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And

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Topic: An empirical analysis of the supply response of cotton in the face of FISP and FRA maize support programs in Zambia

By

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To God be the glory.

Abstract

The supply response of cotton has generally been based on factors that are directly linked to cotton production in Zambia. A relatively neglected aspect of in research concerns the effect of the maize pricing policy and fertilizer programs on cotton production. Therefore this study intends to establish the conventional view that intensification of the maize support program aggravates the competition between maize and cotton for land and labour resources. In 2002 the government of Zambia introduced the Fertilizer Input Subsidy Program (FISP) and up scaled the activities of Food Reserve Agency (FRA) program that purchased maize above market price. The fact that FRA program bought maize at prices higher than the market price, a farm household model that relates the changes in the land area as a result of maize prices or cotton prices was employed to explain the response of cotton to prices. With the hypothesis that an increase in the maize prices and subsidized input (fertilizer) prices maize support programs can cause farmers to shift their land from cotton to maize production. The study uses panel dataset from 2004 and 2008 to assess the factors that influenced farmer's participation in cotton production. Results from a pooled tobit model indicated that after controlling for demographic household characteristic, household assets, cotton prices, maize prices, land size and instrumenting participation for government support programs with an election variable, farmers 'decision to participate in cotton production is influenced by cotton prices, endowment of assets, land size and the maize sale to other traders. However our results did not show any significant effect of maize prices on farmer's decision to participate in cotton production. In order to understand response of cotton to maize prices we developed a model which related the price of maize to the allocation of land to cotton. However, our data did not allow us to sufficiently test our model and to draw appropriate conclusions. Alternatively we regressed cotton and maize output on factors of production and other relevant household characteristics. We observe that whereas maize and cotton both respond to land changes, maize had a larger land elasticity. Also while maize did not respond to labour changes, cotton recorded a positive and significant elasticity of labour. We conclude, although cautiously, that FSP and FRA may have had positive impacts on the intensity with which farmers grow maize and this may have slightly affected the productivity of cotton. Furthermore, our results point to the fact that farmers' decision to participate in cotton production, although linked significantly to prices depends on a number of structural factors like access to markets and inputs. It is recommended that government consider the providing such structural support for cotton farmers

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Chapter 1

Introduction

1.1 Introduction to the study

Cotton production has been successfully supported by private companies of Zambia since liberalization (Kabwe and Tschirley, 2007). Following privatisation cotton companies facilitated production of cotton through an out grower scheme in which smallholder farmers acquired seasonal inputs on loan in exchange for cotton produce. Production of cotton increased from 3 to 6% after market reforms indicating the potential growth that cotton has over other agriculture commodities (Jayne et al, 2010). In 1998 more buyers entered the cotton sector, some companies never financed the production of cotton instead they offered high purchase prices, the default rates on loans rose as a result of side selling by farmers, mistrust between farmers and firms developed. In consequence the firms raised loan prices and farmers received lower prices for their seed cotton. Meanwhile the sector has had dramatic growth in cotton production from 1994 to 1998 and phases of production decline in 2000 and 2007 (Kabwe and Tschiley, 2007).

Beside variation in cotton yields overall cotton production increased following privatization but the entire agriculture sector did not benefit from it as signified by a 15% decline in maize production (Jayne et al, 2010). In 1990 the government removed subsidies of input (fertilizer) and price controls. This reduced the incentives to cultivate maize especially in cotton producing areas of Zambia. Consequently the land that was formerly allocated to maize production was shifted to other crops like cassava, groundnuts, tobacco and cotton (Jayne et al, 2007).

Maize is an important staple food to more than 8.5million people in Zambia. A decrease in maize production from 1,618,000 metric tonnes to 1,304,000 metric tonnes between the period of 1985-1989 and 1990-1995 had important implications for food security and the livelihoods of smallholder farmers (Seshamani,1998). A further decline in maize production took place in the 2001/2002 season when maize production was reported to be 673,673 metric tonnes. This confronted policy markers with a dilemma to increase production and supply maize at affordable prices to consumers (Jayne et al, 2010). This downward trend of maize production continued in spite of the two decade of market liberalization, which was expected to increase production. The government of Zambia therefore re-introduced fertilizer subsidy in 2003 through the implementation of two programmes. First, the Fertilizer Input Subsidy Program (FISP)/Fertilizer Support Program (FSP) and secondly a programme to scale up the Food Reserve Agency of the government was established (Chapoto et al, 2012). In 2009/10 season maize production rose by 48% of this 25-30% increase was attributed to increased fertilizer use, 3% to increased use of hybrid seed, 10-28% to change in maize prices and 49-62% to good weather conditions (Burke et al, 2010; Mason et al 2012).

Not only did the government subsidize fertilizer it also became the chief buyer of maize produced by smallholder farmers through the FRA. The Food Reserve Agency which was mandated to purchase buffer stock of maize for the nation as insurance against possible drought increased its activities by regularly purchasing maize at pan-territorial prices that exceeded market prices (Mason et al, 2012). For instance, in 2006/07 and 2007/8 marketing season FRA bought more than 50% maize from smallholder farmers and increased its purchases to 83% of the smallholder maize in 2010/11 marketing season (Mason et al, 2012). In many Zambian farms, maize and cotton compete for factors of production. However the FISP and FRA programs are not isolated for cotton producing regions of the country and not much is known about their implications on cotton production. Therefore this study seeks to understand the change in the supply response of cotton as a result of maize support program.

1.2 Problem statement

Cotton production has the potential of transitioning smallholder farmers from subsistence farming to market oriented production systems. In spite of all the efforts by the private sector to increase production, the cotton sector has had two periods of production decline. The decline in cotton production in the year 2000was associated with increased default rates and the 2007 decline was linked to the appreciation of the kwacha. The sluggish recovery of cotton production since the second crash of 2007 has been a concern to the cotton sector (Goeb, 2011). In addition all to these problems the cotton yields are comparably lower than those of Zimbabwe, West and Central Africa (World Bank, 2009). Unlike maize, farmers that venture into cotton production acquire credit input at zero deposit. Notwithstanding this support cotton receives, maize still accounts for more than 60% of the land cultivated and increasing maize productivity remains the major priority of Zambia (Chapoto et al, 2012) as signified by maize support programs by fertilizer subsidies and maize pricing policies

(FSP/FISP and FRA) in 2002. Cotton companies strongly argued that the cotton sector is likely to be threatened by the massive input (fertilizer) subsidies and prices in the maize sector (Tschirley et al, 2004).

This argument is consistent with the standard theory of production which assumes a positive supply response when the price change of a crop is positive or vice-versa. This theory also suggests a negative supply response when prices of competing commodity increase (De Janvry, 1991). Basic economic theory also suggests that the supply of an agriculture commodities increases with a decline in input (fertilizer) prices. Based on these theories the maize fertilizer subsidy and pricing policies were hypothesized to result in a decrease in cotton production. In this regard empirical investigations into the effects of the maize support programmes in Zambia have attempted to establish the impact of the maize policies on cotton production however the results has been inconclusive. For example Goeb,(2011) concluded that the FISP and FRA programs did not result in a shift of land from cotton to maize. Similarly Mason et al (2011) studied the land-allocation behaviour of farmers under the FRA policy program and discovered that there was no significant difference in the shift of land from other crops to maize. These studies however do not adequately analyse the land allocation behaviour of Zambian farmers under government policy programs. For example their analysis ignores the influence of household decision making process by not taking into account the interdependence of consumption and production decisions. Secondly these studies fail to model the impact of the price of competing crops on farmer's decision to allocate land to cotton. Hence it is still unknown the extent to which FRA/FISP programs influence the decision of farm households to allocate land to cotton. Therefore this research fills this knowledge gap by employing a household model to explain the effect of the maize pricing policy on cotton production.

1.3 Main research objective

The main objective of this research is to carry out a further investigation on cotton farmer's behavioural response to fertilizer subsidies and FRA activities.

1.4 Specific Questions

1. What factors determine farmer's decision to participate in cotton production?
2. What is the effect of FISP and FRA activities on land allocation between maize and cotton?

1.5 Justification

This study is justified in two of ways. First, the study contributes to the literature on agricultural household's decision making. This is done by deriving a theoretical model which relates the percentage change in cotton area as a result of change in the maize prices for farmers that cultivate both maize and cotton. Second, the findings from this research are of relevance because they contribute to on-going national debate of the impact of government agricultural support programs. The government of Zambia hypothesized that by raising the price of maize and reducing the input prices will increase maize production. Therefore the study seeks to understand if the maize support programs have any effects on cotton production hence suggest solutions or ideas that will contribute to sustainable policy formulation.

1.6 Organisation of the thesis

The remaining part of the thesis is organized into six main chapters. Chapter 2 gives an overview of maize and cotton production in Zambia. Chapter 3 gives the literature review on other studies that looked at supply response of cotton and other crops in Zambia and other countries. Chapter 4 gives the theoretical framework used to explain the change in the supply response as a result of price changes. It also describes the source of data and how it was collected as well as the analytical tools employed in the study. Chapter 5 presents the descriptive statistic, empirical results and thereafter it discusses the results in relation to the situation in Zambia and the theories. Chapter 6 gives a conclusion of the study and the recommendations.

Chapter 2

Overview of Zambian Cotton and Maize Sector

In this chapter we will give an overview of the maize and cotton sectors of Zambia. The chapter describes the production of maize and cotton along with some support programs that influence the production and performance of maize or cotton sector.

2.1 Production of cotton in Zambia.

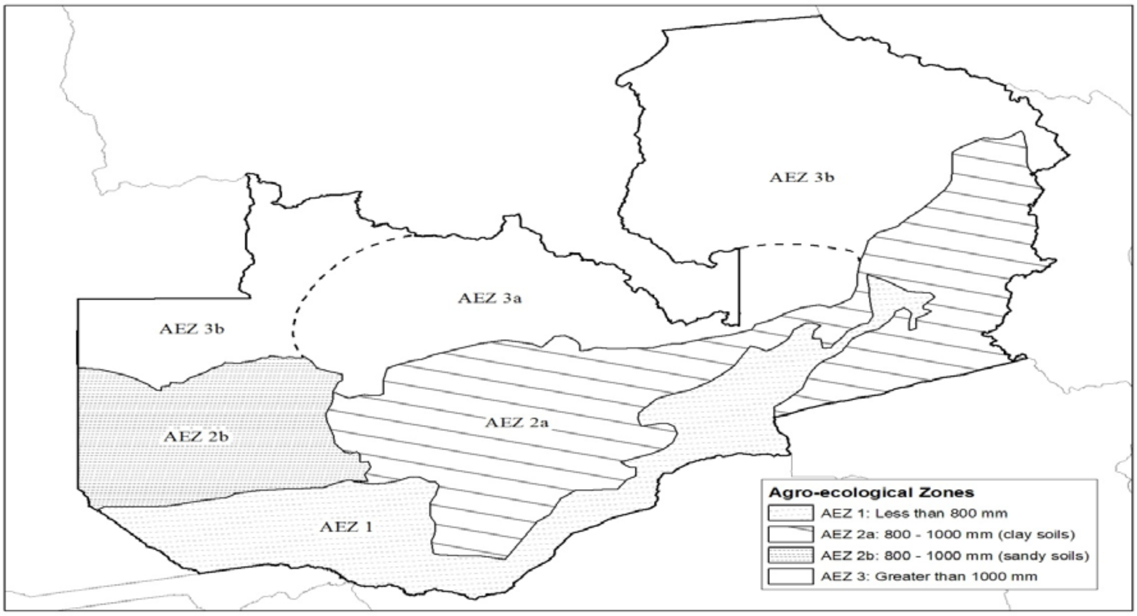
Cotton is a drought-resistant crop grown in drier parts of Zambia and tolerates a wide range of soils. Cotton is commonly rotated with maize but there are other arable lands that are continuously cultivated with cotton or maize only (Denison, 2011). Farmers that cultivate cotton apply little or no fertilizer to cotton fields implying that the success of cotton production depends on the fertility of the soil Goeb, (2011).

