>
<td>HHsize (number)</td>
<td>6.47</td>
<td>6.59</td>
<td>6.37</td>
<td>6.31</td>
<td>6.48</td>
</tr>
<tr>
<td>Age (years)</td>
<td>42.56</td>
<td>43.03</td>
<td>41.94</td>
<td>43.94</td>
<td>42.88</td>
</tr>
<tr>
<td>Educ (years)</td>
<td>20.14</td>
<td>18.93</td>
<td>20.13</td>
<td>19.20</td>
<td>19.44</td>
</tr>
<tr>
<td>Ext (dummy)</td>
<td>11.65</td>
<td>16.0</td>
<td>11.63</td>
<td>21.66</td>
<td>15.25</td>
</tr>
<tr>
<td>NAADS (dummy)</td>
<td>23.04</td>
<td>25.24</td>
<td>17.17</td>
<td>26.43</td>
<td>23.46</td>
</tr>
<tr>
<td>Group (dummy)</td>
<td>4.07</td>
<td>5.57</td>
<td>5.26</td>
<td>8.60</td>
<td>5.72</td>
</tr>
<tr>
<td>Credit (dummy)</td>
<td>3.52</td>
<td>3.32</td>
<td>2.22</td>
<td>6.37</td>
<td>3.65</td>
</tr>
<tr>
<td>Lvstk (Ugx, millions)</td>
<td>0.73</td>
<td>0.32</td>
<td>0.39</td>
<td>0.89</td>
<td>0.51</td>
</tr>
<tr>
<td>Roaddist (km)</td>
<td>4.25</td>
<td>4.34</td>
<td>2.49</td>
<td>3.44</td>
<td>3.82</td>
</tr>
</tbody>
</table>

Note: Continuous variables are expressed as mean while dummy variables are expressed in percent

Source: Author’s calculations based on UNHS 2005/6

Comparison of improved inputs use by region shows that a higher proportion of farmers in Eastern Uganda used improved seed, fertilisers as well as traction in maize production. Other studies including Deininger and Okidi (2001) and Sserunkuma (2007) report similar results. Fertiliser use in Eastern Uganda, particularly in highland areas of Kapchorwa and Mbale districts is a common practice to replenish soil fertility in these areas that are prone to agents of soil nutrient depletion such as erosion (Nkonya et al.
2004). The relatively high proportion of farmers using traction in Eastern and Northern Uganda may be partly due to the long tradition of oxen plough cultivation in these regions, which was introduced in the early 1900s and supported through government extension services over the years (Lubwama, 2000). In the case of fungicides/herbicides use, Central Uganda had 7.2 percent of maize farmers using these chemicals in maize production compared to the national average of 3.3 percent of farmers. The high than national average use of fungicides/herbicides in the Central region may be the alternative method of controlling weeds in the case of herbicides use.

Regarding other inputs in maize production, farmers in Central Uganda used the highest average quantity of manure per hectare of maize cultivated, followed by farmers in Western Uganda. High application of manure in maize production in Central and Western Uganda may be due to the tradition of livestock rearing, farm-yard manure use and mulching in crop cultivation in these areas (Bakunda and Woomer, 1996). Also, under NAADS and the Area Based Agricultural Modernisation Programme (AAMP), farmers in Western Uganda have received adequate training regarding the preparation and use of farm-yard manure that is abundant at household level (Benin et al. 2007). In terms of size of land and hired labour used in maize production, farmers in Western Uganda on average cultivated larger plots of maize as well as spent a higher amount of money on labour hire compared to other regions. Farmers in Central and Western Uganda used more family labour per hectare of maize cultivated than farmers in Northern and Eastern Uganda most likely due to limited use of traction. Comparison of the quantity of hired labour vis-à-vis family labour use indicates that maize farmers in Uganda used about fifteen times more family labour than hired labour.
Regarding farmer characteristics, about 12 percent of maize producers lived in urban centres in Uganda, with the highest of 15.3 percent in Northern Uganda and the lowest of 7.1 percent of maize producers in Central Uganda urban areas (Table 5.1). The somewhat higher proportion of maize farmers in Northern Uganda being in urban areas in 2005/06 may be due the fact that a large number of people in Northern Uganda had abandoned rural locations for safety in urban centres due to civil insecurity brought about by Kony rebels. One percent of maize producers in the study sample lived in IDP camps, specifically in Northern Uganda. Most of the maize plots were managed by male farmers while the average household size of maize producers was 6.5 persons. The average age of the farmer ranged between 41.9 years in Northern Uganda and 43.9 years in Western Uganda. The average level of education of maize farmers was slightly above primary seven (17), with the highest level at 20.1 in Central Uganda and the lowest level at 18.9 in Eastern Uganda.

Access to extension services by maize producers in Uganda was only 15.3 percent, with the highest access rate of 21.7 percent in Western Uganda and the lowest rate of 11.6 percent for farmers in Central and Northern Uganda. About 23.4 percent of maize farmers were enlisted in the NAADS programme, of which, Western Uganda had the highest proportion of maize farmers in the programme and Northern Uganda had the lowest proportion. The average number of maize farmers who reported being in production groups was quite low (5.7 percent) contrary to the proportion of the farmers in NAADS programme, which encourages participation of farmers in production and marketing groups.
A small percentage of maize farmers accessed credit, ranging from 2.2 percent of farmers in Northern Uganda to 6.4 percent in Western Uganda. In addition, on average, maize farmers in Western Uganda had a higher value of livestock compared to their peers in other regions. The final observation to make from Table 5.1 is that farmers in Eastern and Central Uganda were on average 4 km away from the nearest all-weather gravel (murrum) road compared to 2.5 km for farmers in Northern Uganda and 3.4 km for farmers in Western Uganda.

### 5.1.2 Expenditure on Improved Inputs in Maize Production

Table 5.2 shows the average expenditure on improved inputs per hectare cultivated for only those farmers who used these inputs in maize production. Farmers who did not use improved inputs were not included in analysis; since their expenditure on these inputs was zero and hence their inclusion would only distort the true average value for those used the input. The total amount spent on improved inputs per hectare of maize production ranged from as low as Ugx 0.1 million in Northern Uganda to as high as Ugx 0.426 million in Western Uganda.

Table 5.2. Average Expenditure (Ugx, millions) Per Hectare for Farmers who Used Improved Inputs in Maize Production

<table>
<thead>
<tr>
<th>Region</th>
<th>Improved seed</th>
<th>Fertiliser</th>
<th>Fungicides/Herbicides</th>
<th>Traction</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central</td>
<td>0.038</td>
<td>0.028</td>
<td>0.033</td>
<td>0.050</td>
<td>0.149</td>
</tr>
<tr>
<td>Eastern</td>
<td>0.033</td>
<td>0.046</td>
<td>0.027</td>
<td>0.055</td>
<td>0.161</td>
</tr>
<tr>
<td>Northern</td>
<td>0.021</td>
<td>0.002</td>
<td>0.018</td>
<td>0.059</td>
<td>0.100</td>
</tr>
<tr>
<td>Western</td>
<td>0.086</td>
<td>0.087</td>
<td>0.059</td>
<td>0.194</td>
<td>0.426</td>
</tr>
<tr>
<td>Uganda</td>
<td>0.037</td>
<td>0.046</td>
<td>0.032</td>
<td>0.061</td>
<td>0.176</td>
</tr>
</tbody>
</table>

Source: Author’s calculations based UNHS 2005/6
Although a smaller proportion of maize farmers in Western Uganda used improved inputs compared to their counterparts in Eastern and Central Uganda (Table 5.1), these farmers from Western Uganda on average spent the highest amount on improved seed, fertilisers, fungicides/herbicides and traction per hectare of maize cultivated. The comparably high amount of money spent by farmers in Western Uganda on improved inputs in maize production may indicate that these farmers used more quantity of inputs per hectare assuming that the average price of these inputs was fairly the same across regions.

