The Economics of Tobacco Production and Feasible Alternatives in Uganda

By

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Dedication

To my husband, Cuthbert and our daughter, Hope, thank you for your patience, love and care.

To my father and mother, Mr. Edward Takhuli & Mrs. Miriam Takhuli, who educated me in more ways than they could realise.

Declaration

I declare that this thesis I hereby submit for the degree Doctor of Philosophy at the University of Cape Town is entirely my own work and has not been submitted anywhere else for the award of a degree or otherwise.

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

Signed………………………………………………… Signed by candidate

Catherine Namome

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Once people have been made to realise the crippling mutilations imposed by an objectivist framework – once the veil of ambiguities covering up these mutilations has been definitely dissolved – many fresh minds will turn to the task of reinterpreting the world….' *Michael Polanyi, Personal Knowledge: Towards a Post-Critical Philosophy, p.381*

Abstract

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Tobacco control policies are credited with contributing to the well-being of society. But for tobacco producers, such polices can present pitfalls, especially in rural contexts where households are dependent on tobacco leaf production. This study focuses on the adjustment strategies open to tobacco-growing households particularly on Article 17 of the FCTC which is a strategic policy guideline that supports economically viable alternatives to the production of tobacco. The central hypothesis of the study is the consideration of farm household decision-making structures as requisites to FCTC supply policies.

The study uses the agricultural household framework to examine tobacco supply and relative farm efficiency. This framework is applied to a farm survey dataset collected from the West Nile sub-region of Uganda. The study used a probability sampling method to sample households. A sampling frame was provided by the district agricultural offices from the study area. The study developed a bivariate model to examine economic and non-economic incentives to tobacco supply. Relative farm efficiencies are examined with data envelopment analysis. A Tobit model is further used to estimate farm inefficiency among tobacco and other farm households.

The findings demonstrate that there is a clear variation in profitability between tobacco farms and other farms, with alternative farms posting better farm profits. There is considerable evidence in the data that tobacco farmers are capable of responding to staple food and cash crop prices, production value, and other non-economic incentives, as implicitly expected by economic theory. The tobacco output supply is strongly associated with economic incentives such as an export or cash crop price as opposed to a staple food price. This could be that with a cash crop price, tobacco farmers are able to produce at a point where marginal cost is equal to marginal revenue.

Efficiency results reveal that subsistence food crops do not offer a viable alternative to tobacco in West Nile, Uganda. A crop such as coffee can have some potential as a specialised cash crop in West Nile, but none of the grains or pulses do when grown as mono-crops. A balanced mixed of grains and pulses, that includes some coffee, can

certainly compete with tobacco in West Nile. Vertically integrated farmers are at the mercy of powerful buyers/processors who are generally very prescriptive about quantities while at the same time controlling prices so that farmers have very little room to manoeuvre. Overall, it is important to note that both tobacco leaf and alternative farms are too small, and therefore experience increasing returns to scale. Tobacco-specialised farms are over-capitalised and suffer from inefficient management practices. Relying on agricultural support is beneficial to farm efficiency.

Three policy implications are considered. A realistic price strategy in a comprehensive package of government action is required to ensure a sound agricultural base for the development of alternative farming. This would also include a crop diversification strategy to support a broad spectrum of alternative crops. A package of these changes would work well with an improvement in agricultural support, and for this reason the government of Uganda needs to develop an agricultural support framework. The thesis contributes to the empirical, field research and some methodology towards Article 17, and to research on the economics of tobacco production and alternative livelihoods.

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Introduction

1.1 Introduction

When the World Health Organisation (WHO) Framework Convention on Tobacco Control (FCTC) identifies and develops policies on tobacco use and production, one credits them with a belief that they are contributing to the well-being of society. The control of tobacco use is expected to create a healthier and happier society. But for tobacco producers, such polices can present pitfalls, especially in rural contexts where households are dependent on tobacco leaf production. This study focuses on the adjustment strategies open to tobacco-growing households.

The study is concerned with the agrarian structure, crop production systems and ultimately the ability of tobacco farmers to adjust their agrarian systems as tobacco policies change. In addition to the avenues that WHO FCTC uses to control production, it also considers the many challenges tobacco farming households experience, and the impacts of policy-based uncertainty. These considerations are all of importance to the WHO's FCTC since they have implications for how farm households might best be supported in changing their agrarian systems. The central hypothesis of this study is the consideration of farm household decision-making structures as requisites to FCTC supply policies.

1.2 Background to the study

Drawing from these principles, this study is a response to an FCTC policy that encourages governments to develop economically viable alternatives to support farm households engaged in tobacco production. The impacts of such a policy are not only micro-economic; in Africa, tobacco production is traditionally a strong economic driver. From 2006 to 2013, unmanufactured tobacco leaf alone generated approximately USD 13 billion in export earnings on the African continent (FAOstat, 2017).