2.1.1 Geographical zones of cotton in Zambia

Given the characteristics of the soils, cotton is grown in three main provinces of Zambia namely the Eastern, Central, and Southern Province. The Eastern province is the chief grower of cotton contributing 60% of cotton to the national produce. The province consists of 5 districts producing more than one metric tonne of seed cotton. Other provinces like the Southern and Central provinces have comparably lower yields of cotton (Tschirley et al, 2004; Tschirley and Kabwe, 2007). The Northern, North western and the Copper belt provinces produce little or no cotton.

Eastern, Central and Southern provinces are found in Agro-ecological (AE) zone 1 and 2a were cotton is grown as a priority crop. Agro-ecological zone 1 is a drought prone area with erratic rainfall ranging from 700-800mm and AE 2a is the country's most productive region with rainfall averaging 800-1000mm a year. AE1 has low rainfall amount but can sustain cotton production over the 90-120 days and AE2a has 120-150 days for crop production. The Eastern, Central, and the South province constitute a large portion of region 1 and 2a (Denison, 2011)

Fig 2.1 A map representing agro-ecological zones of Zambia



2.1.2 Relevance of cotton to agriculture in Zambia

Cotton is one of the most important agricultural export crops and constitutes a major share of export earnings to Zambia (Fortucci, 2002). In 1980 cotton had no significant contribution to gross domestic product (GDP) in Zambia until 2000 when it contributed 0.9% to the GDP and the percentage of total exports rose to 20% in 2005. Farmers that cultivated cotton in 2000 contributed 26.8% to agricultural exports while those that cultivated cotton in 2005 contributed 32% to agriculture export (Fortucci, 2002; World Bank, 2009). For diversified smallholder farmer's cotton is used as cash insurance and cash income from cotton is used for health care, education and other non farm produce like fertilizers and pesticides (Fortucci, 2002).

According the World Bank (2009), 250 000 smallholder farmers cultivated cotton as a cash crop in Zambia through an out-grower scheme. In 2004/05 and 2006/7 returns to labour from cotton exceeded the wage rate offered in Zambia (Kabwe and Stephen, 2007). Beside income generation cotton production has had other benefits in the agricultural sector of Zambia and other countries in the region. Evidence by Jayne and Govereh (2003) revealed that farmers that ventured into cotton production also gained skills and acquired inputs which were then used to improve the production of other crops.

Companies that supported cotton production also invest in infrastructure development for example roads and ginneries. The entry of cotton companies in the cotton sector attracted also input companies into the agriculture sector thus allowing integration of markets. By supplying input and output markets cotton production has improved market access of smallholder farmers.

2.1.3 Performance of the cotton sector post liberalization

The cotton sector of Zambia was heavily regulated from 1977 to 1994, with the Lint Company of Zambia (Lintco), managing all facets of cotton production and marketing (Tschirley and Kabwe, 2007; Porto and Balat, 2005). In 1994 the government introduced a policy on market liberalization which discouraged monopoly buying of seed cotton by Lintco. This exposed the cotton sector to entry by new companies and competition, firstly Lonhro and Clark took over Lintco and later in 1997 more companies entered the sector. Lonhro and Clark operated an out-grower scheme in which it supplied seeds and inputs to farmers on credit.

Meanwhile an out grower scheme has been characterized by three distinct phases of production**.** At the introductory phase cotton production rose from 20 000 metric tonnes in 1994 to more than 100 000 metric tonnes in 1998 (Tschirley et al, 2004; Brambilla and Porto, 2005)

In 1998 four more companies entered the sector, this introduced competition for seed cotton in many districts and dissolution of localized monopolies (Tschirley et al, 2004). Demand for cotton rose and companies that did not operate out-grower schemes offered higher cotton prices that lured contracted farmers to sell seed cotton to them. The loan default rates increased, and companies retaliated by charging higher rates for loans issued to farmers, mistrust developed between farmers and contracting firms leading to a decline in cotton production. This marked the first crash after 1994, with Lonhro exiting the market and selling its asset to Dunavant (Kabwe and Tschirley, 2007; Balat and Porto, 2005). The production of cotton declined to less that 50000 metric tonnes in 2000.

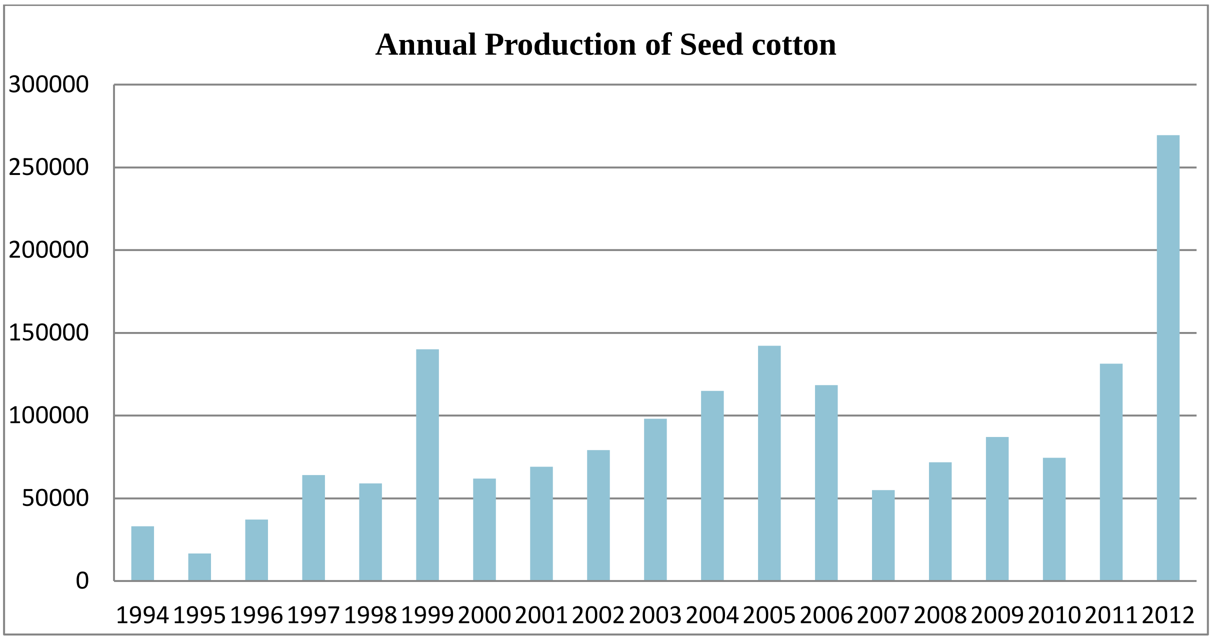
The recovery stage or second boom was associated with increase in cotton production. Duvanant and other companies in the sector established a Farmer distributer system and a Farmer Group System to reduce loan default. The systems improved loan recovery rate to almost 85% in 2001 (Brambila and Porto, 2005). In 2001 to 2002 the government launched

Cotton Out grower Credit Fund (COCF) to supply credit lines to farmers, the farmers' borrowing cost were reduced and small ginners had an opportunity to expand (Kabwe and Tschirley, 2007). Thereafter production of cotton rose to more than 150 000 metric tonnes (Tshirley et al, 2004).

A second crash occurred in 2006 to 2007 when the kwacha appreciated in value firms paid farmers more than what they were supposed to get. Firms responded by adjusting the prices of cotton to match the exchange rate. The prices were not satisfactory to farmers resulting in serious credit defaults and decrease in cotton production (Chapoto et al, 2012). The rise in the world cotton price from 2008 to 2012 incentivized farmers to venture into cotton production and the number of cotton producers doubled during this phase.

Generally cotton yields average 800 kg/ha in Zambia which is lower than the 1200 kg/ha produced by smallholder farmers in other African countries (World Bank, 2009). The annual produce of cotton now oscillates between 100 000 and 250 000 metric tonnes depending on the climatic conditions, price and availability of inputs. Fig 2.2 shows cotton production trends from 1994 to 2012 in Zambia:

Fig 2.2 Annual production of cotton from 1994 to 2012



Source: Faostat

2.2 Zambia's maize sector

2.2.1 Relevance of maize in the agriculture sector

Maize is an important staple food crop for the majority of the 8.5 million people in Zambia (Mwanaumo, 1995). Maize accounts for 60% of the country's energy intake in Zambia (Dorosh et al 2009, Zulu et al, 2007). It is mainly consumed in the southern and eastern regions of Zambia while cassava dominates in the northern part of Zambia. It contributes 25-30% to the gross value of crop output, 12-15% of the maize sales come from commercial farmers while small holder farmers produce 90% of the total maize in the country and supply 80-85% of the market maize crops in Zambia (Jayne et al, 2008, Zulu et al, 2002).

Within the Eastern, Southern and Central parts of Zambia where 98% of cotton is grown, maize is also cultivated by 97% smallholder farmers (Crop Forecast survey, 2007). Its dominance in production is strongly rooted in the historical government policy. The colonial and independent republic government of Zambia (GRZ) supported maize in order to achieve political legitimacy and social stability (Jayne et al, 2008).

2.2.2 Maize production after market liberalization

Production of maize was significantly high between 1960 and 1980 due to subsidized inputs, fertilizers and seed credit (Jayne, et al, 2008). In 1990 the government of Zambia implemented the liberalization policy of maize market which led to removal of fertilizer subsidies and price controls. The withdrawal of state led programs coincided with smallholder crop diversification (Jayne, 2008; Chapoto et al, 2012). Between 1990/91 and 2002/03 seasons, maize production declined from 76% to 55% while that of cassava rose from 10% to 26% in the northern area of Zambia and that of cotton rose from 3% to 6% (Jayne et al, 2008). The decline in maize production from 1990/91 and 2002/2003 was offset by increased production of other crops mostly cassava, cotton and groundnuts. In 2002/3 the government pursued a different policy in which it re-introduced a maize pricing policy and fertilizer input subsidy (Jayne et al, 2008; Chapoto et al, 2012). Evidence has shown that maize production increased over the last decade in part as a result of maize prices, fertilizer subsidies and good weather. Overall the production increased from an average of 1,383,735 tonnes in 2006/07 to 2786 896 tonnes in 2010/11 season Mason (2012).

2.2.3 Fertilizer Input Support programs

In 2002 more than 70% of smallholder farmers could not access fertilizer from any channel, 15-18% of smallholder farmer's sourced fertilizer from retailers and 7-13% accessed fertilizer from government led programs (Mason and Jayne, 2012). The government of Zambia responded by introducing FSP/FISP program to encourage fertilizer use in maize production. The effort of the government to increase fertilizer use was consistent with Hojjati and Jha(1993)'s hypothesis that fertilizer use triggers the transitioning process from subsistence agriculture to commercial farming. Research by Deininger and Olinto (2000) also supported the assertion that increasing fertilizer use can increase maize production and they proved that small application of fertilizer to arable fields that never used fertilizer before can increase the profitability of the crop enterprise.