5.3 Regression Results

Estimated marginal effect values including Z-values of the MLM for improved seed, fertiliser, fungicides/herbicides and traction use in maize production are presented in Table 5.3. In the MLM regression, the base outcome was non-use of improved seed, fertiliser, fungicides/herbicides and traction. The MLM coefficients from which marginal effect values were obtained are given in Appendix 6. Wald Chi square statistic suggests that the overall model is statistically significant at less than one percent level. The predictions from MLM results in the last row in Table 5.3 indicate that the probability of farmers not currently using improved inputs in maize production to adopt and use improved maize seed was about 7 percent; adopt and use fertiliser was one-tenth of one percent; adopt and use fungicides/herbicides was one-third of one percent; and adopt and use traction was 2 percent. The predictions suggest generally of the monumental resources that may be required in terms of advise and training to support farmers effectively increase the use of improved inputs in maize production in Uganda.
Table 5.3: Marginal Effects of the MLM for Improved Inputs Use in Maize Production

| Variable | Improved Seed | | Fertiliser | | Fungicide/herbicide | | Traction | |
|----------|---------------|---------|------------|---------|------------------|---------|----------|
|          | Marginal effect | z       | Marginal effect | z       | Marginal effect | z       | Marginal effect | z       |
| Urban    | 0.042***       | 3.14    | 0.001       | 0.69    | 0.000           | -0.26   | 0.005       | 1.06    |
| IDPcamp  | -0.059***      | -5.86   | -0.002***   | -2.98   | -0.004***       | -4.89   | 0.004       | 0.31    |
| HHsize   | 0.000          | -0.34   | 0.000       | 0.7     | 0.000           | 1.41    | 0.000       | 1.07    |
| Gender   | 0.007          | 0.93    | -0.001      | -0.87   | 0.001*          | 1.8     | 0.001       | 0.36    |
| Age      | -0.001*        | -1.89   | 0.000       | -0.62   | 0.000           | -1.49   | 0.000       | -0.96   |
| Educ     | 0.000          | -0.64   | 0.000       | -1.39   | 0.000           | -1.72   | 0.000       | -0.21   |
| Ext      | 0.007          | 0.61    | 0.001       | 1.36    | 0.000           | -0.2    | 0.003       | 0.79    |
| Group    | 0.009          | 0.54    | -0.001      | -1.55   | 0.004           | 1.26    | 0.000       | -0.09   |
| NAADS    | -0.007         | -0.98   | 0.000       | -0.46   | 0.000           | -0.03   | -0.006***   | -2.11   |
| Credit   | 0.013          | 0.74    | 0.000       | 0.27    | 0.000           | -0.91   | 0.009       | 1.2     |
| Roaddist | 0.007          | 1.00    | 0.002***    | 2.96    | 0.000           | 0.32    | 0.000       | 0.08    |
| Central  | -0.034***      | -4.96   | 0.000       | -0.29   | 0.004           | 1.55    | -0.016***   | -5.66   |
| Northern | -0.034***      | -4.51   | 0.001       | 1.3     | -0.001          | 0.97    | 0.004       | 1.24    |
| Western  | -0.048***      | -7.29   | 0.000       | -0.41   | -0.001          | -1.34   | -0.023***   | -7.88   |
| Ln(Lvstk)| -0.001         | -1.44   | 0.000       | -0.05   | 0.000           | -0.18   | 0.001       | 1.76    |
| Ln(Plotsize)| 0.001      | 0.27    | 0.000       | -0.14   | 0.000           | 0.47    | 0.006***    | 4.56    |
| Ln(manure)| 0.005         | 1.49    | -0.004***   | -2.98   | 0.000           | 0.65    | 0.000       | 0.03    |
| Ln(hiredlbr) | 0.003***      | 4.35    | 0.001**     | 2.33    | 0.001***        | 5.28    | 0.001***    | 4.64    |
| Number of obs. | 1888     |         |             |         |             |         |             |         |
| Wald chi square | 37694.11*** |         |             |         |             |         |             |         |
| Log pseudolikelihood | -3252.89 |         |             |         |             |         |             |         |
| Predicted probability | 0.070   | 0.001   | 0.003       | 0.017   |             |         |             |         |

Note: $Y_j = 0$ is the base outcome, Eastern is the base case region for comparison with regions; ***, ** and * imply statistically significant at 1, 5, and 10 percent.

Source: Author’s calculations based on UNHS 2005/06 data
5.3.1 Determinants of Improved Seed Use in Maize Production

As hypothesized, location of farmers in urban areas, significantly (p<0.01) increased their probability to use improved maize seed while location of farmers in IDP camps reduced the probability to use improved seed. Estimated marginal effect for urban and IDP camp variables suggest that these location factors had a considerable influence on the decisions of farmers to use improved seed in maize production. Location of farmers in urban areas is comparable to being close to markets, which has a positive effect on access and use of improved inputs. This result is similar earlier studies including Deininger and Okidi (2001) who found rural location of farmers as a constraint to access and use of purchased inputs. On the other hand, maize farmers living in IDP camps had a lower probability of using improved maize seed. This was most likely due to the higher level of poverty among people living in Northern Uganda in general and those who were living in IDP camps in particular (UBoS, 2006). From a policy perspective, this result suggests that government efforts to reduce poverty particularly in Northern Uganda would go a long way to increase the use of improved inputs in maize production in the country.

Age had some significant (p< 0.1) influence on the decision of maize farmers to use improved seeds. Results in Table 5.3 suggest that older farmers were less likely to use improved maize seed compared to the young farmers, which supports earlier findings by Deininger and Okidi (2001). Lawal and Oyule, 2008; Akramov, 2009 and Tabi et al, 2010 obtained similar results for their respective studies conducted in Nigeria. The

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5 Due to improved security in Northern Uganda, the IDP camps have been closed down and people formerly living in the camps have been resettled in areas they previously came from at the height of civil insecurity from Kony rebels.
inverse relationship between age and use of improved seeds may be due to information and transport-related constraints that older farmers may face in accessing markets (Langyintuo and Mekuria, 2005), especially in the rural areas of Uganda.

Regional location dummies for Central, Northern and Western Uganda were negative and significant at less than one percent level, suggesting that use of improved maize seed in these regions was much lower than in Eastern Uganda, which was the base case scenario in the analysis. This result is not only similar to that in the descriptive statistics in Table 5.1 but also indicates a high statistical significance, which indicated that a higher proportion of farmers in Eastern Uganda used improved seed in maize production compared to their colleagues in other regions.

Lastly, as hypothesized, use of hired labour was significant (p< 0.01) as far as the decision of farmers to use improved seed in maize production was concerned. Farmers who spent more on hired labour had a higher probability of using improved seed. Ntege-Nanyeenya et al. (1997) is one other study with similar results. Farmers spending more on hiring farm labour are likely to have a higher disposable income, which may as well enable them to purchase and use improved seed in maize production.

### 5.3.2 Determinants of Fertiliser Use in Maize Production

Results in Table 5.3 show that living in IDP camp, distance to all-weather gravel road, manure use and hired labour use had a considerable effect on farmer use of fertiliser in maize production.
The IDP camp variable was negative and statistically significant at less than one percent level. As explained in the preceding sub-section, in Uganda, people who were living in IDP camps in particular and Northern Uganda in general were poorer compared to people not living in IDP camps (UBoS, 2006) and hence farmers in IDP camps were most likely not capable of adequate means to buy and use fertiliser compared to farmers who were not living in IDP camps. Thus, from a policy context, government intervention such as the Peace, Recovery and Development Plan for Northern Uganda (PRDP) that started in 2008 with revitalization of Northern Uganda economy as one its core objectives is important in uplifting the farmers’ capacity to use improved inputs in production of crops such as maize.

Distance of the farmer to all-weather gravel road also had a negative and statistically significant (p< 0.01) impact on farmers’ decision to use fertiliser. Farmers that are isolated from input and output markets due to road infrastructure constraints are less likely to use improved inputs. Other studies have also indicated the inverse relationship between distance to road and use of improved production inputs (Strasberg et al., 1999; Deininger and Okidi, 2001; Sserunkuma, 2005; Stifel and Minten, 2008).

The marginal effect value for manure was negative and highly significant (p< 0.01), implying that farmers using larger quantities of manure were less likely to use fertiliser in maize production. This is not surprising given that in regions such as Central and Western Uganda, organisations such as NAADS and AAMP have trained farmers in

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6 Further details on PRDP, [http://www.ugandachusters.ug/dwnlds/0502Programs/PRDP/AboutPRDP.pdf](http://www.ugandachusters.ug/dwnlds/0502Programs/PRDP/AboutPRDP.pdf)
composting and use of farm-yard manure as an alternative method of soil fertility management (Benin et al., 2007).

The probability of farmers using fertiliser in maize production increased with increased expenditure on hired labour. The result was moreover statistically significant at less than 5 percent level. A related study with similar results is Ntege-Nanyeenya et al. (1997). As explained in the preceding sub-section, farmers who are capable of spending larger amounts of money on hiring farm labour are likely to be better off in terms of income and hence able to purchase and use improved inputs such as fertiliser in maize production.

5.3.2 Determinants of Fungicides/Herbicides Use in Maize Production

Living in IDP camp again stood out as a factor that significantly (p<0.01) reduced the probability of a farmer to use fungicides/herbicides in maize production. As expected, results in Table 5.3 suggest that fungicides/herbicides use in maize production was positively correlated (p< 0.1) with the farm manager or household head being male. The result is similar to Nabbumba (2008) who found that in Uganda, a higher proportion of male headed households than female headed households used fungicides/herbicides in agriculture. The higher probability of male headed households using fungicides/herbicides in maize production than female headed households may be related to economic status and/or level of information access by households. In Uganda, male farm household heads have an upper hand in access to extension training and visits (Nabbumba, 2008) besides being better-off economically (UBoS, 2006; 2010).
Results in Table 5.3 also indicate a statistically significant ($p<0.01$) and positive relationship between fungicides/herbicides use and increased expenditure on hired labour in maize production. The possible explanation to offer for this relationship is similar to that already presented for the observed relationship between farmers’ increased expenditure on hired labour and the higher probability of using improved seed and/or fertiliser.

5.3.2 Determinants of Traction Use in Maize Production

Results in Table 5.3 indicate that farmers being in NAADS programme, Central Uganda, Western Uganda as well as cultivating bigger plots and using hired labour had a highly significant ($p<0.01$) impact on use of traction in maize production.