The Common Market for East and Southern Africa (COMESA) reported that tobacco-related products, such as cigarettes, generated USD 3.78 billion in tax revenue in 2011 (TISA, 2012a). In the same year, the Southern African Development Community estimated that tobacco-related activities employed 3.66 million people, with tobacco products (cigarettes and other products) fetching export earnings worth USD 1.78 billion for southern Africa (TISA, 2012a).

In Uganda, the tobacco industry is a prime traditional export sector. Unmanufactured tobacco leaf contributes extensively to the country's foreign exchange earnings. In 2018, unmanufactured tobacco fetched USD 78 million, ranking third after coffee and tea (BoU, 2019). The Tobacco Institute of Southern Africa (TISA) estimates that at least 150 000 farm households in Uganda are full-time or seasonal tobacco farmers (TISA, 2012b). Aside from providing employment, the tobacco industry remains a formidable influence in the agricultural sector in general. The industry's tobacco value chain system primarily helps farmers with farm inputs and extension services, as well as providing a ready market for their tobacco. Tobacco companies such as Alliance One, Leaf Tobacco Commodities and Uganda Tobacco Services are prominent in Uganda's tobacco industry.

Despite its formidable impact on the local economies, the tobacco industry and tobacco farming remain controversial to the rest of the world. The World Health Organisation (WHO) reports that the use of tobacco products is one of the risk factors for premature mortality (WHO, 2008). The World Health Organisation further reports that, globally, tobacco use causes the premature deaths of over 7 million people a year and accounts for one in ten deaths among adults (WHO, 2008). Jha and Chaloupka (1999) forecast that by 2030 tobacco use would be the single largest cause of premature death globally. In addition, by 2020, 70% of those whose deaths were accelerated by tobacco use would be from low- and middle-income economies (Jha & Chaloupka, 1999). The tobacco controversy spills over into the health costs associated with tobacco consumption. Eriksen, Mackay, Schluger, Islami, and Drope (2015) estimate that 3.6% of global annual GDP is linked to tobacco-related health costs.

Tobacco farming is not immune from the controversy either. A growing number of studies have documented negative impacts of tobacco leaf production (Arcury, Quandt, Preisser, & Norton, 2001; Arcury et al., 2002; Arcury et al., 2003; Schmitt, Schmitt, Kouimintzis, & Kirch, 2007; Lecours, Almeida, Abdallah, & Novotny, 2012). These studies have shown that, because of the absorption of transdermal nicotine, tobacco labourers, particularly harvesters, have chronic health problems. In addition, the intensive use of farm inputs such as agrochemicals, and the curing of tobacco leaf, are linked to soil degradation and deforestation respectively. While some negative environmental impacts can be attributed to other cash crops, studies argue that tobacco production places extra strain on ecosystems and causes specific health and socioeconomic problems (Lecours et al., 2012).

A comprehensive strategy to reduce tobacco use and production is currently being used by countries that ratified the FCTC. Two international institutions have led this campaign, the World Health Organisation and the World Bank. *Curbing the Epidemic* was the first framework by the World Bank that targeted low- and middle-income countries (Jha & Chaloupka, 1999). The World Bank policy provided evidence that taxation of tobacco products and advertising bans are effective tobacco control interventions. However, this framework was not legally binding and, despite the evidence presented, few countries implemented it.

The World Health Organisation's FCTC, which came into force in 2005, dealt with both supply and demand side tobacco control policies. Parties to the Convention are legally bound to implement tobacco control policies within their borders. To control tobacco use (also called the demand-side approach), WHO FCTC strategies include tobacco product taxation, health warnings, advertising bans, and smoke-free environments. The supply-side policies include Articles 17 and 18, which deal with the implementation of economically sustainable alternatives to tobacco production and with the environmental impacts of tobacco (Geist, Chang, Etges, & Abdallah, 2009; WHO, 2014a).

As tobacco is a major source of revenue, both the tobacco industry and tobacco farmers resist tobacco control measures. They see proponents of tobacco control as undermining the industry's activities and endangering the welfare of farmers. Tobacco control strategies threaten bankruptcy for the industry, or at least for some individuals within it. On the other hand, tobacco control advocates argue that control measures are the only effective path to overcoming a public health epidemic. They represent the tobacco sector as a vector of diseases caused by tobacco consumption and production, explicitly comparing them to parasites (Bostic, 2008).

It stands to reason that the effective implementation of tobacco control policies would lead to a fall in global tobacco leaf prices which would have a detrimental impact on the livelihoods of smallholder tobacco-dependent farmers. In consequence, creating an enabling environment for tobacco farmers to transition to non-tobacco crops is necessarily a key element of the Article 17 strategy. The nature, form and determinants of such a transition provide the focus of this thesis. The intention of this thesis is not to undermine tobacco as a crop or to dismiss the views and values of the tobacco-farming communities, but rather to find solutions to the problem at hand, which is to systematically evaluate pathways for the development of alternative cropping systems.