The FISP program targeted farmers that cultivated between one and five hectares of land and had the potential to increase production. Initially the FSP package was calculated for one hectare of land and it contained four 50kg bags of basal fertilizer, four 50kg bags of top dressing and 20kg of hybrid maize. The package was then halved to two 50kg fertilizer bags of basal and two 50kg bags of top dressing and 10kg bag of hybrid maize seed in 2009/10 season in principle doubling the number of beneficiaries (Mason and Jayne, 2012; Ricker-Gilbert, 2013).

Recipients of FISP fertilizer applied through a farmer organisation which then forwarded the application to District Agriculture Committee. The application was further processed by the Program Coordination Office to determine the members that were eligible to receive subsidized fertilizer (Goeb, 2010). The beneficiaries of the program purchased the inputs at 50% less than the market price (Worldbank, 2009; Manson et al, 2011).

2.2.4 Food Reserve Agency in Zambia

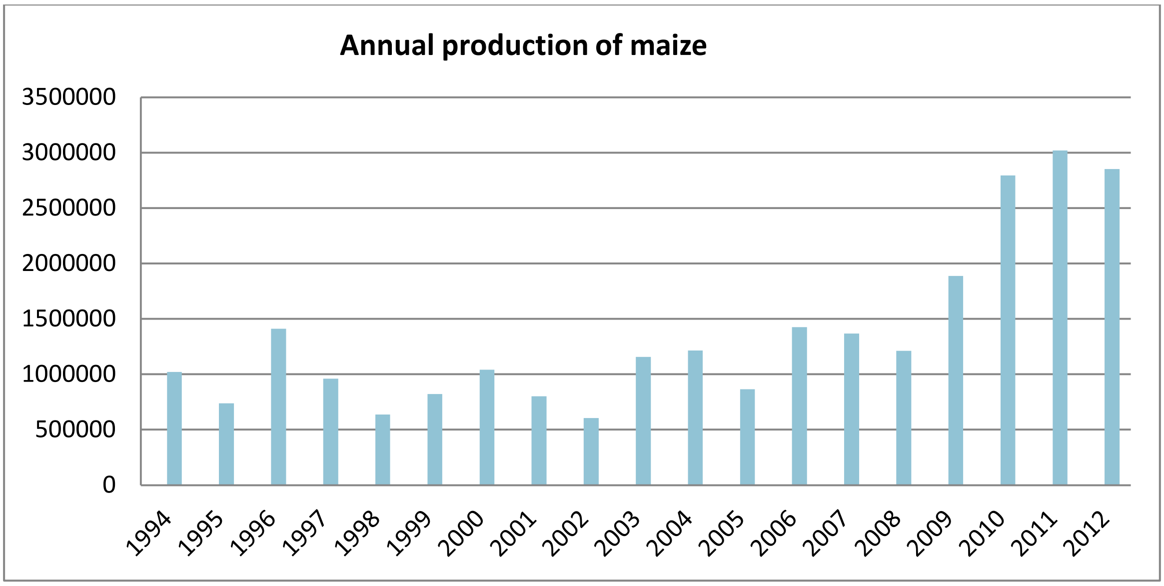
FRA existed from 1996 as a national food reserve agency, though private maize trading was officially authorized FRA held buffer stocks to control price variability (Mwanaumo, 2005; Govereh et al, 2008). Initially FRA functioned in a few districts and purchased maize for national reserves through private traders (Mason, 2012,). After four years of no purchase FRA resumed its maize purchases in 2002/2003 season by sourcing maize directly from the smallholder farmers. FRA maize purchases varied significantly from 2002/2003 to 2011/2012 Firstly the government intended to purchase 200 000 metric tonnes (MT) at pan territorial prices in 37districts and this signalled that the government wanted to dominate the maize market (Mason and Myer, 2013). Lack of funding restricted the government to purchase 54 847 MT. Between 2006/7 and 2007/8 season the FRA scaled up its maize purchases to 400 000MT (86% of smallholder purchases). Another decline in maize purchases took place in 2008/2009 and 2009/10 marketing season but increased to 900 000MT in 2010/2011 season (Mason et al, 2012).

FRA gained market power over other traders as it purchased maize above the market prices and sometimes sold it below market price in domestic markets. The FRA prices exceed the average wholesale prices throughout Zambia. The rationale to provide price above the market price reflected an effort by the government to incentivise farmers to produce more maize. In relation to the neoclassical theorem a number of econometric studies have revealed that an increase the price of the crop increased the production of that crop (Bond, 1983)

2.2.5 Consequences of FISP and FRA

The areas cultivated with maize increased consistently from 2004/5 to 2009/10 while the area cultivated with sorghum and millet declined and that of cassava stagnated. A study by Mason et al, (2012), revealed that maize production increased by 92% from 2006-2008 to 2011 and with the highest percentage increase of 48% in 2009/10 season. The total maize area planted was 28% higher in 2010/11 than in 2006/07. They attributed the increase in the maize area planted to incentives by FISP and FRA. However fertilizer subsidies and maize prices were not the only factors contributing to improved maize production, the weather patterns were favourable as well. Maize production increased by 48% in 2009/2010 season, 25-30% was attributed to fertilizer use, 10-28% to maize prices, 3% to hybrid maize and the largest percentage increase was attributed to good weather (38-62%). Fig 2.2 illustrates the annual production of maize over the period of intensification of the maize support.

Figure 2.3 Annual Maize Productions in Zambia (1994 to 2012)



Source: Faostat

In the same study Mason et al (2012) discovered that access to subsidized fertilizer by household resulted in decreased fertilizer purchases from commercial retailers. Mason and Jayne, (2010) also postulated that receipt of subsidized fertilizer by household decreased fertilizer purchases from commercial retailers by 0.13kg. In places were fertilizer retailing was initially active the displacement rate was higher than that of areas were low fertilizer retailing was minimal resulting in low fertilizer (Xu et al, 2009; Manson and Jayne, 2012).

FRA activities have contributed to an increase in the average level of maize prices and a reduction in price variability. Study by Kuteya et al (2011) revealed that within the smallholder farmers 3-5% benefited from the high average maize prices. The beneficiaries of the high FRA prices owned large portions of land and the net buyers who happen to be rural poor were adversely affected by the high maize prices.

Chapter 3

Literature Review

In this section we discuss literature related to supply response we begin by defining supply response and proceed to look at the theories, the commonly used models and the related studies. Agriculture supply response refers to a change in agriculture output that occurs as a result of price change or more generally as a result of change in the agriculture incentives (Mamingi, 1997). Therefore this section focuses on the theories and empirical evidence that explains the rationale behind supply response.

3.1 Theories of supply response

A number of the economic theories explain the supply response of agriculture. The commonly used economic theory of supply, states that an increase in the price of an agriculture commodity results in an increase in the supply of that particular commodity. A reduction in supply takes place when the prices of the competing commodity changes are positive (De Janvry, 1991). Another dimension is agricultural risk. Generally smallholder farmers are risk averse and price uncertain, uncertainty has a significant role in production decisions. Farmers encounter a number of uncertainties due to unpredictable weather conditions and unstable markets. There economic evidence that risk has a negative and significant effect on agriculture supply

Alongside the economic theory of supply the structuralism theory was established. The structuralism theory therefore takes into account other exogenous factors like socioeconomic factors, demographic and cultural indicators (Beynon, 1989). Structuralists argue that poor structural development and technological advancement are the root cause of low supply response in agriculture.

However some researchers have used both approaches to explain the dynamic relationship between supply and deterministic factors. The researchers assume that the effect of producer prices cannot be considered in isolation to other variables, for instance government policies that set prices for cash crops also have strong effect on the production of cash crops

Several models used to explain the supply response of agriculture produce specify the characteristics of either the economic theory of supply or the structuralism. The commonly used models in agriculture supply response are the Nerlove (1958) model and the farm household model designed by Singh and Squire (1986). The Nerlove model assumes that farmers make their decisions based on expected prices; therefore output (or area) is a function of expected prices, output (area) adjustment and some exogenous variable (Mamingi, 1997). In most research the distributed lag are used to estimate the price expectation but the lag structure varies from one crop to another due to growth patterns of the crops.

Other researchers have built upon Singh and Strauss, (1986) farm household model to explain the behavioural response of farmers to policy changes. The farm household model assumes that utility maximization is subject to a set of constraints and that a non linear farm production function assumes a decrease in marginal returns to labour (De Janvry, 1991).

3.2 Factors that influence supply response

Prices are important in determining the supply response of agricultural produce both at microeconomic and macroeconomic level (Mamingi, 1997). In most cases agriculture prices are influenced by macroeconomic policies such as trade policies, exchange rate policies, and fiscal policies. These policies have an impact on the farmer’s income and terms of trade between tradable and non tradable agriculture commodities like cash and food crops. Essentially the real exchange rate determines the ratio at which tradable and non tradable are exchanged (Mamingi, 1997). In agriculture acreage decisions are based on future prices or lagged expected prices, but these prices are subject to government support programs. Some government programs affect the price of the crop in such a way that they raise the supply response of that particular crop.

Beside prices the supply response of agriculture produce is also affected by other factors like investment in infrastructure development e.g. roads, demographic characteristics (educational level, life expectancy, research and extension) as postulated by Binswanger et al, (1987). Investment in agriculture equipment is expected to have a positive effect on productivity consequently increases the agriculture output.

The household size also has some positive implications for agricultural output the more members a household has the greater the chances of intensifying agriculture production. However, sometimes the household size can alter the production and consumption decision of farmers. The more members a household the less likely the household will participate in cash crop production (Bauer and Bahta, 2012).

Adult literacy rate or education also plays a role in that farmers that are able to read and write can retrieve, interpret and assimilate information thereby increase their likelihood of adopting technical advancement faster. Adult education is positively related to agricultural output because education is also indicator of farmer management ability. Income level have positive impact on the agricultural output in that the more income a farmer has the easier the farmer can acquire the much needed inputs that can boost productivity (Mamingi, 1997)

Technology or advancement in research can substantially increase output of agricultural produce in Africa. Therefore an investment in research can stimulate output growth and environmental conservation through land use intensification as postulated by Mamingi, (1997). However some technological advancement can disturb the ecosystem especially in cases were input use is excessive therefore precautionary measures should be taken. Rural infrastructure development is also important in agriculture production; poor infrastructure (roads) can deprive farmers from price incentives and in most cases smallholder farmers are located in remote areas of the country (Bahta and Bauer, 2012).

3.3 Empirical Evidence of supply response for agriculture commodities

There is an array of prices in any economy and a change in any one of the price can lead to a change in agriculture production. Of interest in this study is the difference between the elasticity of response to price changes of marketed surplus of food crops and production of cash crop (Bond, 1993). Therefore this section will review econometric evidence of price and non price factors on the supply response of cotton and other crops.

According to Bond (1983) studies conducted in Nigeria, Sudan and Uganda indicated that short run and long run acreage response were significant in influencing cotton production. Cotton indicated a significant elasticity of own price with an average of 0.5 in both short run and long run. Short run can be defined as a period in which productive capacity cannot be altered using fixed capacity with variable inputs. Studies revealed that short run price elasticities were smaller than the long run elasticities due to adjustment of many factors. Evidence from cross price elasticities indicated that a rise in the producer price of cotton in relation to coffee was associated with an increase in the production of cotton that was significantly larger than that of coffee output. This implied that cotton competed with other crops specifically coffee and groundnuts.