The marginal effect values for Central and Western were negative and had the highest magnitude. This suggests that the probability of maize farmers in Central and Western Uganda to use traction was considerably lower than in Eastern Uganda. These results are in line with the observation made by Lubwana (2000) that traction use (particularly animal traction) is dominant in Eastern Uganda and least practised in Central and Western Uganda since the introduction of animal traction technology in Uganda in 1909. Although availability of livestock such as cattle is one of the necessary conditions for use of animal traction, abundance of livestock in Western and Central Uganda has not led to increased use of animal traction in cultivation. According to Lubwana (2000), this is partly due to inherent cultural barriers, related to use animal traction by both men and women. Besides animal traction, use of tractors in Central and Western region is also
estimated to be lower compared to Eastern Uganda (Odogola and Olaunah, 2002 cited in Sambrook, 2005).

Contrary to expectation, the probability of maize farmers under NAADS using traction was lower compared to farmers not in NAADS programme. The low probability for NAADS farmers as far as use of traction is concerned may be related to the fact that a large proportion of farmers in NAADS programme were from Western and Central Uganda (Table 5.1), where use of traction in cultivation is inherently low.

As hypothesized, traction use was positively associated with area cultivated and use of hired labour. The marginal effect for plot size was high and significant ($p<0.01$), confirming the proposition that use of traction, particularly oxen-ploughing in Eastern Uganda was associated with farmers who cultivated larger areas (Lubwama, 2000). The positive relationship between traction use and increased expenditure on hired labour may arise from the fact that farmers who spend more on hired labour may be non-poor and hence are capable of procuring and using other factor inputs such as traction in maize production.

4.6 Summary

This chapter examined the internal and external factors that influence the decision of farmers to use improved inputs in maize production in Uganda. A higher proportion of farmers in Eastern Uganda than any other region used improved seed, fertiliser and traction in maize production while more farmers in Central Uganda used fungicides/herbicides. Maize farmers in Central Uganda on average used more manure
and family labour while farmers in Western Uganda on average cultivated larger plots and spent more on hire labour.

Results of MNL regression revealed that farmers living in Northern Uganda in general and IDP camps in particular had a lower probability of using improved seed, fertilisers and fungicides/herbicides in maize production. Farmers living in Central and Western Uganda had a lower probability of using improved seed and traction in maize production compared to those in Eastern Uganda. Maize producers spending more on hired labour had a higher probability of using all improved inputs (improved seed, fertilisers, fungicides/herbicides and traction). Use of manure in maize production was observed to be more of a substitute to fertiliser use than a compliment. Maize producers residing in urban areas had a higher probability of using improved seed while those who cultivated larger plots were associated more with traction use.
6.1 Introduction

This chapter examined the relationship between improved inputs use and productivity in maize production in Uganda, and hence addressed objective two of the study. The descriptive analysis is presented in section 6.2 while the econometric analysis is presented in section 6.3. Section 6.4 summarises the findings in the chapter.

6.2 Descriptive Analysis

6.2.1 Descriptive Statistics on Maize Production and Productivity

The mean value of variables on maize production and productivity per hectare by region, are presented in Table 6.1. Examination of Table 6.1 reveals that farmers in Western Uganda, on average used more resources including area cultivated, labour (which includes both hired labour and family labour), and amount spent on purchased inputs per hectare of maize produced, than their peers in any other region. Furthermore, farmers in Western Uganda obtained the highest output and revenue from maize production.
<table>
<thead>
<tr>
<th></th>
<th>Variable</th>
<th>Central</th>
<th>Eastern</th>
<th>Northern</th>
<th>Western</th>
<th>Uganda</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Area (ha)</td>
<td>0.25</td>
<td>0.30</td>
<td>0.27</td>
<td>0.41</td>
<td>0.31</td>
</tr>
<tr>
<td>B</td>
<td>Total labour (man-days)</td>
<td>96.1</td>
<td>101.72</td>
<td>80.55</td>
<td>145.81</td>
<td>103.91</td>
</tr>
<tr>
<td>C</td>
<td>Output (t)</td>
<td>0.5</td>
<td>0.72</td>
<td>0.37</td>
<td>0.73</td>
<td>0.61</td>
</tr>
<tr>
<td>D</td>
<td>Maize price (Ugx/kg)</td>
<td>213</td>
<td>190</td>
<td>202</td>
<td>195</td>
<td>198</td>
</tr>
<tr>
<td>E</td>
<td>Total variable cost (Ugx, millions)</td>
<td>0.045</td>
<td>0.036</td>
<td>0.028</td>
<td>0.068</td>
<td>0.042</td>
</tr>
<tr>
<td>F</td>
<td>Imputed cost of family labour and land (Ugx, millions)</td>
<td>0.277</td>
<td>0.233</td>
<td>0.133</td>
<td>0.38</td>
<td>0.247</td>
</tr>
<tr>
<td>G</td>
<td>Overall cost of production (Ugx, millions)</td>
<td>0.322</td>
<td>0.269</td>
<td>0.161</td>
<td>0.448</td>
<td>0.289</td>
</tr>
<tr>
<td>H</td>
<td>Total revenue (Ugx, millions)</td>
<td>0.204</td>
<td>0.247</td>
<td>0.134</td>
<td>0.299</td>
<td>0.226</td>
</tr>
<tr>
<td>I</td>
<td>Yield (t/ha)</td>
<td>1.92</td>
<td>2.25</td>
<td>1.42</td>
<td>1.86</td>
<td>1.96</td>
</tr>
<tr>
<td>J</td>
<td>Labour productivity (kg/man-day)</td>
<td>5.23</td>
<td>7.04</td>
<td>4.61</td>
<td>5</td>
<td>5.83</td>
</tr>
<tr>
<td>K</td>
<td>Labour productivity (Ugx/man-day)</td>
<td>1114</td>
<td>1339</td>
<td>933</td>
<td>975</td>
<td>1154</td>
</tr>
<tr>
<td>L</td>
<td>Agriculture labour wage (Ugx/man-day)</td>
<td>1775</td>
<td>1178</td>
<td>1046</td>
<td>1214</td>
<td>1276</td>
</tr>
<tr>
<td>M</td>
<td>Labour productivity/wage (ratio)</td>
<td>0.6</td>
<td>1.1</td>
<td>0.9</td>
<td>0.8</td>
<td>0.9</td>
</tr>
<tr>
<td>N</td>
<td>Gross profit (Ugx, millions)</td>
<td>0.158</td>
<td>0.211</td>
<td>0.107</td>
<td>0.23</td>
<td>0.184</td>
</tr>
<tr>
<td>O</td>
<td>Net profit (Ugx, millions)</td>
<td>-0.119</td>
<td>-0.022</td>
<td>-0.026</td>
<td>-0.149</td>
<td>-0.063</td>
</tr>
</tbody>
</table>

Note: Continuous variables are expressed as mean.
Source: Author’s calculations based on UNHS 2005/06
On the other hand, farmers in Northern Uganda used on average the lowest resources in terms of area cultivated, labour and amount spent on purchased inputs per hectare of maize cultivated. In addition, farmers in Northern region obtained the lowest output and revenue from maize production, although the average price of maize grain in this region was the second highest in the country.

As regards productivity, maize farmers in Western Uganda obtained the second lowest average yield and labour productivity but the highest average gross profit on one hand and highest negative net profit on the other hand. In contrast, maize farmers in Eastern Uganda obtained the highest average yield, labour productivity and the lowest negative net profit. Considering the value of labour productivity in maize production vis-à-vis agricultural wage rate (Row M) the monetary payback to labour expended in maize production in Central, Northern and Western Uganda was lower than the community wage rate.

6.2.2 Improved Inputs Use Options and Maize Productivity

Farmers face challenges in deciding on what combination of inputs to use in production given the diverse inputs on the market and the expected outcomes from using such inputs. This is besides their economic status that also has an effect on the choice of improved inputs to use in production. Some of the outcomes on yield, labour productivity and gross profit as regards the different combinations of improved inputs that farmers used in maize production, given other inputs are presented in Table 6.2.
### Improved Inputs Use Combinations and Maize productivity