1.3 Statement of the Thesis

Article 17 of the FCTC is a strategic policy guideline supporting economically viable alternatives to the production of tobacco. In 2008, the FCTC's Third Conference of Parties (COP 3) mandated the creation of a working group to study Article 17 of the framework convention, which focuses respectively on alternative livelihoods for tobacco farmers (FCA, 2014). The group developed a research agenda and policy recommendations (henceforth Article 17 policy guidelines) to assist parties to the Convention to address the challenges associated with tobacco cultivation.

This was adopted by COP 6 of the FCTC in 2014 (WHO, 2014a). Yet the Article 17 policy guidelines, as well as the wider research paradigm of Articles 17, remain inadequately studied. Bostic (2008) explains that Article 17 and other supply-side policies are treated as less urgent than the demand-led approaches. In addition, the Framework Convention Alliance (FCA) reports that Article 17 policy options have minimal or no guidelines for supply-side strategies (FCA, 2014). The hypothesis drawn from the FCA's report is that the ineffectiveness of Article 17 guidelines results from the inadequacy of research on alternative livelihoods (Article 17); the area on which this thesis focuses.

The literature on the economics of tobacco-farming, as a sub-area of the literature on Article 17, remains scanty. Research to date identifies two supply side issues: the financial viability of tobacco leaf (Keyser, 2002; Keyser, 2007; Magati, Kibwage, Omondi, Ruigu, & Omwansa, 2012; Makoka et al., 2017) and farmer diversification strategies (Altman, Levine, Howard, & Hamilton, 1996; Altman et al., 1998; Vargas & Campos, 2005; Beach, Jones, & Tooze, 2008; Geist et al., 2009; Akhter, Buckles, & Tito, 2014).

Many studies of farm production and crop budget analyses call into question the revenues and profitability of tobacco leaf compared to non-tobacco crops. However, the impartiality of these studies has been challenged, and they are often perceived as rebuttals to the tobacco industry's claim that tobacco is the best crop for farmers. In fact, Natarajan (2017) points out that financial viability studies often treat tobacco cultivation as a problem to be solved.

The second area of research has analysed transition and diversification strategies for tobacco farmers, and their attitudes. Whilst these studies suggest that tobacco farmers favour transition to alternative crops and diversification from tobacco cultivation (Altman et al., 1998; Vargas & Bonato, 2007; Beach et al., 2008; Akhter et al., 2014), they do not make reference to the broader question: why do farmers grow tobacco in the first place? In addition, these studies discuss the diversification of tobacco farms without a clear view of the agrarian contexts of tobacco farming, especially the productivity and efficiency of tobacco farms compared to non-tobacco farms.

A basic problem remains: it is generally not known how efficient tobacco farming is and if tobacco farming can improve its performance, nor how tobacco-farm households would respond to changes in policy aimed at supporting alternative farming. The problem is compounded by the fact that generally there is limited *ex-ante* knowledge of crop diversification strategies, the productivity of tobacco, and the production choices in rural farm communities. There is, therefore, good reason to argue that research that captures farm-household production behaviour is needed in order to understand the production behaviour of tobacco households and how they respond to their external and internal environments.

This thesis, therefore, aims to examine three research gaps which have not been adequately addressed and recognized in earlier literature on Article 17, especially in the context of tobacco growing in Uganda. The first is the profitability of farming tobacco leaf, compared to selected alternative crops. The second is the determinants of tobacco supply, including the effects of economic stimuli and resource endowments on tobacco-supply response. The last is the productive efficiencies of tobacco farms and non-tobacco farms.

1.4 Objectives and research questions

This study explores the nature of tobacco production and the economic behaviour of farm households in Uganda. Emphasis is therefore placed more on the conceptual and empirical results of the models. The study does so by:

a) Presenting a descriptive and detailed structure of sample farm household characteristics and analysing the comparative profitability in tobacco and alternative farms;
b) Examining the productive efficiency of tobacco farms and alternative farms and the decomposition of these differences into technical and allocative efficiencies, and further identifying the sources of farm efficiency, and
c) Developing a model that can be used empirically to study decision-making practices, and for the prediction of economic behaviour of tobacco-farming households in Uganda.

The study fulfils these objectives through the following research questions:

- Do tobacco farms have a higher profit per unit than equivalent non-tobacco farms? Are profits from other crops more sensitive to prices of inputs and outputs, and if so why? These questions are answered in Chapter 4.
- What incentives determine the supply of tobacco leaf in Uganda? How do tobacco farmers respond to price variations between alternative cash and food crops? Do these farmers also respond to non-price aspects such as physical outputs of cash crops and subsistence crops, farmland, and possibly demographic factors? These questions are answered in Chapter 5.
- Are tobacco-farming households efficient users of resources? Is there a systematic difference in efficiency between tobacco growers and others? Could farmers that grow other crops become as efficient as those growing tobacco? And, are there factors that deter tobacco-growing households from farming with alternative crops? These questions are answered in Chapter 6.