Lamb (2000) analysed the food and export crop response to agriculture policy in Africa by estimating a structural model. Evidence showed that food supply responded positively to its own price and negatively to contemporaneous export price. The estimated supply elasticity for food crop with respect to price was 0.17 while that of export crop price was negative with a coefficient of -0.30 and statistically significant at 1% level. An estimation on lagged prices were little different from the current prices with food supply responding negatively to export prices (-0.24 significant at 1 %.). The explanation was that food and export crops are substitutes therefore farmers shift resources from one crop to another. Evidence also suggested that while aggregate agricultural output responds positively to increase in food prices, it also responds negatively to increases in export prices in the short run.

Karama and Ozkan (2011) carried out a study on the long and short run dynamics of acreage response for main cotton producing regions of Turkey (Cukurova, Aegean, Antalya and South East). They used a co integration analysis which incorporated the dynamic structure of the Nerlove model and spurious regression in the estimating factors that influenced acreage response to cotton production. In the long run liberal policies and labour shortages were observed to be the cause of a decline in the acreage of cotton for the three regions studied. Finding in Cukurova revealed that cotton prices were significant in increasing cotton production area, yet prices of maize, price risk and wages reduced the cotton acreage. In Aegean region cotton price variations positively influenced the rise in cotton production. Tomatoes and labour inadequacy had a negative and significant coefficient indicating that an increase in their prices caused a decline in` cotton area. In Antalya wheat and cotton prices were found to have positive influence on cotton area while maize and wage prices reduced acreage to cotton. With more investment in irrigation equipment more land was opened to cotton production in the areas of Cukurova and Antalya

Vitale et al, (2009) carried out a study on the supply response of cotton and other cereal crops in smallholder production systems of Mali. A panel data set of 82 farmers was used to evaluate the extent to which cotton producers responded to price changes. An adaptive expectation model of Nerlove (1956) was employed with the assumption that farmers make partial adjustments in crop area based on their future expectations. A system of equations for cotton and other cereals crops were derived and estimated using a two stage least square regression model. The response of cotton to its own price elasticity was positive and significant while the cross price elasticity of cotton to maize was positive but not statistically significant. Sorghum and millet coefficients were significant with sorghum having an unexpected positive sign to cross price elasticity of cotton. Other statistical significant variables were oxen owned equipment, labour, dummy variable for the year and village. From the assessment of the acreage response cotton seemed to be less responsive to prices in the short run with a supply response of 0.15, however the response to price increased in the long run to 0.497.

Mahofa, (2007) studied factors that affected the production of cotton in Zimbabwe by specifying a supply response model of cotton based on Nerlove (1956). The Nerlove model was selected on bases of price determination mechanism observed in the country during the time of study. Due to inflation farmers did not know the producer price of cotton at planting time and prices were announced at harvest time they based their expectation on previous year price. Time series data were employed for analysis on selected variables. Six models were specified and estimated using the ordinary least squares. Contrary to Vitale et al,(2009) their results revealed that own price elasticity was positive but not statistically significant in influencing decision to plant cotton. The cross price elasticity of maize was positive and not significant indicating that there was no competition between maize and cotton. Inclusion of other variables like structural adjustment decreased the own price elasticity of cotton. Government expenditure extended to agriculture research and extension and farmer's access to short term credit had a positive effect on cotton production and these were statically significant. The policy implications from the study were that the government, private sector and non- governmental organisation (NGOs) were suppose to promote extension and training programs to farmers and continue lobbying for removal of policies in developed countries that contributed to depression of the cotton prices.

Omamo(1998) incorporated a costly exchange into an agriculture household model and a numerical non separable version of the model to explain the inefficiency associated with crop choice in Siaya District of Kenya. He hypothesized that smallholder farmer's sacrifice vast amounts of land to food crops than they do to cash crops with high market prices (Omamo, 1998). A simulation model was used with a Leontief representation of the farming systems and a translog utility function as an analytical tool. The findings suggested that without transport cost all representative farmers choose export oriented production plans. When transport costs were included optimal choice of the farmers was to cultivate maize. In a case were production and consumption decisions were associated with high cost, household preferred to produce their own food. He therefore concluded that policy interventions should be designed such that they reduce structural impediments (roads, markets) to exchange and promote specialization that raises farm incomes with time. The policy implications were that investment in the public utilities like transport and communication infrastructure in the rural areas will promote specialization and raise farmer's income and eventually result in even distribution of income.

Jayne (1994) agrees with Omamo (1998) in that cultivation of cash crops with higher returns to land and labour may not be economically viable especially in a scenario where farmers incur high marketing cost. Otherwise production of cash crops is dependent on the degree of grain self sufficiency of a household. The model suggested that, ceterisparibus, the viability of producing cash crops by net grain purchasing household is negatively related to the acquisition price of grain meal. So the greater the acquisition cost of the staple food relative to the producer prices of the cash crops the lower the incentives for the grain deficient household to diversify ceterisparibus. The theoretical implications of the model are estimated using the cross sectional data of grain deficient and grain surplus household that ventured into cash crop production. The equations are estimated using Ordinary least square regression in which the area planted to oilseed is regressed on predetermined variables of a standard production function such as the draft animals, labour input and capital equipment and the degree of household grain sufficiency. The econometric results revealed that all household assets except labour were statistically significant and had a positive effect on oilseed production. Grain sufficient household cultivated 0.70ha of land on average compared to 0.47 ha by the grain deficient households.

Arslan (2011) used the farm household model to theoretically explain why farmers do not respond to market signals in land allocation. The national household dataset was employed to show the effect of shadow prices on land allocation to traditional maize varieties and by subsistence farmers in Mexico. Arslan (2011) established the effect of shadow prices in land allocation by specifying three equations. The first specification consisted of market prices only, the second model specification constituted of the shadow prices and the third model had both shadow and market prices. When used alone the market prices were not significant in explaining the land allocation to traditional maize varieties. A 1% increase in the market price indicated that the area to traditional maize varieties increased by 0.0004units. On the other hand the shadow prices were highly significant in forecasting the land allocation to traditional maize varieties. A 1% increase in the market price corresponded with a 0.001 unit increase in the proportion of land allocated to traditional maize varieties.

3.4 Conclusion of supply response empirical evidence

From the empirical evidence of the supply response we get an understanding that farmer's decision to supply agricultural produce is rational and dependent on the own prices of the crop and cross prices of other crops. Farmer's incentives to increase production are not only motivated by a rise in the producer price. The relationship between price and output produced does not tell us much about agricultural supply response. A host of climatic factors, infrastructure and policy factors play a significant role in the supply response of agriculture produce and sometimes can wipe off the effects of price incentives.

This paper extends from the previous research by explicitly modelling the percentage changes in the land area of cotton as a result of FRA maize and FISP programs in Zambia. The empirical application has provided the evidence of price effect on supply response on cotton and other crops in other countries with government support programs. But this research wants to establish the extent to which land shifts from cotton to maize as a result of change in the maize prices through FRA maize policy program in Zambia.

3.5 Empirical evidence of characteristics of cotton growers

Land size plays a major role in the production of cash crops however this is a constraint for most subsistence farmers in Zambia such that the contribution of cotton and other cash crops to household income is small (Sitko et al, 2011). Studies by Tschirley (2004) revealed that farmers who indulged in cotton production had more family labour and cultivated more than 1.5ha of land. He also postulated that head of the households were younger and slightly more educated than the non cotton growing households. Farmers who participate in cotton production earned more income than farmers who participated in maize production only (Tschirley, 2004).

Abdulai and CroleRees, (2001) study in Mali agrees with Tschirley, (2004) in that the farm size and value of equipment positively influenced farmers' participation in cotton production. Other variables like proximity of the market, household size and level of education were analyzed on farmers' decision to participate in cotton production. Wealthy farmers with large farm size and income appeared to have a greater opportunity of diversifying production and participating in private market initiatives. The variables representing food price variability was positive and significant suggesting that volatile food prices increased the likelihood of farmer's participation in cotton production. However, variables that resembled demographic characteristics like number of children and number of female members were not significant.

A study by Jayne et al (2003) on cash and food cropping synergistic effects in Zimbabwe also revealed that cotton growers had more landholding size than non cotton growers and that landholdings increased with intensity of cotton production. On the other hand cotton growers owned more draught animals and farm assets which facilitated greater area to be cultivated. Jayne et al (2003) findings corresponded with those of Abdulai and CroleRees (2001) and Tschirley (2004) in that household that cultivated cotton had higher crop income per capital almost four times higher than that of the non cotton growers. Cotton growers observed by Jayne, (2003) attained higher yields of grain than the non cotton participants and could secure their household with sufficient grain.

Chapter 4

Methodology

This chapter focuses on the theoretical framework used to explain the relationship between price and farmer's decision to allocate land. The chapter proceeds to explain the data and analytical techniques used for the assessment of the effect of government maize support programs on seed cotton production. It further defines the variables incorporated in the econometric model and the estimation strategies to be used for the analysis.

4.1 Theoretical Framework

To understand the behavioural response of cotton farmers in case of FRA pricing policy and fertilizer subsidies we outline a theoretical framework that is built upon Singh and Strauss, (1986), farm household model. We assume that smallholder farmers in Zambia are semi-subsistence producers of maize and cotton. Zambian farmers differ in terms of their production and consumption decision. With regards to production decisions, whereas some farmers focus mainly on one crop, others are involved in intercropping systems. Still on production patterns, the farmers differ in terms of the scales of production. In terms of consumption, farmers differ in the proportion of their produce they sell in or keep for household consumption. Assuming that there are two production functions one for maize and the other for cotton, for the ease of explanation we suppose both to be Cobb Douglas functions

Suppose a farmer has an option to produce maize and cotton for sale at constant returns to scale. We expect the farmer to specialize in the production of a crop with highest profits. To explain this we use the general profit function for commercial farmers producing either maize or cotton as:

$$\pi = pq - wl \tag{4.1}$$

And a production function:

$$q = \alpha A^{\varphi} l^{1-\varphi} \tag{4.2}$$

Where p=price, w=wage q=quantity produced, A denotes land area and l the quantity of labour used. The maximum profits per hectare are obtained by setting the first order conditions:

$$p\alpha A^{\varphi}(l-\beta)^{-\varphi} = w \tag{4.3}$$

The optimal labour allocation is expressed as

$$l^{*} = \left[\frac{p}{w}\alpha(1-\varphi)\right]^{\frac{1}{\varphi}} A \tag{4.4}$$

The profit of the farmer is then expressed as:

$$\frac{\pi}{A} = \varphi(\alpha p)^{\frac{1}{\varphi}}\left[\frac{w}{1-\varphi}\right]^{1-\frac{1}{\varphi}} \tag{4.5}$$

The variable A does not occur on the right hand side meaning that the profit per ha does not change if the area changes. The consequence of this is that if the farmer decides to grow either maize or cotton, the crop with the highest profit is selected. Therefore the farmer chooses to specialize and not grow both crops. The reason behind this is that the production function is linear homogeneous.

However farmers tend to grow both crops due to uncertainties associated with weather conditions, growth patterns of the crop and unpredictable market prices and proneness of maize to drought. The prospects of ongoing price volatility of cotton and proneness of maize to drought discourages farmers from making exclusive investment on one crop since they are already overburdened by increased costs of inputs such as fertilizer and transaction cost. Therefore farmers do not specialize instead they diversify their production.