<table>
<thead>
<tr>
<th>Row</th>
<th>Improved input use option</th>
<th>Percentage of farmers</th>
<th>Yield (t/ha)</th>
<th>Labour productivity (Ugx/man-day)</th>
<th>Gross Profit (Ugx, millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>No improved inputs used</td>
<td>55.19</td>
<td>1.869</td>
<td>1218</td>
<td>0.240</td>
</tr>
<tr>
<td>B</td>
<td>Improved seed only</td>
<td>7.10</td>
<td>2.475</td>
<td>1701</td>
<td>0.259</td>
</tr>
<tr>
<td>C</td>
<td>Fertiliser only</td>
<td>0.2</td>
<td>1.234</td>
<td>1076</td>
<td>0.146</td>
</tr>
<tr>
<td>D</td>
<td>Fungicides/herbicides only</td>
<td>0.8</td>
<td>2.075</td>
<td>2896</td>
<td>0.252</td>
</tr>
<tr>
<td>E</td>
<td>Traction only</td>
<td>5.2</td>
<td>1.918</td>
<td>3182</td>
<td>0.151</td>
</tr>
<tr>
<td>F</td>
<td>Improved seed and fertiliser only</td>
<td>0.95</td>
<td>1.902</td>
<td>1147</td>
<td>0.33</td>
</tr>
<tr>
<td>G</td>
<td>Improved seed and Fungicides/herbicides only</td>
<td>0.53</td>
<td>3.776</td>
<td>12059</td>
<td>0.778</td>
</tr>
<tr>
<td>H</td>
<td>Improved seed and traction only</td>
<td>2.38</td>
<td>2.816</td>
<td>8700</td>
<td>0.808</td>
</tr>
<tr>
<td>I</td>
<td>Improved seed, fertiliser and Fungicides/herbicides only</td>
<td>0.42</td>
<td>3.99</td>
<td>1097</td>
<td>0.06</td>
</tr>
<tr>
<td>J</td>
<td>Improved seed, fertiliser and traction only</td>
<td>0.64</td>
<td>5.258</td>
<td>5009</td>
<td>0.693</td>
</tr>
<tr>
<td>K</td>
<td>All improved inputs (improved seed, fertiliser, Fungicides/herbicides and traction)</td>
<td>0.26</td>
<td>2.471</td>
<td>1218</td>
<td>0.213</td>
</tr>
</tbody>
</table>

Author’s calculations based on UNHS 2005/6
The combinations of improved inputs that farmers used in maize production range from non-use of improved inputs (Row A) to use of all the four improved inputs (Row K). Out of the total sample (1888), the proportion of farmers using different combinations of improved inputs is shown in column two. About 55 percent of maize farmers never used improved seed, fertiliser, fungicides/herbicides and traction in production while about one-quarter of one percent of maize farmers used all the four improved inputs in maize production. The results reveal generally that very few of farmers who used a package of two or more improved inputs in maize production.

Results show that different input combinations led to different yield, labour productivity and gross profit outcomes. Farmers who did not use any improved input in maize production obtained the second lowest average yield, labour productivity and gross profit. The lowest average yield, labour productivity and gross profit were registered by farmers who used fertiliser only, given other factor inputs (row C). This result suggests that it is unproductive both in physical and economic terms to use fertiliser without other complementary improved inputs in maize production.

Taking other inputs as given, maize producers who used a combination of improved seed, fertiliser and traction obtained the highest yield (row J), but lower labour productivity compared to farmers who used a combination of improved seed and fungicides/herbicides only (row G). Farmers who used a combination of all four improved inputs obtained the second lowest gross profit (row K) possibly due to the high cost of improved inputs compared to the marginal yield value. Farmers who
combined improved seed and traction only given other inputs obtained the highest average gross profit (row H) probably due to the high marginal yield value of improved seed on one hand and lower per hectare cost of production associated with traction.

Overall, results in Table 6.2 suggest that simultaneous use of all improved inputs in maize production does not necessarily lead to high productivity just like non-use of improved inputs does not also lead to high productivity. Furthermore, results suggest that use of a combination of high yielding inputs such as improved seed and fertiliser, and labour saving technologies such as traction, may present the ideal mix of inputs to optimally increase maize yield as well as household income in Uganda.

6.3 Econometric Results

Table 5.3 shows the estimated coefficients of SFA model for yield, labour productivity and gross profit in maize production. In the gross profit model, factor inputs and gross profit data were normalised by dividing each of them by maize grain price. Unlike yield and labour productivity data, gross profit data was not transformed into logarithm at the outset, as the data contained negative observations which would be lost if directly transformed. The coefficients of the factor inputs variables reported in Table 6.3 under the gross profit model are the elasticities calculated from the original coefficients (Appendix 6). Wald chi-square statistics of all the models were statistically significant (p< 0.01), suggesting that estimated results were robust.
Table 6.3. SFA model of the Determinants of Maize Productivity

<table>
<thead>
<tr>
<th>Explanatory variables</th>
<th>Dependent variables</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ln(yield)</td>
<td>Ln(labour productivity)</td>
<td>Gross profit (normalised)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Coef.</td>
<td>z</td>
<td>Coef.</td>
<td>z</td>
</tr>
<tr>
<td>Factor inputs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ln(seed)</td>
<td>0.002</td>
<td>0.66</td>
<td>-0.007</td>
<td>-1.4</td>
</tr>
<tr>
<td>Ln (fertiliser)</td>
<td>0.033**</td>
<td>2.14</td>
<td>0.058***</td>
<td>2.49</td>
</tr>
<tr>
<td>Ln (fungicides/Herbicides)</td>
<td>0.026*</td>
<td>1.66</td>
<td>0.017</td>
<td>0.71</td>
</tr>
<tr>
<td>Ln (traction)</td>
<td>0.009**</td>
<td>2.06</td>
<td>0.010**</td>
<td>2.02</td>
</tr>
<tr>
<td>Ln (manure)</td>
<td>0.004</td>
<td>0.13</td>
<td>-0.069*</td>
<td>-1.68</td>
</tr>
<tr>
<td>Ln (plotsize)</td>
<td>0.339***</td>
<td>-10.74</td>
<td>-0.687***</td>
<td>-18.6</td>
</tr>
<tr>
<td>Ln(hired labour)</td>
<td>0.034***</td>
<td>4.94</td>
<td>0.016</td>
<td>0.92</td>
</tr>
<tr>
<td>Intercept</td>
<td>7.360***</td>
<td>59.29</td>
<td>2.279***</td>
<td>9.74</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ln(\tilde{\nu})</td>
<td>-0.381**</td>
<td>-2.43</td>
<td>0.447***</td>
<td>3.68</td>
</tr>
<tr>
<td>Inefficiency variables [Ln (\tilde{\nu}^2)]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>0.242</td>
<td>1.34</td>
<td>-0.063</td>
<td>-0.14</td>
</tr>
<tr>
<td>IDP camp</td>
<td>0.207</td>
<td>0.59</td>
<td>0.014</td>
<td>0.03</td>
</tr>
<tr>
<td>Hhsize</td>
<td>-0.038**</td>
<td>-2.08</td>
<td>0.023</td>
<td>0.88</td>
</tr>
<tr>
<td>Sex</td>
<td>-0.044</td>
<td>-0.33</td>
<td>-0.448</td>
<td>-1.58</td>
</tr>
<tr>
<td>Age</td>
<td>0.013***</td>
<td>5.56</td>
<td>0.013***</td>
<td>3.66</td>
</tr>
<tr>
<td>Educ</td>
<td>0.003</td>
<td>0.66</td>
<td>-0.026</td>
<td>-1.61</td>
</tr>
<tr>
<td>Ext</td>
<td>-0.334</td>
<td>-1.49</td>
<td>-1.174</td>
<td>-1.31</td>
</tr>
<tr>
<td>Group</td>
<td>-0.208</td>
<td>-0.72</td>
<td>0.568</td>
<td>0.73</td>
</tr>
<tr>
<td>NAADS</td>
<td>0.215***</td>
<td>2.54</td>
<td>0.296*</td>
<td>1.93</td>
</tr>
<tr>
<td>Credit</td>
<td>0.358**</td>
<td>2.28</td>
<td>0.283</td>
<td>1.03</td>
</tr>
<tr>
<td>Roaddist</td>
<td>0.040</td>
<td>0.37</td>
<td>-0.094</td>
<td>-0.54</td>
</tr>
<tr>
<td>Ln(lvstk value)</td>
<td>-0.023***</td>
<td>-2.07</td>
<td>-0.048*</td>
<td>-1.75</td>
</tr>
<tr>
<td>Central</td>
<td>0.301***</td>
<td>4.88</td>
<td>0.317***</td>
<td>3.17</td>
</tr>
<tr>
<td>Northern</td>
<td>0.575***</td>
<td>5.31</td>
<td>0.221***</td>
<td>2.02</td>
</tr>
<tr>
<td>Western</td>
<td>0.462***</td>
<td>5.06</td>
<td>0.829***</td>
<td>4.34</td>
</tr>
<tr>
<td>Wald Chi square</td>
<td>135.61***</td>
<td>351.81***</td>
<td>72.62***</td>
<td></td>
</tr>
<tr>
<td>Log pseudolikelihood</td>
<td>-2095072</td>
<td>-2300215</td>
<td>-814248</td>
<td></td>
</tr>
</tbody>
</table>

Notes: ***, ** and * imply coefficients statistically significant at 1, 5 and 10 per cent respectively.

Elasticity of coefficient for gross profit variables obtained as $e_i = \frac{\partial \pi}{\partial \ln x_i} \cdot \frac{1}{\pi}$, where $\frac{\partial \pi}{\partial \ln x_i}$ is the coefficient $i^{th}$ input variable, and $\pi$ = mean gross profit.

Source: Author’s calculations based on UNHS 2005/06
6.3.1 Determinants of Maize Yield

Results in Table 6.3 indicate that increase in maize yield was positively related with increase in expenditure on fertiliser, traction, fungicides/herbicides and hired labour while increase in area cultivated had a negative effect on yield.