1.5 Hypotheses to be tested

Three hypotheses are tested in this study:

Hypothesis 1 is that tobacco farms yield higher profits per unit of output than farms that produce non-tobacco crops. This is calculated from farm survey data and represents a benchmark for the analysis in the study. If the hypothesis is accepted, tobacco farmers will need to be incentivised to switch crops, since they are contract farmers. This is because contract farming lowers the transaction costs of selling in thin or uncertain markets, whilst providing higher or steady prices from tobacco companies who are fairly certain that tobacco leaf farmers can deliver quality output on time. Such contracts help tobacco farmers to share risks and capture economies of scale, for example in the bulk purchasing of inputs through tobacco companies.

If hypothesis one is rejected, it suggests that tobacco-farm producers will not be able to sustain their farms, even with the advantage of contract farming. Rejecting hypothesis one does not necessarily imply that tobacco farmers will have to switch crops to survive, as profit margins of tobacco leaf could be less sensitive to changes in factor and output prices than those of non-tobacco crops.

Hypothesis 2: Tobacco supply responds to market incentives. Variables considered include leaf prices received, input costs, prices of substitutes in production, and the presence of scale economies.

Hypothesis 3: Tobacco farms use resources more efficiently than non-tobacco farms *ceterius paribus*, where farm inefficiency is associated with agricultural support, land tenure, cropping system practices, and household characteristics. By efficient, the researcher means the combination of technical efficiency, in terms of producing the most output with a given set of inputs, and allocative efficiency, in terms of using the most efficient combination of inputs given prevailing prices. If hypothesis one above and the present hypothesis both fail to hold, there is little incentive for continuing to farm tobacco leaf, since the combination of lower profits and inefficiency would mean that tobacco-leaf producers are not in a position to compete effectively with other farms in the long run.

1.6 Conceptual framework

The conceptual framework for this thesis draws on Nakajima (1986)'s theoretical frameworks of subjective equilibrium and Sing, Squire, and Strauss (1986)'s agricultural household model, both of which were used by De Janvry, Fafchamps, and Sadoulet (1991) and by De Janvry and Sadoulet (2006) to analyse decision-making by rural households.

1.6.1 A conceptual model

A conceptual framework for analysing the economic behaviour of farm households is illustrated in Figure 1.1. This framework is based on the decisions made by a farm household allocating scarce resources between different household activities in accordance with the household's utility function. This framework describes why a farm household grows tobacco and whether alternative crops are attractive options. It represents three areas likely to influence the decision, i.e. the farmer's resource allocational efficiency, the profitability of alternative crops, and the farm's ability to supply them.