The general production function for a farmer producing maize or cotton at decreasing return to scale is:

$$q = \alpha A^{\alpha} l^{\lambda}, \text{ where } 0<\alpha+\lambda<1 \tag{4.6}$$

The farmer decides on the optimal labour allocation between maize and cotton which is given

$$as\ l^{*} = \left[\frac{p}{w}\alpha\lambda\right]^{\frac{1}{1-\lambda}} A^{\frac{\alpha}{1-\lambda}} \tag{4.7}$$

Incorporating optimal labour into the production function gives a profit of:

$$\pi = (1-\lambda)\left(ap\frac{\lambda}{w}\right)^{\frac{1}{1-\lambda}}\left(\frac{w}{\lambda}\right)A^{\frac{\alpha}{1-\lambda}} \quad (4.8)$$

Indicating that profits per ha decrease with increase in the land area. Therefore the elasticity of the profit with respect to p is $\frac{1}{1-\lambda}$ and with respect to wage is $\frac{-\lambda}{1-\lambda}$.

Having the production function of maize and cotton expressed as $q_m = mA_m{}^{\mu}l_m{}^{\lambda}$ (4.9) and $q_c = cA_c{}^{\gamma}l_c{}^{\beta}$ (4.10) respectively, the first order condition for profit maximization of the farmer is derived as in the equation 4.11:

$$\frac{\partial\pi_c}{\partial A} = \mu(mp_c\frac{\beta}{w})^{\frac{1}{1-\beta}}\left(\frac{w}{\lambda}\right)A^{\frac{\gamma}{1-\beta}-1} = \frac{\partial\pi_m}{\partial A} = \mu(mp_m\frac{\lambda}{w})^{\frac{1}{1-\lambda}}\left(\frac{w}{\lambda}\right)A^{\frac{\mu}{1-\lambda}-1} \quad (4.11)$$

Assuming that the government support programs raises the price of maize, the marginal profits of maize land rises inducing a shift of land from maize to cotton. The extent to which the land of cotton decreases is dependent on marginal change in profit in response to maize price. The relative change in marginal profit for maize is

$$\partial\, ln\, \pi_m = \frac{\partial\, ln\, p_m}{1-\lambda} + (\frac{\mu}{1-\lambda})\partial\, ln\, A_m \quad (4.12)$$

And for cotton:

$$\partial\, ln\, \pi_c = (\frac{\gamma}{1-\beta})\partial\, ln\, A_c \quad (4.13)$$

When the price of maize rise by 1% the marginal profit changes by $\frac{1}{1-\lambda}$ per kwacha causing the marginal profit for cotton land to change by $[\left(\frac{\gamma}{1-\beta}-1\right)(1-\lambda)]^{-1}$ per kwacha. Sometimes the changes maybe small but what changes in cotton is added to maize. The absolute area that switches from cotton to maize must be equal therefore we need a starting ratio maize and cotton to convert the relative changes. Suppose the original ratio is r (area of maize to cotton) than the relative change in cotton area equals the relative change in cotton area equals r times the relative change in maize. To determine the change we then derive the equation 4.14 below:

$$\partial\, ln\, A_c = [(1-\lambda)\left(\frac{\gamma}{1-\beta} - 1 - \frac{\mu}{r(1-\lambda)} + \frac{1}{r}\right)]^{-1}\partial\, ln\, P_m \quad (4.14)$$

Our theoretical model suggests that if the land and labour elasticities of maize and cotton can be estimated, then they can be substituted into the relation $[(1-\lambda)\left(\frac{\gamma}{1-\beta} - 1 - \frac{\mu}{r(1-\lambda)} + \right.$

$\frac{1}{r}\Big)]^{-1}$ to arrive at the percentage change in area cultivated under cotton in response to the price of maize. For semi subsistence farmer the decreasing returns to scale are assumed to be much stronger in maize production. The reason behind this is that with the influence of government support programs maize prices rises incentivising farmers to produce.

4.2 Estimation Strategy and Model Specification

4.2.1 Tobit model

In this study, farmers' decision to participate in cotton production is analysed. Farmers' decision to venture into any production system is determined by the utility they expect to derive from that production system (de Janvry et al, 1991). If the marginal utility derived from cultivation of cotton is greater than the marginal utility derived from cultivating maize, economic theory suggests that, the farmer will decide to grow cotton. This decision to participate in cotton production is however unobservable (latent). We therefore assume a latent variable (y*) which captures this decision making process and relates to a vector of socioeconomic characteristics. The standard Tobit model is used to estimate effects of socioeconomic characteristics on the latent variable (Tobin, 1958): This model aids us to then estimate the probability that a farmer of a specific characteristic will grow cotton. The standard Tobit model is given as follows:

$$Y_c^* = X_i\beta_i + u_i \quad u_i \sim N(0,\sigma^2) \quad i = 1,\ldots\ldots\ldots.,n \tag{4.15}$$

$$Y_c = Y_c^*, \qquad Y_i^* \text{if} > 0$$
$$Y_c = 0, \qquad \text{otherwise}$$

The decision to participation in cotton production Y_c* is an unobserved continuous latent variable but can be proxied by the actual hectares of farm land allocated to cotton (Y_c). In our model the latent variable is observed if it is greater than or equal to zero. Thus the model becomes:

$$Y_c = \max(Y_c, 0) \tag{4.16}$$

X_i is the matrix of the explanatory variables corresponding to the *ith* household; β is the vector of parameters to be estimated. The Tobit model is however restrictive and estimates the coefficients on the decision to plant cotton i.e. the probit model Prob (Y_c>0) and the extent of production i.e. the truncated regression Y_c (Y_c>0) in the same way.

Using the theoretical framework presented in the previous section, land area and expected crop prices are employed as explanatory variables for estimating farmer's decision to participate in cotton production. Some variables were selected on bases of previous findings by other researchers. Table 4.1 outlines the key variables used. The mean, standard deviation and ranges of these data are presented in Table 5.2. For this study, land area allocated to cotton was used as a proxy to farmer's decision to participate in cotton production. The land area allocated to cotton is treated as a dependent variable because the output produced is subject to a number of factors like weather conditions which are beyond the farmers' control.

Other variables used will reflect the household characteristics. Household characteristics are constructed using five variables namely age of the household head, gender of the household head, dependency ratio and number of adults in the family. Age of the head of the household is a proxy of household experience in farming and it also indicates how knowledgeable the household is in cotton production. However Tschirley (2004) discovered that as the farmer ages there is less participation in cotton production we therefore anticipate that as the farmers age there is less participation in cotton production.

The gender of the household head indicates the advantage that the household has over production resources. A male household has more credibility as contractual partner and the customary laws are in favour of man in allocating land. Therefore with more males that participate in cotton production the higher the likelihood that farmers will participate in cotton production.

An adult equivalent variable is a proxy for availability of family labour and a combination of adult equivalent and dependency ratio indicate the size of the household and its impact on the production and consumption decisions. With increase in dependency ratio we expected the participation in cotton production to decrease. However with more adult the participation in cotton production is expected to increase since more labour force was available for production.

Farm mechanisation and availability of draft power reduces the labour allocated per hectare and increases crop output. Therefore we expect an increase in the likelihood of participation in cotton production with more assets

The recipients of subsidized fertilizer are not randomly selected variables including government support programs would have been ideal for this analysis. Therefore to ensure exogeneity of the explanatory variables we use the electoral variables to instrument for the government support programs. The use of the electoral variable as an instrumental variable for participation in government support programs is guided by Coperstake (1998) and Pletcher (2000). They postulated that the primary goal of the maize support programs was to fulfil the political patronage objective through intentionally distribution of unrecovered loan to designated local influential party supporters. Mason et al (2012) also hypothesized that FISP and FRA beneficiaries were closer to a party that won elections during the previous years (Mason et al 2012). With all these consideration we anticipate that participation in cotton production is influenced by the farmer's location.

Table 4.1 Definition of variables used in the tobit model and expected signs.

Variable name	**Description of variable**	**A prior expectation**
Education	Level of education that the household head reached	-
Dependency ratio	The number of children below the age of 15years and adult above the age of 65	-
Age	Age of the household head is measured in years	+
Distance to the a maize market	Measured in kilometres	+
Gender	It a dummy variable male=1 or otherwise	+
Land size	Total number of hectares that a household owns	+
Production asset	Number of production assets that a household has e.g. ox drawn plough, sprays	+
Transportation asset	Number of transport asset like bicycle and tractor owned by a household	+
Cattle owned	Number of cattle that a household owned	+
Cotton price	Price of cotton measured in kwacha	+
Maize price	Price of cotton measured in kwacha	-
Maize sale to other	Ability of a household to source a market	-

A number specification tests were conducted to ascertain the appropriateness of the Tobit model.

Multi-collinearity Test: Multi-collinearity occurs when two or more explanatory variables are highly correlated. In the presence of multi-colinearity coefficient estimators are inconsistent and very responsive to small changes in the model or data. Before estimating our Tobit model the relationship between variables is tested for multi-colinearity by inspecting the correlation coefficient matrix. The correlation coefficient ranges from 0-1, a correlation coefficient of 0.8 and above between explanatory variables indicates high association between them. One of those variables is therefore dropped from the final regression equation.(Results for multicollinearity see Table 8.1 appendix)

Endogeneity Test: The presence of endogeneity in the model contributes to unbiased and inconsistent estimators. Endogeneity is when there is a correlation between the explanatory variable and the error of term. In our case endogeneity may arise in the tobit model because of unobserved variables. For example, participation in cotton production can be influenced by factors like farmer's connection to FISP and FRA programs or farmer's union. Farmers that participate in FISP and FRA are not randomly selected instead they are chosen at district level. Therefore the quantity of fertilizer received by the district and the extent at which FRA purchases maize depends on the dominance of the ruling party in that area. We suspect endogeneity to be a problem if the dummy variable on FISP and FRA are considered as explanatory variables without taking into account the dominance of the ruling party. To establish the presence of endogeneity in our Tobit model, the Smith and Bundell (1986) approach to testing exogeneity is employed. In this test, the dependent variable (in our case area allocated to cotton) is regressed on the suspected endogenous variables and instrumented by a set of exogenous possible instrumental variables. The residuals from each the instrumental regressions are included in a Tobit model. Estimation of the model gives rise to a test for the joint hypothesis that each of the coefficients on the residual series are zero. Under the null hypothesis, the models are appropriately specified with all explanatory variables as exogenous. Under the null hypothesis, the models are appropriately specified with all explanatory variables as exogenous. Under the alternative hypothesis, the suspected endogenous variables are expressed as linear projections of a set of instruments, and the residuals from those first-stage regressions are added to the model.

4.2.2 Estimation of the yield output equation

Production is a combination of inputs and techniques to produce particular output. Estimating the factors that influence farmer's participation decision in cotton production may not be sufficient in explaining how the supply response of cotton is affected by the maize policy programs. Theoretically maize programs could affect resource allocation (land and labour), between maize and cotton. We therefore specify a yield equation for farmers that grow both crops by estimating the production function that relates labour and land to output. The production function for cotton can be given as:

$$\ln y_c = \beta_i x_i + \alpha_i z_i + \varphi_i t_i \tag{4.17}$$

Where is x a vector variable denoting the determinants of cotton production such as demographic characteristic, farm size, educational level of the farmer inputs , assets , family labour, relative price of maize to cotton and household characteristic. In the model we include location variables z like the province which represents agricultural characteristics that are common to each farmer. Prices are included in the model to account for imperfectly measured labour which does not take into account the number of hours allocated to maize and cotton (Brambilla and Porto, 2005). Suppose the price of maize raises the farmer responds by allocating more labour to maize than they would do to cotton. We capture the effect of time by using a dummy variable t for year. With these variable specified we using the ordinary least squares regression to estimate the model.