One percent increase in average amount spent on fertiliser per hectare of maize cultivated was found to have a statistically significant (p< 0.05) effect that would increase yield by 3 percent. This result was expected, as fertiliser is recognised worldwide for increasing crop yield (World Bank, 2007). Results further indicate a 3 percent increase in yield arising from a one percent increase in amount spent on fungicides/herbicides per hectare of maize cultivated. Stemerooff et al. (1988) and Muthamia et al. (2002) are some of the other studies that have found a positive relationship between yield and fungicides/herbicides in maize production.

In the case of traction use, the results were significant at 5 percent level, implying a one percentage point increase in expenditure on traction per hectare maize production would lead to one percent increase in yield. The positive relationship between traction and maize yield may be due to the timeliness of farm cultivation associated with traction use. The result is similar to other studies (Barrett, 1982; Reardon et al., 1997) that also report modest impacts of traction on crop yield.

Increase in plot size or area cultivated was found to have a highly significant (p< 0.01) effect on yield, suggesting that smaller-holder farms obtained higher yields compared to producers with larger farms. Increase in area cultivated by one hectare would on average reduce maize yield by 34 percent. The result is consistent with previous studies (Barrett, 1996; Udry, 1996; Pender et al., 2004; Stifel and Minten,
2008; Okoye et al., 2008; Unal, 2008). The possible reason for the observed inverse relationship is that households cultivating smaller plots use household resources such as labour optimally, for timely cultivation and proper weed management, which increase yield while increase in area cultivated dilutes the effect of available household resources and lowers yields (Udry, 1996).

The relationship between expenditure on hired labour and maize yield was positive and highly significant (p< 0.01), confirming the expectation. In Chapter 5, highly positive relationships between expenditure on hired labour and use of improved seed, fertiliser, fungicides/herbicides and traction in maize production were observed. Implying that farmers who spent a higher amount of money on hired labour in maize production also used improved inputs; which have a positive effect on yield. Other studies, including Evenson and Mwabu (1998) and Deininger and Okidi (2001) report similar results.

In addition to the findings discussed above, other interesting findings regarding the impact of farmer characteristics on maize yield merge in Table 6.3. Regarding the demographic variables, on one hand, household size had positive and significant (p< 0.05) effect on maize yield while on the other hand, household head’s age was significantly (p< 0.01) negative in relation to maize yield. The result about household size supports the argument made by Udry (1996) that a larger household size relaxes the labour constraint, which is one of the key resources in production and hence facilitates yields to rise. The negative relationship between age and maize yield may be linked to the inverse relationship between age and use of improved inputs that was observed in Table 5.3 in Chapter 5. Lower use of improved inputs
obviously has a negative effect on productivity. A study by Unal (2008) also found a negative relationship between age and yield among Turkish farm households.

Contrary to expectation, coefficients of NAADS and credit were positive and significant (p< 0.05), which in terms of SFA interpretation implies that maize farmers who were in NAADS as well as those who accessed credit were associated with yield inefficiency (lower yield). Results indicate that farmers in NAADS programme were associated with 22 percent lower yield while farmers who accessed credit had 36 percent lower yield compared to farmers who were not in NAADS programme and did not access credit respectively. The NAADS result is supported by a recent study (Okoboi et al., 2010) that observed that in districts such as Iganga, farmers under NAADS programme were somewhat less efficient compared to non-NAADS farmers due to institutional inefficiencies in the implementation of NAADS programme. Inefficiency in the implementation NAADS programme negatively affected the timely delivery of inputs to beneficiaries thereby negatively affecting productivity.

As expected, farmers with higher value of livestock owned were associated with higher maize yield and the result was statistically significant (p< 0.01). One percentage increase in average livestock wealth was associated with 2 percent increase in maize yield. Productivity gains associated with livestock ownership could be explained by the prospect of farmers using more improved inputs by selling some of the livestock products such as milk and eggs or even the real livestock (animal/poultry). Furthermore, it possible that farmers practising integrated crop and animal husbandry, applied farm-yard manure in maize production to boost yields.
Results of Central, Northern and Western region dummies were positive and significant \((p< 0.01)\) with respect to Eastern region as a control. This implied that maize producers in Central, Northern and Western Uganda had lower yield compared to farmers in Eastern Uganda, which is consistent with descriptive results in Table 6.1. This result is not surprising considering that in Table 5.1, it was observed that a higher proportion of farmers in Eastern Uganda used improved inputs in maize production compared to farmers in other regions.

### 6.3.2 Determinants of Labour Productivity

Factors affecting labour productivity in maize production are shown under the labour productivity model in Table 6.3. In the table, it is observed that factors that had a significant effect on labour productivity in maize production are to some extent similar to, but only differ in magnitude and statistical significance to those that influenced yield.

Since labour productivity and yield are positively related through the output function, explanations offered in the foregoing discussion on the determinants of yield may also be extended to explain the determinants of labour productivity. That is, all else equal, increase/decrease in yield leads to increase/decrease in labour productivity. Hence explanations for variables including fertiliser use, area cultivated, age, livestock wealth and dummies for regions, in Table 6.3, that have a statistically significant effect on labour productivity originate by extension from explanation of factors driving the changes in yield.

Much as the explanations for changes in labour productivity may be derived from reasons for changes in yield, a few variables in Table 6.3 that affect labour
productivity may merit their own explanations though. These are variables that have a direct bearing on saving or increasing on the quantity of labour required in production and hence increasing or decreasing labour productivity. For example, manure use in crop production may require more man-days in preparation and application while traction greatly saves on the man-days necessary for ploughing.

Results in Table 6.3 indicate that farmers who spent more on traction were associated with one percent increase in labour productivity. The result was statistically significant at 5 percent level. As observed in previous studies (Bray, 1994; Curtis and Gadbois, 1996; Reardon et al., 1997; Smith, 2008), use of traction either tractor or animal power directly reduces on labour inputs and increases labour productivity for a given level of output.

The coefficient of manure with respect to labour productivity was negative and statistically significant at 10 percent. This result underscores findings from other studies that observe that whereas manure use may enhance yield, production and use of manure is labour intensive (Reardon et al., 1997; Enyong et al., 1999), and thus negatively affects labour productivity.

6.3.3 Determinants of Gross Profit

Results of the gross profit model in Table 6.3 indicate that whereas increased expenditure on improved seed, fertiliser, fungicides/herbicides and traction in maize production had the expected positive effect on gross profit, the outcomes were not statistically significant. Lack of statistical significance of these variables implies that the coefficients of these variables are statistically not different from zero. Comparison of these results with those on yield and labour productivity, suggest that
whereas increased expenditure on fertiliser and traction had a statistically significant effect on yield and labour productivity, the impact on gross profit was of no statistical importance. The limited effect of improved inputs use intensity on gross profit confirms the long held view by rural farmers in Uganda that improved inputs are expensive and hence of limited significance to improvement of their income (Nabbumba and Bahiigwa, 2003).

Examining the coefficient of manure indicates that it was negative and significant at 5 percent level. One percent increase in quantity of manure used in maize production would be associated with about 2 percent decrease in gross profit. As mentioned in sub-section 6.3.2, manure preparation and use is a laborious task that requires more labour (family or hired labour). More labour input, particularly hired labour increases to the cost of production. Furthermore, Appendix 7 shows that farmers who used larger quantities of manure essentially bought the manure, which increases the production cost, yet, as further indicated in the figure (Appendix 7) farmers who used larger quantities of manure were associated with lower yield. Thus, the additional costs associated with use of larger quantities of manure in maize production most likely outweighed the marginal value, leading to the observed negative relationship between increased manure use and gross profit.

The estimated relationship between area cultivated and gross profit was positive, statistically significant (p< 0.01) and in line with expectation. The result indicates that increase in area cultivated with maize by one hectare would lead to 82 percent increase in gross profit. This result may be related to economies of scale arising from reduction in average production costs on one hand and increase in output on the other hand that is associated with increase in area cultivated. Appendices 8a, 8b
Appendix 8a shows that farmers who cultivated larger plots obtained higher output, while figures in Appendix 8b and 8c show that increase in output as well as gross profit was to some extent associated with lower average cost in maize production.

With regard to the inefficiency variables, as can be seen in Table 6.3, the coefficient of household size was negative and significant (p< 0.05); implying that maize farmers with more people in the household were associated with higher gross profit. Other studies with similar results include Bravo-Ureta and Pinheiro (1997) and Kolawole (2007). As observed in Table 5.1, most farmers in Uganda rely more on family labour than hired labour in maize production. Since household size and quantity of family labour use are positively related (Udry, 1996) it is most likely therefore that farmers with larger families relied more on family labour, hence minimising the production costs and increasing gross profit.