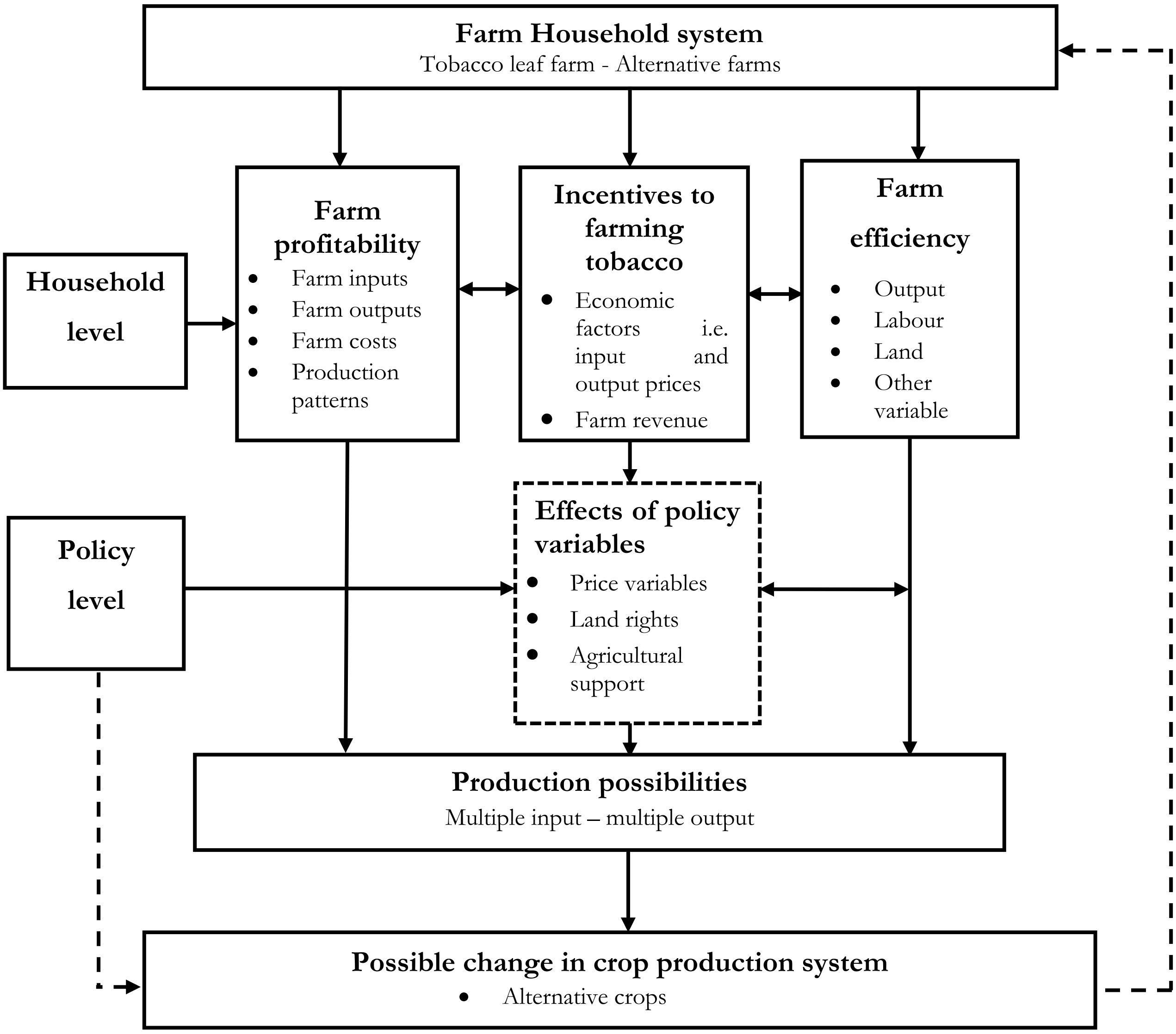


Figure 1-1: Conceptual framework for the study

At the household level, the conceptual framework considers the interaction between farm profitability, incentives to farm tobacco, and efficiency, as the main constructs in farm household decision-making. It is expected that the supply of tobacco leaf will be driven by both the local and external environments, i.e. incentives related to the characteristics of the farm and the household, and incentives driven externally by the prevailing policy framework.

Many incentives to tobacco farming are viewed as important, for example prices of inputs and outputs, availability of land, and household characteristics. However, it is hypothesised that incentives such as the price ratio of an alternative crop relative to tobacco should significantly induce the supply response of tobacco. In order to examine substitution possibilities, the conceptual framework incorporates harvested output from a cash and food crop relative to tobacco output. It is assumed that the harvested outputs of other crops relative to that of tobacco should significantly influence the supply of tobacco. Furthermore, changes in farm revenue may influence decisions regarding the supply of tobacco which could encourage farmers to continue farming tobacco.

With respect to farm efficiency, it is assumed that decisions to farm tobacco or other crops are made based on expected return on the value of all factors of production. If tobacco or an alternative crop is produced inefficiently, but remains profitable, then a farmer will farm that crop and ensure efficiency in the next season. However, if a farmer is presently indifferent between tobacco and an alternative crop, in the presence of new technology that can enhance efficiency in tobacco, the farmer would choose to farm tobacco because there would be no incentive to switch crops. For example, if tobacco farmers have better support services, such as extension services, they could become efficient at producing the crop, which would influence the decision to farm tobacco rather than an alternative crop.

At a policy level, household decisions can be driven by exogenous issues, such as governmental policies that affect product or factor prices. For example, land reform policies or capital subsidies may influence decisions regarding the type of crop that a household opts to grow. Such policies can clearly help provide an enabling environment for a transition between crops.

1.6.2 Towards a theory for the study

The idea that the decision to farm tobacco or an alternative crop might have some logical basis other than simple profit maximisation has not been considered sufficiently in the literature. The choice of crop could be rationally made on the basis of constraining factors such as risk, farm costs, capital outlay, or perhaps complexity and incompatibility with aspects of crop production systems on other parts of a farm. Two key issues are therefore discussed here in the context of Uganda: 1) whether or not the decision to farm tobacco is part of a carefully reasoned maximisation process, and 2) what could be the farmer's objective function?

In perhaps his most influential work, Schultz (1964) put forth his "efficient but poor" hypothesis, which rejected the notion that farmers in poor communities were inefficient because of cultural characteristics (Allen IV, 2012). Schultz asserted that such farmers make efficient decisions with the scarce resources they can access. Ultimately, the problem is not the decision-making processes, but rather the lack of resources and technology. Schultz's thesis implies that the most effective way to assist such farmers is to introduce and encourage the adoption of new factors of production that increase a farmer's productive potential, and train the human capital needed to exploit it.