4.2.3 Description of data used

For this study we extract data from three household surveys for the Eastern, Southern, Central and Lusaka provinces of Zambia. The 2003/4 and 2007/8 surveys are a repeated cross section of the same farmers after every four years and are combined to form a panel dataset. The 2012 dataset is compiled from a different set of farmers thus will be treated as a cross section. The two sets of data were used to shed light on the underlying consideration of farmers that grow both cotton and maize.

The 2003/4 and 2007/8 supplementary survey constituted of 2110 and 2025 farmers respectively while the 2012 rural agricultural survey had 4360 farmers. The advantage with the use of these surveys is that they captured different levels of FRA involvement. The activities of FRA were minimal in 2003/4 but scaled up in 2008 and 2012. The method used in data collection was a stratified three stage sampling design. Census supervisory areas

(CSA) were first selected within the district. From then the standard enumeration areas (SEA) were sampled from each selected CSA. Lastly samples of households were selected from a list of households within each SEA. An attempt was made to retrieve and compile data on the landholdings, land allocation, crop patterns, assets, demographic characteristics such as age of the household head, level of education, and other variables like livestock and farm infrastructure.

Chapter 5

Results and Discussion

In this chapter we will present the results obtained from the analysis and discuss our findings in relation to the literature. The chapter includes both the descriptive statistics and the empirical results. Descriptive statistics will provide a summary about the sample used for the analysis of this study and the observations made in this study. The empirical results will be used to infer if the hypothesis made for this study are true or not and this will be interpreted from a tobit model and a linear production function to draw conclusions.

5.1 Descriptive Statistics

In this section we use means and standard deviations to describe the nature of our data. In this section we will start by giving the distribution of farmers that cropped either maize or cotton and other crops: Table 5.1 illustrates the distribution of farmers

Table 5.1 Distribution of farmers in maize and cotton production

Type of production	Year	Number of farmers
Maize only	2004	1524
	2008	1504
	2012	2784
Cotton only	2004	6
	2008	3
	2012	31
Both maize and cotton	2004	517
	2008	472
	2012	1320
Other crops	2004	63
	2008	46
	2012	225

With intensification of the FRA and FISP activities one would expect a reduction in cotton production. Table 5.1 above shows that there was a slight decrease in cotton production from 2004 to 2008, the percentage of farmers that cultivated cotton decreased slightly. However the amount of fertilizer application to cotton increased for those farmers that applied fertilizer to their crops. The descriptive results coincide with the hypothesis that maize support programs can lead to reduction in cotton production. In 2012 more respondents participated in cotton production 32.1% farmers participated in cotton compared to 24.8% and 23.5% in 2004 and 2008 respectively.

Table 5.2 Production characteristics of cotton and maize farmers by year

Variables description	Marketing year	Participation in	
		Cotton	Maize
Percentage of farmers	2004	24.80	96.70
	2008	23.50	97.50
	2012	32.10	95.50
Mean hectares(ha)	2004	0.26	1.27
	2008	0.24	1.57
	2012	0.39	1.70
Mean fertilizer application (kg)	2004	171.00	335.88
	2008	200.00	497.69
	2012	133.14	501.62
Mean output harvested (kg)	2004	289.20	2264.76
	2008	212.84	2759.54
	2012	324.82	4233.53

The averages fertilizer application averages are compiled for those farmers with positive application

5.2 Description of different types of cotton farmers

The table 5.2 presents a summary statistics of the characteristics of smallholder farmers growing cotton and non-cotton growers. One would expect the participants in cotton production to be better endowed with large land holding sizes as hypothesized by Tschirley et al (2004); Chapoto et al(2012). From Table 5.2 we interpret that farmers that participated in cotton production had more household members than non cotton growers for all the years. For 2004 and 2008 the number of household members for cotton growing households are 6% higher than the non-cotton growing households while for 2012 the values are 11% higher than the non cotton growing households.

Table 5.3 Comparison of household characteristic of cotton participants and non participants

Descriptive Variables	Growing Status for 2004		Growing status for 2008		Growing status for 2012	
	Cotton grower	Non cotton grower	Cotton growers	Non cotton growers	Cotton growers	Non cotton growers
Household size	7.89	7.41	7.22	6.41	6.19	5.82
Male headed	0.87	0.76	0.86	0.74	0.87	0.77
Age of the head	46.52	50.09	50.10	53.34	44.57	45.32
Education of head	5.07	5.11	4.9	5.34	6.20	6.75
Adult equivalence	5.85	5.34	5.96	5.29	5.38	4.98
Agricultural Characteristics						
Land holding size	3.30	2.22	3.93	4.08	5.88	4.44
Land cropped with maize	1.32	1.22	1.51	1.58	2.27	2.48
Land cropped with cotton	1.04	-	1.03	-	1.39	-
Maize produce	2414	2122	2372	2848	5925.	6825
FISP fertilizer	44.09	47.05	57.63	82.14	211.47	182.30
Ownership of assets						
Production assets	1.62	0.93	1.62	1.21	2.24	1.64
Cattle ownership	4.29	4.08	4.88	4.78	5.32	6.14
Transportation assets	0.93	0.72	1.02	0.84	1.42	1.21
Distance to next vehicular road	6.68	5.13	6.02	4.01	6.72	7.33
Net off farm income	488,238	1,240,916	1,238,262	2,509,192	3,094,323	6,847,031

The result obtained from members of households are consistent with Tschirley (2004) that cotton growers had more households members than non cotton growers. However the results differ in that the cotton household in this case appear to be less educated. Level of education of cotton participants is 4.9 versus 5.34 for non participants in 2008. These results are similar to those of Tschirley,(2004) in that for cotton producers household heads are younger and possess more land than the non participants. For example 2004 the mean value of age for cotton participants is 46.52 while that for non participants is 50.09. Cotton producers seem to be dedicating additional land to cotton production, they do not appear to sacrifice maize production for cotton. Households that venture into cotton production appear to be better endowed in terms of assets but with more alternatives of net off farm incomes..

Table 5.4 Summary statistics of explanatory variables used in the tobit

Variable	Mean	Std. Dev.	Min	Max
Cotton hectares	0.2508	0.7409	0	19.845
Age	51.197	15.1038	16	98
Male	0.7854	0.4105	0	1
Land size	3.3179	13.206	0	612.1
Education level	5.0964	3.7966	-8	19
Dependency ratio	1.0066	0.8409	0	7
Adult equivalent	5.5481	2.9725	0.4167	32.538
Production assets	1.237	2.1279	0	26
Transportation assets	0.8329	0.8901	0	9
Cattle	4.6282	16.8491	0	693
Cotton price	1179.48	52.06	435.78	1225
Maize prices	1017.37	130.16	871.6	1157.78
Maize sale to other traders	0.3144	0.4643	0	1
Percentage spread of election	33.892	22.378	1.6421	87.314
Eastern province	0.443	0.4968	0	1
Lusaka province	0.0539	0.2259	0	1
Southern province	0.2747	0.4464	0	1
year 2008	0.4897	0.49995	0	1

For t-test on the differnces of the level of education , adult equivalent land size and transport assets for cotton and non cotton farmers see Appendix tables 8.5,8..6 and 8.7. Of the four variables level of education and farm size of cotton farmers were statistically different from the non cotton growers.

5.3 Empirical Results of a Tobit model

The Table 5.3 below shows the empirical results of a Tobit model for each with variables that account for household decisions to engage in cotton production. To determine the factors that influence farmer's participation in cotton production we estimated pooled censored Tobit model. Our intention is to first establish whether or not socioeconomic variables of farmers in Zambia predict the probability that farmers will decide to participate in cotton production. Second, we then seek to quantify this probability and then finally estimate the actual change in land allocated to cotton among farmers with a positive probability of participating in cotton production. In table 5.5 we present with the coefficient of the Tobit regression, the Un-decomposed marginal effects and the change in cotton area as a result of the change in probability of participating in cotton production.

Table 5.5 Marginal Effects and Probabilities of factors that affect land allocation to cotton

Variable Name	Tobit coefficient		Unconditional marginal effects E(y | y,x)		Conditional marginal effects E(y | y>0,x)	
	Coef	Robust Std. Err	dy/dx	Delta-method Std. Err.	dy/dx	Delta-method Std. Err.
Age	-0.00186	0.0020	-0.00037	0.0004	-0.00032	0.0003
Male	0.11382	0.0692	0.02252	0.0137	0.01949	0.0122
Land size	0.01180	0.0056**	0.00234	0.0011**	0.00202	0.0008**
Education Level	-0.01596	0.0097	-0.00316	0.0019*	-0.00273	0.0017
Dependency Ratio	0.01225	0.0406	0.00242	0.0080	0.00210	0.0069
Adult equivalency	0.02626	0.0179	0.00520	0.0035	0.00450	0.0030
Production assets	0.16344	0.0265***	0.03234	0.0048***	0.02799	0.0044***
Transport Assets	0.22212	0.0884**	0.04396	0.0163***	0.03804	0.0141***
Cattle size	-0.01611	0.0077***	-0.00319	0.0014**	-0.00276	0.0012**
Cotton price	0.00572	0.0019***	0.00113	0.0004***	0.00098	0.0002***
Maize price	-0.00033	0.0003	-0.00007	0.0001	-0.00006	0.0001
Maize sale to traders	0.21946	0.0960**	0.04343	0.0181**	0.03759	0.0160**
Spread of elections	-0.00049	0.0022	-0.00010	0.0004	-0.00008	0.0004
Eastern Province	0.35048	0.1834*	0.06936	0.0344**	0.06003	0.0284**
Lusaka Province	-0.18850	0.1842	-0.03730	0.0369	-0.03228	0.0331
Southern Province	0.05267	0.1487	0.01042	0.0293	0.00902	0.0252
Year 2008	0.34182	0.1583**	0.06765	0.0304**	0.05854	0.0224***
Constant	-6.38133	2.4880				
Sigma	1.089722					

Sample size	4,077
F (17, 4,060)	7.24 (0.000)
Pseudo R	0.5541
Log pseudolikelihood	-1,506.29
Probability of being uncensoured	.197899

Inspecting the results of the first column of table 5.5 (coefficients) for a panel of 2004 and 2008, it is seen that the decision to cultivate cotton is positively influenced by price of cotton, land size, production assets, participation of the farmer in the traders maize market, and location of farmers in the Eastern province. The parameter estimates of these variables showed that increase the probability of participation in cotton production is more than the increase in the area allocated to cotton. The numbers of cattle owned and level of education were negative and statistically significant in influencing the likelihood of farmer's participation in cotton production. Other variables like the extent to which presidential elections were won by the ruling party and price of maize were expected to be negatively related to the dependent variable but the results revealed that these variables had no influence on the decision to participate in cotton production and the parameter estimates signs were not as expected.