Results indicate that male household heads cultivating maize were associated with lower gross profit. The coefficient was statistically significant at 10 percent level of significance. One possible reason why male farm household heads would be associated with lower gross profit compared to female farm household heads was the higher average grain price that female farm household heads received compared to male maize producers (Appendix 9). Higher prices received by female farm household heads may be because male farmers in Sub-Saharan Africa usually sale crops soon after harvest when prices are lower compared to women who usually store the crop for home consumption and in case of sell, it is at latter time (Manda and Mvumi, 2010) when prices are usually high.
The result for age was negative and significant (p< 0.1); implying that older maize farmers obtained somewhat higher gross profit compared to young farmers. Rahman (2003) and Kolawole (2006) obtained comparable results. The possible reason in support of this result may be related to the marginal cost incurred by older farmers in maize production as compared to younger farmers. For example, in Table 5.3, a negative relationship between age and expenditure on improved seed, fertiliser, fungicides/ herbicides and traction was found. All else equal, a lower marginal cost has a positive effect on gross profit.

Another important finding pertains to education level. As expected, the coefficient was negative; implying that farmers with higher level of education were associated with higher gross profit. The result was statistically significant at less than one percent level of significance and contrasts that for yield. Kolawole (2006) and Hyuha et al. (2007) are some other previous studies with similar results. The implication of this result is that farmers with higher education were not yield efficient but nonetheless profit efficient possibly by selling their maize crop at a higher price (Appendix 10).

The last statistically significant (p< 0.01) result in the gross profit regression is with regard to access to extension services. The result indicates that maize farmers who had access to extension services obtained higher gross profit compared to farmers who did not access extension services. Previous studies with similar results include Ali and Flinn (1989), Bravo-Ureta and Pinheiro (1997), Rahman (2003), Kolawole (2006), and Hyuha et al. (2007). Farmers who access extension services get information on sources and prices of inputs, advice on improved inputs use as well
as other crop husbandry practices, and market information (Langyintuo and Mekuria, 2005) which are important for enhancing productivity and marketing.

6.4 Summary

The relationship between improved inputs use and productivity in maize production was examined in this chapter. Descriptive results indicated that farmers in Eastern Uganda obtained the highest average yield, labour productivity and the lowest negative net profit in maize production. Results indicated that simultaneous use of all improved inputs in maize production does not necessarily lead to higher yield. Instead, a combination of improved seed and fungicides/herbicides use was shown to offer better yield, labour productivity and gross profit. Other combinations of improved inputs use such as improved seed and traction only also had promising results particularly in relation to gross profit.

Results of the SFA regressions indicated that while all the four improved inputs (improved seed, fertiliser, fungicides/herbicides) in maize production had a positive effect on yield, labour productivity and gross profit, it is fertiliser and traction that had a significant impact on yield and labour productivity. The size of area cultivated is found to have considerable negative implications on yield and labour productivity but positive effect on gross profit. Household size, age, education level, access to extension services and location in Eastern Uganda are some of the other factors that were found to have a significant effect on productivity.
CHAPTER 7

IMPROVED INPUTS USE AND MAIZE OUTPUT COMMERCIALISATION

7.1 Introduction

The relationship between improved inputs use and the level of output commercialisation in maize production in Uganda was examined in this chapter. In so doing, the chapter responded to the third and last objective of the study. A descriptive analysis of the linkage between improved inputs use and output commercialisation in maize production is presented in section 7.2 while the regression model is presented in section 7.3. A summary of the findings in the chapter is presented in section 7.4.

7.2 Descriptive Analysis

7.2.1 Maize Output Commercialisation by Region

The distribution of output commercialisation in maize production across regions of Uganda is presented in Table 7.1. Commercialisation is given as an index, that is output commercialisation index (OCI) and the distribution is in quartile range including zero for pure subsistence production and 100 percent for pure commercialisation. The overall average OCI in maize production was 41 percent, with Western region having the highest OCI and Northern region the lowest OCI.
Table 7.1. Output Commercialisation in Maize Production, by Region

<table>
<thead>
<tr>
<th>OCI (%)</th>
<th>Central</th>
<th>Eastern</th>
<th>Northern</th>
<th>Western</th>
<th>Uganda</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>38.5</td>
<td>36.61</td>
<td>54.29</td>
<td>27.37</td>
<td>38.6</td>
</tr>
<tr>
<td>1 - 25</td>
<td>2.2</td>
<td>5</td>
<td>4.96</td>
<td>3.19</td>
<td>4.3</td>
</tr>
<tr>
<td>26 - 50</td>
<td>13.5</td>
<td>20.41</td>
<td>16.91</td>
<td>21.35</td>
<td>18.48</td>
</tr>
<tr>
<td>51 - 75</td>
<td>16.2</td>
<td>18.88</td>
<td>9.43</td>
<td>19.44</td>
<td>16.58</td>
</tr>
<tr>
<td>76 - 99</td>
<td>16.2</td>
<td>13.8</td>
<td>7.22</td>
<td>12.77</td>
<td>12.85</td>
</tr>
<tr>
<td>100</td>
<td>13.3</td>
<td>5.3</td>
<td>7.2</td>
<td>15.92</td>
<td>9.2</td>
</tr>
</tbody>
</table>

Overall mean OCI 44.78 39.30 30.85 51.41 41.37

Source: Author’s calculations based on UNHS 2005/06

At the national level, 39 percent of maize producers were engaged in pure subsistence production, with Northern region having the highest proportion (54%) and Western region the lowest proportion (27%) of maize farmers engaged in pure subsistence production. With regard to production purely for the market, Table 7.1 indicates that on average 9 percent of maize producers were engaged, with highest proportion being from Western region and lowest proportion from Eastern region.

Table 7.1 indicates that a higher proportion (45 - 48 percent) of maize farmers in Central and Western region sold at least 51 percent of their crop compared to only 25 - 38 percent of farmers in Eastern and Northern Uganda whose crop sale was 51 percent or higher. The fact that farmers in Western Uganda and to some extent Central Uganda sold a larger proportion of their maize output than farmers in other regions may be explained partly by food habits (Von Braun and Kennedy, 1994). Maize is not a known staple food for most people in Western and Central Uganda, as it is the case for people in Eastern Uganda (Ferris et al, 2006).
7.2.2 Improved Inputs Use Options and Maize Output Commercialisation

Table 7.2 indicates the OCI associated with the different combinations of improved inputs that maize producers used in production. The combinations of improved inputs that farmers used in maize production range from non-use of improved inputs (Row A) to use of all the four improved inputs (Row K). Results indicate that farmers who did not use any improved inputs in maize production on average sold about 41 percent of their maize output while those farmers who used the four improved inputs in maize production sold 60 percent of the crop. To note is that farmers who used improved inputs combinations that included fungicides/herbicides (for example row D and I) were associated with higher levels of OCI.

Table 7.2. Improved Inputs Use Combinations and Maize Output Commercialisation

<table>
<thead>
<tr>
<th>Row</th>
<th>Improved input use option</th>
<th>OCI (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>No improved inputs used</td>
<td>40.88</td>
</tr>
<tr>
<td>B</td>
<td>Improved seed only</td>
<td>45.51</td>
</tr>
<tr>
<td>C</td>
<td>Fertiliser only</td>
<td>45.36</td>
</tr>
<tr>
<td>D</td>
<td>Fungicides/herbicides only</td>
<td>61.78</td>
</tr>
<tr>
<td>E</td>
<td>Traction only</td>
<td>44.72</td>
</tr>
<tr>
<td>F</td>
<td>Improved seed and fertiliser only</td>
<td>11.69</td>
</tr>
<tr>
<td>G</td>
<td>Improved seed and Fungicides/herbicides only</td>
<td>55.95</td>
</tr>
<tr>
<td>H</td>
<td>Improved seed and traction only</td>
<td>43.41</td>
</tr>
<tr>
<td>I</td>
<td>Improved seed, fertiliser and Fungicides/herbicides only</td>
<td>69.07</td>
</tr>
<tr>
<td>J</td>
<td>Improved seed, fertiliser and traction only</td>
<td>59.50</td>
</tr>
<tr>
<td>K</td>
<td>All improved inputs (improved seed, fertiliser, Fungicides/herbicides and traction)</td>
<td>60.00</td>
</tr>
</tbody>
</table>

Author’s calculations based on UNHS 2005/6
7.4 Econometric results

The marginal effect estimates of the tobit regression of the determinants of output commercialisation in maize production are presented in Table 7.3. Wald Chi square statistic was statistically significant at less than one percent level of significance, suggesting that the overall model was good.

Increase in area cultivated (Plotsize) had a positive and significant (p< 0.01) effect on the proportion of output sold. Results show that increase in area cultivated by one hectare would increase the proportion of maize output sold by 9 percent. Increase in area cultivated increases output and marketable surplus and hence commercialisation (Chattopadhyay and Sen, 1988; von Braun et al., 1994).