Whilst impoverished farmers may not equate their marginal costs with their marginal revenue, Schultz's work implies that such farmers can still be rational (Duflo, 2006). This implies that subsistence farmers have to be treated as rational agents. In fact, Allen IV (2012)'s work on Malian farmers mentions that if social and cultural values are understood, and a set of economic incentives given, farmers' decisions tend to be logical and perhaps predictable. The rationality of low-income farmers is seldom asserted in the literature on Article 17. Common social presumptions may explain this. Such conventions explain how it may be logical for an older male to have several wives in a homestead, and a large number of children, but not consider educating them. Consider that in Uganda, household decisions are made by older male members of the household, whose social status derives from the number of their wives and children.

In rural Uganda, public respect is highly valued. It is customary to drink the local brew in the evening hours after farm work, and brewing beer to share with neighbours and extended family earns and maintains respect in the village. Conversely, refusing to sit and drink the local brew is considered rude. Educating and spending time with their children is often ignored, and many rural Ugandan farmers have yet to be convinced of education's value. Similarly, some Ugandan households will share household resources with extended family when children in the donor household are malnourished. The decision may appear perverse, but its rationality can only be questioned after defining the specific value system employed by farm households. This thesis assumes that its study population, i.e. tobacco and other farmers, are rational agents who face a set of market and social incentives that may easily be misunderstood by the researcher. The goal of the research is to analyse the use of resources and factors in such a rational decision-making structure.

To reach this goal, it must be established what the farm household hopes to maximise. This problem is complicated by the semi-commercial and subsistence nature of many Ugandan farms. This means that farm households share characteristics of both producers and consumers (De Janvry & Sadoulet, 2006; Allen IV, 2012). Whilst they are strongly engaged in agricultural production, making decisions concerning the allocations of inputs and sale of outputs, they also consume a significant proportion of their own production. Even if the goal of competing producers is to maximise profit by producing to the point where marginal revenue is equal to marginal cost, the goal of an individual consumer is to maximise utility, that is, the preference for a certain set of goods over others, given a budget constraint (Nicholson & Snyder, 2011) as cited in Allen IV (2012). As heads of farm households, do tobacco farmers seek to maximise profit, utility or both?

In the presence of perfect factor and output markets, and with zero transaction costs, it should be safe to assume that farming households seek to maximise profit. In such a scenario, farm households would choose the crop or a set of crops in which they hold a particular comparative advantage. In essence, they would choose to produce efficiently and maximise profit than produce with less profit. In other words, if every utility maximisation problem is subject to a budget constraint, then the primary objective of the household would be to loosen the budget constraint by increasing their income through profit maximisation. This profit level directly affects consumption, but consumption does not affect production decisions, i.e. they are separable (Sadoulet & De Janvry, 1995).

Non-separability occurs when a household's production decisions are affected by its consumer characteristics, such as the farmer's taste preferences or the household's demographics. This is often the case when market failures limit the household's ability to utilise additional profit earned through specialisation (De Janvry & Sadoulet, 2006). In a case like Uganda, such market imperfection occurs when the cost of a transaction outweighs any consequent potential utility gain; i.e. even if such a market existed, farmers would not use it for transactions (De Janvry et al., 1991). For example, if a farmer can choose to specialise in growing tobacco or diversify to an alternative crop, that decision would depend on factors other than output prices.

Risk-related market failures involving land, labour and credit can also lead to non-separability in the household model. Udry (1996) as cited in Allen IV (2012) tested separability with land and labour market imperfections in two African settings. His work suggested that farmers were not maximising profits. His findings certainly weaken the view that tobacco-farming households that also devote space to subsistence crops would seek to maximise profits.

Given non-separability, one can still argue that mixed subsistence/tobacco farmers aim to maximise expected household utility, which is a function of the expected utility of each individual in the household. For this maximisation problem, agricultural production can then be incorporated as part of the household's resource constraints. For example, tobacco production is a determinant of a tobacco household's budget constraint. The more land allocated to tobacco, the less there is for other crops; it thus dictates the mix of real and pecuniary income. Since markets are unreliable, many tobacco farmers make production decisions based on their consumption preferences. This assumption forms the basis for the agricultural model: a utility-maximising model that is subject to budget and other resource constraints.

For this reason, an extension of the agricultural household model is developed that captures the effects of a household's consumption and production decisions. The model's utility-maximising approach seems to be more congruent with the ways in which Ugandan farmers appear to perceive agricultural production in their lives. For instance, when asked why they farm tobacco, most farmers responded that the crop has a ready market; few respondents mentioned its profitability. This could be perhaps that tobacco-farming households do not think that tobacco farming will lead to them becoming rich; it is thus rational that tobacco farming is more of a means to utility maximisation.