Cotton price is our main variable of interest here. The results suggest that, 1 unit change in cotton price is expected to change the probability of participating in cotton production by 0.00113 units. For an average cotton producer there is a condition change of 0.00098 units of cotton land with a unit change in cotton price. Increasing land endowment by one unit leads to 0.0023 unit changes in the probability of participating in cotton production. From the conditional marginal effects in table 5.5, we also observe that holding other factors constant, a unit change in land endowment leads to 0.00202 unit change in land allocated to cotton for an average farmer. The results correspond to those of Tschirley et al (2004) who observed that household with more than 1.5ha of land increased farmer's participation in cotton production in Zambia. Furthermore the land size permits the farmer to produce surplus maize for family and gives the farmer a leeway to venture into cotton production. This also prevents the negative impacts that dependency ratio has on the likelihood of farmer's participation in cotton production. For the average cotton producer when production assets change by one unit, cotton land also changes by 0.0044 units in the same directions. While the probability of participation increases by 0.0048 with more production asset endowment.

It is also expected that a unit increase in maize sale to other traders increases participation in cotton production by 0.04343 units. Conditional on participation in cotton production maize sale to other traders increases the land area allocated to cotton by 0.03759 units. This implies that farmers that cannot sale maize to FRA farmers opt to sale to other traders such farmers tend to grow cotton more often. Generally the results coincide with those of Jayne and Govereh, (2003) who concluded that the spill over effects from cash crop production benefits food crops the opposite is true with food production in Zambia. The spill over effects of participating in a maize market also benefits cash crop production in that the profits obtained from the sale of maize can be ploughed back to cotton production. Even though the variable used to measure maize prices were not significant in influencing participation in cotton production it could be that the provincial prices used as a proxy for maize prices reflected cross sectional differences instead of variation in maize prices overtime. Therefore the sale of maize to private traders underscores the importance of the maize prices.

5.4 Empirical Evidence from the production function

A salient objective of this thesis is to find out the extent to which the FSP and FRA interventions by the government in Zambia influenced allocation between maize and cotton by farmers. To aid us address this objective we developed a household production model (see section 4.1). The model related change in price of maize to allocation of land. Our original intention was to estimate appropriate maize and cotton production functions, and substitute the elasticities of land and labour for both crops into Equation 4.14. Hence our variables of interest here are land and labour

5.4.1 Cotton production function

In table 5.6, we present empirical results of cotton production function for farmers that produced both maize and cotton.

Table 5.6 Estimation results of cotton production for farmers that cultivated both maize and cotton a panel of 2004 and 2008

Variable name	dy/dx	Std. Err.
Ln(cotton hectares)	0.5839***	0.0679
Ln(adult equivalent)	0.1476**	0.0685
Ln(production asset)	0.2066***	0.0570

Ln(Age)	-0.0395	0.1161
Ln (dependency ratio)	0.0094	0.0424
Ln(transport asset)	0.1335	0.0811
Ln (farmsize)	0.1031	0.0736
Education level	0.0119	0.0087
year2008	-0.2728**	0.0607
Eastern	0.2727***	0.0716
Lusaka	-0.0643	0.1545
R-Square within 0.3981		
between 0.4579		
overall 0.4929		
Wald chi2(12) = 393.60		
Prob > chi2 = 0.0000		

Dependent variable = Ln cotton output

From the production function of cotton estimated for 2004 and 2008 panel data set the factors identified as significant and positively affecting cotton production are cotton hectares, adult equivalent, production assets Eastern province. The dummy variable for year 2008 was negative and statistically significant indicating that in 2008 the production of cotton declined by -0.2728units. The explanation to this could be that a decrease in the world market price demoralized farmers from cultivating cotton. In contrast to the year variable land allocated to cotton was positive and strongly significant. A 1% increase in the land area for cotton resulted in 0.5839% increases in output of cotton, holding other variables constant. This is less than one implying that the supply response of cotton with respect to land is inelastic. The labour allocated to cotton was statistically significant in influencing the production of cotton. A 1% increase in labour resulted in a 0.1476% increase in cotton production. The result implies that a household with more members has greater chances of intensifying cotton production by allocating extra labour to cotton.

A rise in the price of cotton cause farmers to respond by changing their land area to cotton we therefore use the elasticities estimated in table 5.6 to establish the change in cotton area. Using the differential expression of elasticity with respect to land in equation 4.1 we derive the change in cotton land as a result of change in price as follow:

$$\frac{\partial A}{\partial p} * \frac{P}{A} = \frac{1}{1-\lambda} = \frac{1}{1-0.5839} = 2.4$$

This implies that an increase in the price of cotton results in 2.4% increase in the cotton area.

Maize production function

Estimates of maize output function is outlined in table 5.7. It can be deduced from the result that land allocated to maize, transport assets production assets, educational level are statistically significant in influencing production of maize. Our data shows that holding other factors constant, a 1% increase in land of maize results in 0.8106% increase in the output of maize. This implies that maize production has higher responsiveness to land area compared to cotton. The explanation of this high responsiveness of maize is that maize is a staple food farmers are more willing to put their land to it than they do with cotton. Additionally, smallholder farmers are land constrained and production in rural areas is dependent on farm size the larger the farm size the more easily the farmer can expand production. Farm sizes of smallholders in Zambia could be the reason why farmers do not increase production area even in a case of economic incentives. The education level had a positive coefficient indicating that farmers that were highly educated increased maize production.

Table 5.7 Production equation for maize for farmers that grow both maize and cotton

Variable Name	dy/dx	Delta-method Std. Err.
ln(maize hectares)	0.8106***	0.0818
ln adult equivalent	0.0823	0.0861
ln production assets	0.1824***	0.0693
ln age	0.0283	0.1404
lndependcy ratio	-0.0029	0.0465
lntransport assets	0.1506***	0.0839
ln(farmsize)	0.0086	0.0918
Education level	0.0295***	0.0100
year2008	-0.1944***	0.0665
Eastern Province	-0.0020	0.0884
Southern Province	-0.0235	0.1836
Rsquare		
Within = 0.2360		
Between = 0.5586		
Overall = 0.5519		

Dependent variable = Ln maize output

The explanation to this is that the knowledgeable households are able to assimilate process and use information acquired accordingly which gives positive effects on production. The variable for family labour was positive but insignificant meaning that family labour had no influence on output of maize production. Contrary to our expectation, elasticity of labour was not statistically significant. Perhaps with extra labour farmers are more willing to invest in cash crops to earn some money for their households. This may explain why cotton production increases with more labour. Production asset in this study refer to tools and implements of farmers. Our results suggest that a 1% increase in the number of production assets will result in a 0.2% increase in maize output. This is similar to the results in table 5.6 for cotton; indicating that farmers do not assign different production assets to different crops. Transport assets and production assets have a positive influence on maize production. Transport assets may not contribute directly to cotton production. To establish a change in the maize area as a result of change in the maize price we compute the change as follows: $\frac{\partial A}{\partial p} * \frac{P}{A} = \frac{1}{1-\lambda} = \frac{1}{1-0.8106} = 5.27$. This implies that a 1% increase in the prices of maize results in 5.27% increase in land allocation to maize.

5.5 Concluding Remarks

Based on the production function of maize and cotton estimated in table 5.6 and 5.7 above it is indicative that generally, cotton and maize respond positively to land and labour resources. However maize appears to be more responsive to changes in land area than cotton. This implies that of the cotton revenues received by a farm household in Zambia, a relatively smaller share (58%) can be attributed land compared to the proportion of maize revenues (81%) attributed to land shifts. Other variables like production assets, location variable like the Eastern province and adult equivalent also showed some significant relationship with cotton and maize.

However we failed to fit our data to a number of appropriate production functions. For instance, the assumption of constant returns to scale of the Cobb-Douglas was contrary to our main assumption of decreasing return to scale. The much more flexible translog production function also failed to produce useful estimates, thus disputing the assumption of decreasing returns to scale for cotton and maize as hypothesized in the theoretical framework. Therefore we run a much general function relating output to likely determinants; especially land and labour. Even though we are unable to substitute labour and land elasticities into Equation 4.14, it must be noted that with a much more appropriate data set, it will be interesting to quantify the effect of maize prices on cotton output.

Chapter 6

Conclusions and Recommendation

This chapter presents a summary of the study, the salient findings and concisely outlines the conclusions that were made as a result of the study. Key recommendations are then distilled.

6.1 Summary

In this study, two questions have been addressed: (1) what factors determine farmer's decision to participate in cotton production? and (2) what is the effect of FISP and FRA activities on land allocation between maize and cotton? To address the first question, a Tobit model was estimated with area of land allocated to cotton as dependent variable regressed on a number of household factors. The impact of FSP and FRA were estimated more indirectly in two steps. First, we developed theoretical model which builds on farm household decision making and related changes in the price of maize to changes in the area of farm allocated to cotton. The underpinning theory is that with the FSP and FRA maize support programs, price of maize changed. This change in price of maize had consequences on household decision making in terms of allocation of land. The theoretical model required the estimation of an appropriate production function to obtain elasticities which will then be used to calculate the impact of price changes due to FISP. Our data however failed to fit a proper production function. Hence, we regressed maize and cotton output to a set of household and factors of production and drew generalized conclusions. The results show that, the price of cotton, size of farmlands (including fallow lands) and time were the main determinants of the probability that farmers will grow cotton in Zambia. Another important finding of this study is that maize responds to change in land allocation more than cotton, signifying that maize is more productive than cotton in the study areas.

6.2 Conclusions and recommendations

A number of conclusions can be drawn from the result of the study. The findings that participation in cotton production is influenced by the own price, asset endowment asset endowment and the land size, indicates the important of prices for cotton production. Though we used a repeated cross sectional data with limited price variation to establish the effect of prices on decision to participate in cotton production, the effect of cotton prices revealed the high likelihood that of motivating farmers to allocate more land to the crop. However, there is a lack of public support programmes for the crop. These results alone highlight that the theory of structuralism is important in explaining supply response of farmers to price changes and other economic incentives. Therefore infrastructural development and establishment of maize markets has positive spill over effects on cotton production. This implies that a farmer that can access a maize market is able to diversify production to cash crop. Land is another important factor in cotton production farmers with more land are able to participate in cotton production.

Our theoretical framework related the effect of maize prices on allocation of farmlands to cotton but our data did not allow us to make causal linkages about the direction of impact. However, we were able to estimate the effect of factors of production on maize and cotton output. One interesting outcome was that cotton and maize output responded differently to land indicating that land contributed a smaller share of 58% to cotton revenues than the 81% of maize revenue. Our conclusion is that both crops respond positively to land allocation with maize having a higher magnitude of response. However, our analysis could not establish the change in cotton area as result of FRA and FISP programs for maize. Further studies are required in this regard as this study was fraught with many empirical limitations.

6.3 Limitations of the data and recommendation for future research

Our data was limited in a number of ways which restricted us from making causal statements and drawing important recommendation for policy. For instance, we could not access appropriate data for labour in cotton and maize farms in Zambia. The closest variables we could get to proxy labour was the number of person in a household. This variable is a poor indicator of labour since there is no assurance that member of the household are involved in farming. Also this research could have been more reliable with the use of time series data. Time series data would at least reflect the changes in the prices of maize over time. Another limitation was unavailability of data for important variables like price of maize at household level and fertilizer.

Future studies on the impact of policy reforms and prices on resource allocation decision of household should consider the using time series data. Such future studies may build on the model of maize prices and cotton land we have developed.