Increase in output price stands out in Table 7.3 as an important factor in the decision of maize producers on the proportion of output to sell. The result was expected and statistically significant (p< 0.01); indicating that a unit increase in the price would lead to 29 percent increase in maize output sold. Other studies including Larson and Deininger (2001); Tefera et al. (2003) and Komarek (2010) also report similar results. As observed in the Plan for the Modernisation of Agriculture, increase in the price of agricultural crops acts as an incentive to increased commercialisation of smallholder production while low prices act as a deterrent to market-oriented farming (MAAIF and MFPED, 2000).
Table 7.3: Tobit Regression of Determinants of Output Commercialisation in Maize Production

<table>
<thead>
<tr>
<th>Explanatory variables</th>
<th>Marginal effect</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ln(seed)</td>
<td>-0.005</td>
<td>-1.520</td>
</tr>
<tr>
<td>Ln (fertiliser)</td>
<td>-0.007</td>
<td>-0.620</td>
</tr>
<tr>
<td>Ln (fungicides/herbicides)</td>
<td>0.010</td>
<td>1.390</td>
</tr>
<tr>
<td>Ln (traction)</td>
<td>-0.006</td>
<td>-1.580</td>
</tr>
<tr>
<td>Ln(manure)</td>
<td>0.014</td>
<td>1.180</td>
</tr>
<tr>
<td>Ln(Plotsize)</td>
<td>0.091***</td>
<td>18.260</td>
</tr>
<tr>
<td>Ln(maize price)</td>
<td>0.288***</td>
<td>3.650</td>
</tr>
<tr>
<td>Ln(yield)</td>
<td>0.274***</td>
<td>22.200</td>
</tr>
<tr>
<td>Ln(hiredlbr)</td>
<td>0.000</td>
<td>-0.140</td>
</tr>
<tr>
<td>Urban</td>
<td>-0.124**</td>
<td>-2.210</td>
</tr>
<tr>
<td>IDPcamp</td>
<td>-0.375**</td>
<td>-2.180</td>
</tr>
<tr>
<td>HHsize</td>
<td>-0.021***</td>
<td>-5.220</td>
</tr>
<tr>
<td>Gender</td>
<td>0.008</td>
<td>0.250</td>
</tr>
<tr>
<td>Age</td>
<td>-0.001</td>
<td>-1.450</td>
</tr>
<tr>
<td>Educ</td>
<td>-0.003**</td>
<td>-2.090</td>
</tr>
<tr>
<td>Ext</td>
<td>0.018</td>
<td>0.410</td>
</tr>
<tr>
<td>Group</td>
<td>-0.036</td>
<td>-0.580</td>
</tr>
<tr>
<td>NAADS</td>
<td>0.074**</td>
<td>2.390</td>
</tr>
<tr>
<td>Credit</td>
<td>-0.039</td>
<td>-0.660</td>
</tr>
<tr>
<td>Roaddist</td>
<td>0.025</td>
<td>0.870</td>
</tr>
<tr>
<td>Ln(Lvstk)</td>
<td>0.002</td>
<td>0.710</td>
</tr>
<tr>
<td>Central</td>
<td>0.112**</td>
<td>2.340</td>
</tr>
<tr>
<td>Northern</td>
<td>-0.048</td>
<td>-1.160</td>
</tr>
<tr>
<td>Western</td>
<td>0.173**</td>
<td>3.590</td>
</tr>
<tr>
<td>Number of Obs.</td>
<td>1888</td>
<td></td>
</tr>
<tr>
<td>Wald Chi square</td>
<td>32.9***</td>
<td></td>
</tr>
<tr>
<td>Log pseudo likelihood</td>
<td>-941156.67</td>
<td></td>
</tr>
</tbody>
</table>

Note: OCI: 733 left-censored observations at 0, 985 uncensored observations; and 170 right-censored observations at OCI =100.

***, ** and * imply coefficients statistically significant at 1, 5 and 10 per cent respectively.

Source: Author’s calculations based on UNHS 2005/06
Increase in yield was found to be positively and significantly (p < 0.01) related to increased maize output commercialisation. The result indicated that a unit increase in maize yield would lead to 27 percent increase in the proportion of maize output sold. All else equal, increase in farm yield to a great extent increases farm-household marketable surplus and consequently commercialisation (Chattopadhyay and Sen, 1988; von Braun et al., 1994). The implication of this finding is that any effort to increase maize output commercialisation would greatly succeed if first of all the constraints to increased productivity are addressed.

Maize producers residing in urban areas were associated with lower output commercialisation compared to their counterparts in rural areas, which is contrary to expectation. The result was statistically significant at 5 percent level and indicated that maize farmers residing in urban areas sold 12 percent lower output than rural farmers. This result suggests that maize farmers in urban areas mainly produced maize for subsistence. The lower proportion of maize output sold by farmers in urban areas compared to farmers in rural areas may be due to the fact that subsistence farming contributes less than 5 percent of the income of households residing in urban areas compared to about 50 percent of the income of rural households in Uganda (UBoS, 2010).

The result for IDP camp was notably negative and statically significant (p < 0.01); implying that maize producers who were residents in IDP camps were much disadvantaged in terms of output commercialisation compared to their peers not in IDP camps. The result indicated that maize farmers residing in IDP camps sold 38 percent lower output than farmers not residing in IDP camps. As mentioned earlier in Chapter 5, settlement of people in IDP camps, particularly in Northern Uganda
was due to civil insecurity brought about by rebels of Kony’s Lord Resistance Army (LRA). Maize farmers in IDP camps most likely had limited access to land and hence produced mainly for subsistence (Appendix 11). Besides, it is likely that the civil insecurity existing in Northern Uganda at that time (2004 -2005) scared away potential buyers of maize, thus negatively impacting on the level of desired sells by maize producers.

Maize producers with a large size of family were found to have a lower level of output commercialisation. The result was statistically significant at less than one percent level of significance. One possible reason for this outcome is that maize farmers in Uganda with large families produce mainly for home consumption. Previous studies including Chattopadhyay and Sen (1988), von Braun et al. (1994) and Larson and Deininger (2001) reported similar results.

As expected, maize farmers in NAADS programme were found to be associated with a higher level of output commercialisation. The result was statistically significant (p< 0.05) and indicated that maize producers in the NAADS programme sold about 7 percent more output compared to their peers not enrolled in the programme. In the evaluation of the impact of NAADS programme, Benin et al. (2007) found that some farmers in NAADS programme had significantly increased the share of their crops marketed. This is mainly because farmers in NAADS programme are given training in marketing skills, provided with market information and supported to form marketing groups (Benin et al., 2007), all of which have a positive effect on market access and participation in output markets.
The last set of variables to consider is Central and Western region dummies, which were all positive statistically significant ($p<0.05$). These results are similar to and collaborate well with the descriptive statistics (Table 7.1) that indicated that maize producers in Central and Western Uganda sold a higher proportion of maize output compared to producers in Eastern Uganda who were considered as the base category in the analysis. The higher level of maize output commercialisation by farmers in Central and Western region may be explained by the fact that maize is not an important commodity in the diet of people in these regions, and as such most of the output produced is sold than consumed. This finding is in line with von Braun et al. (1994) who argue that food habits have a great influence on level of participation of farmers in crop markets.

### 7.5 Summary

Farmers in Western region had the highest level of maize output commercialisation while those in Northern region had highest level of maize production for subsistence. Farmers who used improved inputs combinations that included fungicides/herbicides were associated with a higher level of maize output commercialisation. Factors that had a positive effect on the level of maize output commercialisation were size of area cultivated, increase in yield, increase in grain price, membership in NAADS, and location in Central and Western regions. Factors that had a negative influence on maize output commercialisation were household size, education level, and location of farmers in urban area and IDP camp.
CHAPTER 8

SUMMARY, CONCLUSIONS AND IMPLICATIONS FOR POLICY AND RESEARCH

8.1 Summary

Uganda’s agriculture is faced with challenges of low productivity and low commercialisation. Government is encouraging farmers to increasingly use of improved inputs in production so as to increase productivity and output commercialisation. The goal of this study was to examine extent to which use of improved inputs (improved seed, fertiliser, fungicides, herbicides and traction) by Uganda maize producers influenced their productivity and commercialisation level. Specifically, the study investigated the factors that influence maize producers’ level of expenditure on improved inputs; and the effect of improved inputs use (measured by expenditure) on yield, labour productivity, gross profit and output commercialisation in Uganda. It was anticipated that understanding these relationships would assist policymakers come up with suitable policies to address productivity and commercialisation challenges that maize producers in particular and crop framers in general face in this country.

The study utilised Uganda National Household Survey (UNHS) 2005/06 data collected by Uganda National Bureau of Statistics (UBoS). The survey was nationally representative. Econometric approaches utilised to answer the objectives included multinomial logit model (MLM) for analysis of the determinants of improved inputs use; stochastic frontiers analysis (SFA) for analysis of productivity determinants; and the tobit model for analysis of the determinants of output
commercialisation. STATA/SE 10.0 statistical package was used in the analysis. Inflation factors/weights were incorporated in the analysis to increase the efficiency of the results as well as make the study national in dimension.

Analysis of improved inputs use revealed that maize producers spending more on hired labour had a higher probability of using improved inputs (improved seed, fertilisers, fungicides/herbicides and traction). Also, maize producers residing in urban areas had a higher probability of using improved seed while those who cultivated larger plots were associated more with traction use. On the other hand, farmers living in Northern Uganda in general and IDP camps in particular had a lower probability of using improved inputs in maize production while farmers living in Central and Western Uganda had a lower probability of using improved seed and traction.