Thus far it has been argued that tobacco farmers or farmers in rural Uganda are rational and their households' primary objective is to maximise expected utility subject to a set of resource constraints. Assuming utility maximisation, two elements of farm household production behaviour are examined: the technological relations between a combination of inputs and the resulting levels of outputs, and the farm household's behaviour in its choice of production, given the market prices for tobacco and competing crops, and for tradable factor inputs, and the availability of fixed factors. A detailed theoretical household model for the study is presented in Appendix G.

1.7 Research methodology overview

This study uses a positivist approach. The positivist approach defines, enumerates, and measures facts, and uses them to predict outcomes. It also uses a quantitative strategy, collecting data that are not readily available, particularly crop production input and output data. The survey research design (see section 3.5) was used to obtain information from participants. The sections below outline the data collection and analysis methods used in this study.

1.7.1 Literature review

This study examines the household production behaviour of tobacco farmers and non-tobacco-producing farmers, investigating three separate but inter-related aspects: farm profitability, incentives to produce tobacco, and the efficiency of tobacco and non-tobacco farms. Each chapter has a separate literature review that discusses the methodology, suitable variables for analysis, and expected findings.

1.7.2 Survey questionnaire

The lack of farm records containing crop production or cost data for rural farming communities meant that a farm household survey was required. The survey instrument had six sections: general information, demographic information, structure of land tenure and access to finance, crop production and marketing, farm inputs and their costs (fixed and variable costs), and labour usage. Respondents were selected using probability sampling. Data were collected through a cross-sectional survey. Questionnaires (N=185) were distributed among the sampled farm households. All farms were actively producing tobacco leaf and/or other crops. The response rate was 68%, i.e. an active sample of 126 respondents.

1.7.3 Data analysis

Three types of software were used for data analysis, each for a specific task. The principal component analysis and cluster analysis used in characterisation of farms types, were performed with SPSS (Statistical Package for Social Science) version 23. STATA version 14 was used to present descriptive statistics, to develop bivariate and multiple regression models for tobacco-supply response, and to test for farm efficiency. The Data Envelopment Analysis Program (DEAP) was used to analyse farm efficiency.

1.8 Contribution of the study

This thesis examines farm profitability, supply response, and the productivity of tobacco and other farms. The research is intended to inform a number of debates such as: 1) whether tobacco farmers have viable crop choices, 2) the profitability of tobacco, 3) the impacts of internal and external shocks on tobacco production, and 4) relative farm efficiency of tobacco and other crops. The thesis provides new perspectives on the opportunity costs associated with Article 17 of the FCTC, on the economics of tobacco production and on alternative livelihoods by providing empirical, field research and methodological contributions.

This research adds to the limited literature on tobacco-leaf supply's determinants and the efficiency of resource allocation among tobacco and other farm households. It offers empirical evidence on relative farm efficiencies in rural economies, using a non-parametric frontier-data envelopment analysis model to compare farm efficiencies of tobacco and alternative-crop farms. This helps to inform differences in farm efficiencies, examines the nature and form of tobacco together with alternatives, despite differences in historical farming backgrounds, and the special interventions by the tobacco industry to support tobacco farms. The study also examines the factors associated with farm efficiency in a rural context.

Methodologically, the thesis introduces an extended version of bivariate models and linear programming methods such as Data Envelopment Analysis to the economics of tobacco production and its alternatives. Unlike multiple-regression and stand-alone discrete techniques, the extended version of the double-hurdle model estimates the incentives governing tobacco-supply's responsiveness and the amount of tobacco produced with the given incentives. The research findings may assist policy makers seeking to support and improve the transition process for tobacco farmers who wish to switch to alternative crops. Lastly, the findings contribute to the literature on Article 17 of the FCTC.

It is clear that tobacco farmers are capable of interpreting market signals and responding to changes in output prices. However, this research suggests that their supply responses are particularly influenced by the physical outputs of other crops, their value, and the availability of farm resources. Several policy recommendations are made that could benefit tobacco farmers. The first is to redirect public resources away from the current practice of discretionary interventions, and towards more effective investments, such as market information systems, extension services, and, more importantly, market regulations. Provision of these public goods is likely to support a more effective price transmission along the value chains of export crops and stimulate the more active participation of tobacco farmers responding to price signals.

The research found that there are differences in how tobacco farms use farm resources when compared to other farmers. The inefficiencies are not so much a matter of differences in ownership and production types, but rather of sub-optimal input allocations. In particular, a significant number of farms are too small, measured by the quantities of inputs used (land, labour and fertiliser) to enjoy potential economies of scale. In short, because of the small size of most tobacco farms, farm diversification is appropriate. The crucial issue is, how to provide optimal alternative-production farm types for tobacco farmers? This research recommends the provision of well-functioning factor markets so as to facilitate adjustments that improve the technical and scale efficiencies of non-tobacco crops. The findings have implications for the development and implementation of guidelines, legislation and policies for Articles 17, and for rural development as a whole.