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Appendix

Appendix table 8.1: Results for Multicollinearity Test

. corr age sex1 tot_hect levelschool depratio ae prodast transast cattle ctnprice mzprkg mzothersale pctptspread_pre prov2 prov3 prov4 y
> ear2
(obs=4077)

	age	sex1	tot_hect	levels~l	depratio	ae	prodast	transast	cattle	ctnprice	mzprkg	mzothe~e	pctpts~s
age	1.0000												
sex1	-0.1821	1.0000											
tot_hect	0.0273	0.0252	1.0000										
levelschool	-0.3253	0.2954	0.1054	1.0000									
depratio	-0.1047	0.1019	-0.0255	-0.0176	1.0000								
ae	-0.0594	0.2073	0.0549	0.1765	0.0840	1.0000							
prodast	0.0828	0.1529	0.2782	0.1600	-0.0592	0.3444	1.0000						
transast	-0.0767	0.2166	0.1757	0.2432	-0.0289	0.2915	0.4737	1.0000					
cattle	0.0477	0.0721	0.2365	0.1240	-0.0544	0.2149	0.5011	0.2792	1.0000				
ctnprice	-0.1033	0.1242	0.0150	-0.0160	0.0165	0.0882	0.1128	0.0990	0.0033	1.0000			
mzprkg	0.0073	-0.0032	-0.0214	-0.1483	0.0468	-0.0767	-0.0991	0.0280	-0.0647	0.2147	1.0000		
mzothersale	-0.0407	0.0745	0.0905	0.1530	-0.0204	0.1092	0.2818	0.2466	0.1289	-0.0652	-0.0095	1.0000	
pctptsprea~s	-0.0225	0.0419	0.0078	0.1264	-0.0008	0.1112	0.1610	0.0050	0.0874	-0.1579	-0.3691	0.0380	1.0000
prov2	-0.0026	-0.0307	-0.0618	-0.2288	0.0269	-0.1576	-0.2037	-0.0086	-0.1036	0.2704	0.6746	-0.1686	-0.4876
prov3	0.0350	0.0094	-0.0237	0.0398	0.0113	0.0281	-0.0198	-0.0479	-0.0143	-0.0848	-0.0387	-0.0021	-0.1053
prov4	-0.0388	0.0400	0.0580	0.1459	-0.0096	0.1581	0.2058	-0.0385	0.1559	-0.1605	-0.4652	-0.0246	0.6445
year2	0.1024	-0.0327	0.0550	0.0368	0.1432	-0.0229	0.0434	0.0618	0.0131	-0.0387	0.0107	0.0715	0.0673

	prov2	prov3	prov4	year2
prov2	1.0000			
prov3	-0.2171	1.0000		
prov4	-0.5417	-0.1444	1.0000	
year2	-0.0103	-0.0024	0.0017	1.0000

Table 8.2 :Regression of the pooled tobit

. tobit $ylist $xlist,ll(0)robust

Tobit regression   Number of obs   =   4077
                                                  F(17,   4060) =   7.24
                                                  Prob > F   =   0.0000
Log pseudolikelihood = -1506.2922   Pseudo R2   =   0.5541

ctnha	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
age	-.0018596	.002022	-0.92	0.358	-.0058239	.0021047
sex1	.1138173	.0692491	1.64	0.100	-.0219489	.2495836
tot_hect	.0117991	.0055682	2.12	0.034	.0008824	.0227158
levelschool	-.0159594	.0096899	-1.65	0.100	-.0349569	.0030381
depratio	.0122452	.0405935	0.30	0.763	-.0673403	.0918307
ae	.026261	.017908	1.47	0.143	-.0088485	.0613705
prodast	.1634387	.0264504	6.18	0.000	.1115814	.2152961
transast	.2221217	.0883956	2.51	0.012	.0488179	.3954255
cattle	-.0161079	.0076615	-2.10	0.036	-.0311286	-.0010872
ctnprice	.0057242	.0019456	2.94	0.003	.0019097	.0095386
mzprkg	-.0003295	.000327	-1.01	0.314	-.0009707	.0003116
mzothersale	.2194636	.0959865	2.29	0.022	.0312775	.4076497
pctptspread_pres	-.0004872	.0022393	-0.22	0.828	-.0048774	.003903
prov2	.3504842	.1833781	1.91	0.056	-.0090374	.7100058
prov3	-.1885034	.1841719	-1.02	0.306	-.5495813	.1725746
prov4	.0526694	.1486547	0.35	0.723	-.2387753	.344114
year2	.341816	.1583103	2.16	0.031	.031441	.652191
_cons	-6.381329	2.487993	-2.56	0.010	-11.25916	-1.503498
/sigma	1.089722	.17129			.7538994	1.425544

Obs. summary: 3082 left-censored observations at ctnha<=0
                      995   uncensored observations
                        0 right-censored observations

Appendix 8.3: Production function for cotton

```
Random-effects GLS regression                   Number of obs      =       471
Group variable: hhid                            Number of groups   =       362

R-sq:  within  = 0.4011                         Obs per group: min =         1
       between = 0.4561                                        avg =       1.3
       overall = 0.4818                                        max =         2

                                                Wald chi2(11)      =    388.90
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000

                                   (Std. Err. adjusted for 362 clusters in hhid)
```

lnctnkgharv	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
lnctnha	.5839181	.0679468	8.59	0.000	.4507448	.7170914
lnae	.1476452	.0684542	2.16	0.031	.0134774	.281813
lnprodast	.2066156	.0570067	3.62	0.000	.0948845	.3183466
lnage	-.039499	.1161217	-0.34	0.734	-.2670933	.1880953
lndepratio	.0093932	.0424438	0.22	0.825	-.0737951	.0925816
lntransast	.1335187	.0811367	1.65	0.100	-.0255064	.2925438
lntot_hect	.1030695	.0736403	1.40	0.162	-.0412627	.2474018
levelschool	.0119179	.0087491	1.36	0.173	-.0052301	.0290658
year2	-.2727667	.0607226	-4.49	0.000	-.3917808	-.1537525
prov2	.2727197	.0716045	3.81	0.000	.1323774	.413062
prov3	-.0642964	.1545102	-0.42	0.677	-.3671309	.2385381
_cons	6.254135	.4546684	13.76	0.000	5.363001	7.145269
sigma_u	.1438583					
sigma_e	.61306853					
rho	.05218838	(fraction of variance due to u_i)				

Appendix 8.4: Test for endogeneity

```
. do "C:\Users\PHAMEL~1\AppData\Local\Temp\STD01000000.tmp"

. tobexog age sex1 tot_hect levelschool depratio ae prodast transast cattle ctnprice mzprkg mzothersale (fsp=pctptspread_pres) prov2 pro
> v3 prov4 year2, ll(0)

Smith-Blundell test of exogeneity:   .344962  F( 1,4060)  P-value =   .557

.
end of do-file
```

Appendix 8.5 Production function for maize

```
. do "C:\Users\PHAMEL~1\AppData\Local\Temp\STD01000000.tmp"

. xtreg lnctnkgharv lnctnha lnae lnprodast lnage lndepratio lntransast lntot_hect levelschool year2 prov2 prov3 if bothmzctn, re robust

Random-effects GLS regression                   Number of obs      =       471
Group variable: hhid                            Number of groups   =       362

R-sq:  within  = 0.4011                         Obs per group: min =         1
       between = 0.4561                                        avg =       1.3
       overall = 0.4818                                        max =         2

                                                Wald chi2(11)      =    388.90
corr(u_i, X)   = 0 (assumed)                    Prob > chi2        =    0.0000

                                 (Std. Err. adjusted for 362 clusters in hhid)
------------------------------------------------------------------------------
             |               Robust
 lnctnkgharv |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     lnctnha |   .5839181   .0679468     8.59   0.000     .4507448    .7170914
        lnae |   .1476452   .0684542     2.16   0.031     .0134774     .281813
   lnprodast |   .2066156   .0570067     3.62   0.000     .0948845    .3183466
       lnage |   -.039499   .1161217    -0.34   0.734    -.2670933    .1880953
  lndepratio |   .0093932   .0424438     0.22   0.825    -.0737951    .0925816
  lntransast |   .1335187   .0811367     1.65   0.100    -.0255064    .2925438
  lntot_hect |   .1030695   .0736403     1.40   0.162    -.0412627    .2474018
 levelschool |   .0119179   .0087491     1.36   0.173    -.0052301    .0290658
       year2 |  -.2727667   .0607226    -4.49   0.000    -.3917808   -.1537525
       prov2 |   .2727197   .0716045     3.81   0.000     .1323774     .413062
       prov3 |  -.0642964   .1545102    -0.42   0.677    -.3671309    .2385381
       _cons |   6.254135   .4546684    13.76   0.000     5.363001    7.145269
-------------+----------------------------------------------------------------
     sigma_u |   .1438583
     sigma_e |  .61306853
         rho |  .05218838   (fraction of variance due to u_i)
------------------------------------------------------------------------------
```

Table8.6 Test on the differences between means for maize and cotton farmers

```
. ttest levelschool, by(ctn)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
      no |    3137    5.146956    .0695622    3.896102    5.010564    5.283348
     yes |     998    4.937876    .1096091    3.462675    4.722785    5.152967
---------+--------------------------------------------------------------------
combined |    4135    5.096493    .0590426    3.796674    4.980738    5.212249
---------+--------------------------------------------------------------------
    diff |            .2090799    .1379591               -.0613942     .479554
------------------------------------------------------------------------------
    diff = mean(no) - mean(yes)                                   t =   1.5155
Ho: diff = 0                                     degrees of freedom =     4133

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.9351         Pr(|T| > |t|) = 0.1297          Pr(T > t) = 0.0649
```

The result on t-test indicated that there is a significant difference that level of education for cotton farmers is lower than those of maize farmers

Table 8.6 T-test on land size

. ttest tot_hect, by (ctn)

Two-sample t test with equal variances

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
no	3137	3.218584	.2680659	15.01408	2.692982	3.744186
yes	998	3.630212	.118422	3.741087	3.397827	3.862597
combined	4135	3.317932	.2053747	13.20641	2.915287	3.720577
diff		-.4116283	.4799696		-1.352627	.5293705

diff = mean(no) - mean(yes) t = -0.8576

Ho: diff = 0 degrees of freedom = 4133

Ha: diff < 0	Ha: diff != 0	Ha: diff > 0
Pr(T < t) = 0.1956	Pr(|T| > |t|) = 0.3912	Pr(T > t) = 0.8044

From the *ttest* results there is no statistical difference in the total hectares of farmers that do maize or cotton production.

Table 8.7 T-test for transport asset

. ttest transast, by (ctn)

Two-sample t test with equal variances

Group	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
no	3137	.7832324	.0158409	.8872319	.7521728	.814292
yes	998	.988978	.0279064	.8815954	.9342159	1.04374
combined	4135	.83289	.0138426	.8901339	.805751	.8600289
diff		-.2057456	.032195		-.268865	-.1426261

diff = mean(no) - mean(yes) t = -6.3906

Ho: diff = 0 degrees of freedom = 4133

Ha: diff < 0	Ha: diff != 0	Ha: diff > 0
Pr(T < t) = 0.0000	Pr(|T| > |t|) = 0.0000	Pr(T > t) = 1.0000

Table 8.8

```
. ttest ae, by(ctn)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
      no |    3137    5.407744     .052168    2.921872    5.305457    5.510031
     yes |     998    5.989312    .0977071     3.08668    5.797577    6.181047
---------+--------------------------------------------------------------------
combined |    4135    5.548108    .0462265    2.972547    5.457479    5.638737
---------+--------------------------------------------------------------------
    diff |           -.5815678    .1076636               -.7926464   -.3704893
------------------------------------------------------------------------------
    diff = mean(no) - mean(yes)                                   t =  -5.4017
Ho: diff = 0                                     degrees of freedom =     4133

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 1.0000
```