Analysis of maize productivity determinants, showed that use (measured by expenditure) of improved seed, traction as well as hired labour significantly increased yield and labour productivity but not gross profit. Increase in area cultivated reduced yield and labour productivity but increased gross profit. Increased use of manure reduced labour productivity and gross profit. A large household had a positive effect on yield and gross profit while age had a negative effect on yield and labour productivity but positive relationship with gross profit. Education level and access to extension services had a positive effect on gross profit. Yield and labour productivity was negatively related with membership in NAADS programme. Lastly, farmers in Central Northern and Western Uganda had lower yield and labour productivity compared to those in Eastern Uganda.
Analysis of maize output commercialisation determinants, indicated that increased expenditure on improved inputs had no influence on output commercialisation level. Instead, area cultivated, grain price, yield, membership in NAADS programme, residence in Central and Western Uganda positively and significantly influenced output commercialisation while education level, household size, residence in urban area and IDP camp negatively influenced output commercialisation.

8.2 Conclusions and Policy Implications

Results showed on one hand that a higher proportion of farmers in Eastern Uganda used improved inputs while a lower proportion of farmers in other regions particularly Northern Uganda used such inputs. On the other hand that farmers in Eastern Uganda obtained higher yield and labour productivity. This suggests that if government is planning to support farmers for example through NAADS to increase the use of improved inputs as well as productivity, urgent support should be directed to regions such as Northern and Western Uganda that are lagging in use of improved inputs as well as productivity and not Eastern Uganda, which is already at an advantage both in the use of improved inputs in maize production and productivity.

Results indicated that use of improved inputs, particularly fertiliser and traction in maize production had a major impact on physical productivity (yield and labour productivity) but not economic productivity (gross and net profit). Since results suggest that use of improved inputs on low value crops such as maize is not economically viable at present, it is important that before any real recommendations on use of improved inputs are made, there is need to undertake crop-specific studies to understand the potential physical vis-à-vis economic impacts of improved inputs.
use. Otherwise blanket or one-size-fits-all recommendations may instead lead to lower adoption and use of improved inputs once found to be of no economic benefit.

Farmers living in Northern Uganda in general and IDP camps due to Kony rebels’ instigated civil instability in particular, had a lower probability of using improved inputs in maize production as well as lower yield, labour productivity, gross profit and output commercialisation. This finding suggests that government programmes such as the PRDP to bring about stability and return of people to their homes in Northern Uganda would go a long way in promoting use of improved inputs as well as enhancing agricultural productivity and commercialisation in Northern Uganda.

Membership in NAADS programme was found to be negatively related with maize yield and labour productivity but positively with output commercialisation. This result may be due the fact that NAADS programme has focussed more effort on commercialisation than productivity. This is more so given that the results indicated lower use of improved inputs by farmers in NAADS compared to those not in NAADS programme. The policy implication of this outcome is that there is need to streamline the NAADS programme to effectively focus more on extension services to promote the use of improved inputs to increase agricultural productivity in the country.

Access to extension services was found to have limited effect on physical productivity but a positive effect on gross profit. This result is related to the fact that extension services outreach in Uganda is not only through NAADS but is low. Under the NAADS programme, extension services are largely focussed on provision of marketing information through farmer groups and not the provision of crop-
specific extension advice and training. The implication of this finding is that government should revisit the extension services delivery mechanism in the country so as to reach a large number of farmers and with information which is not only focused on marketing but also on production.

### 8.3 Suggestions for Further Research

As with any other research, this study was subject to some limitations. The following suggestions are proposed for the benefit of those interested in pursuing further research on subject of improved inputs use, productivity and commercialisation in Uganda’s in general and the maize sub-sector in particular.

First, the present study was based on cross-sectional survey data. Farm-level panel data was not utilised, as it was not available. Analysis based on cross-sectional data has some limitations, such as lack of capability to track the dynamics of producer performance over time. In the near-future however, it will be possible to undertake farm-level panel-data analysis in agriculture. This is because UBoS has started collecting this data.

Second and lastly, this study focused on maize. It is possible to do a similar level of analysis for other crops, such as beans or sesame. It is also entirely possible to include more than one crop or even non-crop commodities such as livestock in the analysis. That is multi-commodity analysis, which is realistic in smallholder farming. The only limitation with such analysis is availability of data.
References


Kelly, V. and Murekezi, A., 2000. Fertiliser Response and Profitability in Rwanda: A Synthesis of Findings from MINAGRI Studies Conducted by the


MFPED, 2010. Background to the Budget 20010/11 Fiscal Year: Strategic Priorities to Accelerate Growth and Socio-Economic Transformation for Prosperity. Kampala, Uganda: MFPED.


Appendices

Appendix 1. Agriculture Sector and Population growth rates

Data source: Background to the Budget, 2006 -2011 issues
Appendix 2: Area Cultivated, Output and Yield of Maize in Uganda; 1990-2007

Appendix 3. Distribution of Study sample.

<table>
<thead>
<tr>
<th>Region</th>
<th>Year and season</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2004:2</td>
<td>2005:1</td>
</tr>
<tr>
<td>Central</td>
<td>161 (8.5)</td>
<td>208 (11.0)</td>
</tr>
<tr>
<td>Eastern</td>
<td>268 (14.2)</td>
<td>576 (30.5)</td>
</tr>
<tr>
<td>Northern</td>
<td>79 (4.2)</td>
<td>282 (14.9)</td>
</tr>
<tr>
<td>Western</td>
<td>181 (9.6)</td>
<td>133 (7.0)</td>
</tr>
<tr>
<td>Total</td>
<td>689 (36.5)</td>
<td>1199 (63.5)</td>
</tr>
</tbody>
</table>

Note: Values in parentheses are in percent.

Source: Author’s calculations based on UNHS 2005/06
Appendix 4a: Yield distribution

(i) Yield

(ii) Ln (yield)

Appendix 4b: Labour productivity distribution

(i) Labour productivity

(ii) Ln(labour productivity)

Appendix 4: Some Normalised Distribution Graphs
Appendix 4c: Output commercialisation index (OCI) distribution

(i) OCI before censoring

(ii) OCI after censoring at 0 and 1

Appendix 4: Continued

Source. Author’s calculations based on UNHS 2005/6
Appendix 5. Pair-wise Correlation Matrix of Maize Producer Characteristics

<table>
<thead>
<tr>
<th></th>
<th>Urban</th>
<th>IDP camp</th>
<th>Hhsize</th>
<th>Sex</th>
<th>Age</th>
<th>Educ</th>
<th>Ext</th>
<th>Group</th>
<th>NAADS</th>
<th>Credit</th>
<th>Road dist</th>
<th>Ln(lvstk)</th>
<th>Central</th>
<th>North</th>
<th>West</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>1.00</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>IDP camp</td>
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<td>1.00</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Hhsize</td>
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<td>1.00</td>
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<tr>
<td>Sex</td>
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<td>Age</td>
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<td>1.00</td>
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<td>Educ</td>
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<td>1.00</td>
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<tr>
<td>Ext</td>
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<td>0.03</td>
<td>0.11</td>
<td>0.03</td>
<td>0.02</td>
<td>0.13</td>
<td>1.00</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Group</td>
<td>-0.03</td>
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<td>0.09</td>
<td>-0.03</td>
<td>0.05</td>
<td>0.08</td>
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<td>1.00</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>NAADS</td>
<td>-0.13</td>
<td>-0.06</td>
<td>-0.01</td>
<td>0.04</td>
<td>0.00</td>
<td>-0.03</td>
<td>0.16</td>
<td>0.24</td>
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<td></td>
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</tr>
<tr>
<td>Credit</td>
<td>0.02</td>
<td>-0.02</td>
<td>0.07</td>
<td>0.03</td>
<td>-0.03</td>
<td>0.03</td>
<td>0.07</td>
<td>0.06</td>
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<td>1.00</td>
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Source: author’s calculations based on UNHS 2005/06
## Appendix 6. Determinants of Gross Profit in Maize Production in Uganda

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<td>Ln(area)</td>
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| Ln(\(\nu^2\))        | -1.60*** | -8.03 |

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</tr>
<tr>
<td>West</td>
<td>1.11</td>
<td>1.14</td>
</tr>
</tbody>
</table>

| Wald chi²(7) | 72.62 |
| LP           | -814248 |

Source: author’s calculations based on UNHS 2005/06
Appendix 7. Average Yield and Manure Cost and associated Manure Quantity in Maize Production

Source: Author’s calculation based on UNHS 2005/6
Appendix 8a. Output and Area Cultivated in Maize Production

Source: Author’s calculation based on UNHS 2005/6

Appendix 8b. Average Total Cost and Output in Maize Production

Source: Author’s calculation based on UNHS 2005/6
Appendix 8c. Average Total Cost and Gross profit in Maize Production

Source: Author’s calculation based on UNHS 2005/6

Appendix 9: Average Maize Grain price by Sex of Farmer

Source: Author’s calculations based on UNHS 2005/06
Appendix 10. Average Maize Grain Price by Education Level of Farmer

Source: Author’s calculation based on UNHS 2005/6
Appendix 11: Area Cultivated and Output by IDP camp Status of Maize Farmers

Source: Author’s calculations based on UNHS 2005/06