1.9 Concluding remarks and links to other chapters

This chapter identifies the conceptual issues underlying the study and lays out the plan for the entire thesis. The general introduction summarises the controversies relating to both the supply and control of tobacco use. This remains a contentious issue, but it must again be emphasised that this thesis remains neutral and endeavours to provide evidence. The statement of the thesis provides the philosophy of why the study has been carried out and the important gaps in the literature that need to be addressed. Research objectives and questions provide the guideline for inquiry of the thesis.

The thesis is made up of seven chapters organised as follows. Chapter 2 reviews and discusses the history of tobacco production in Uganda. It is a background chapter that discusses the growth of tobacco cultivation in farming communities in Uganda and the marketing structures available in the country. Chapter 3 discusses the research method, the study area, the implementation of the cross-sectional survey, and the characteristics of the sample. The thesis uses a cross-sectional data set. Chapter 3 also presents a brief rationale for the methodologies used in the subsequent research chapters. Chapter 4 presents the preliminary analyses of the farm structure and farm profitability. These lay the groundwork for the estimations made in subsequent chapters. The chapter provides a description of the data and further examines farm profitability among farms.

Chapter 5 develops econometric models, which are followed by a discussion of the effects of market forces, demographic structure, and resources and what these imply for estimation. Chapter 6 presents the results of the farm efficiency analysis. Efficiency is decomposed into technical efficiency and allocative efficiency for tobacco, in comparison with alternative crops. The analysis in Chapter 6 combines the DEA model with a censored (*Tobit*) model. Chapter 7 presents the study's conclusions and recommendations. The chapter includes a summary of the research findings, and specific policy implications for Article 17. The chapter further presents areas for further research and also acknowledges the limitations of the research.

Chapter 2

Tobacco leaf production in Uganda: a synopsis

2.1 Introduction

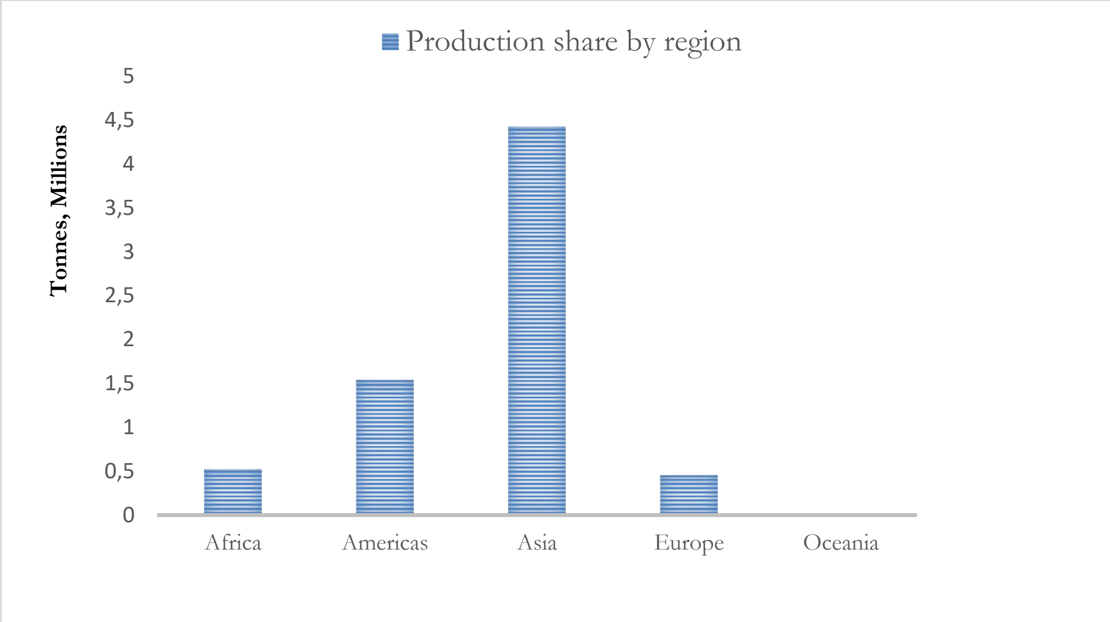
Almost 90 years have passed since tobacco began to be grown commercially in remote areas of Uganda. During that time, and especially in the more recent decades, tobacco production has experienced dramatic changes. Political instability, economic reforms, and tobacco control policies have all played major roles in bringing about those changes, and the tobacco industry and its institutions have evolved. This overview discusses important structural changes in the country's tobacco industry and their impact on tobacco production.

A secondary purpose of the discussion is to show that there are alternative crops that could be introduced, crops that do not share the uncertainties of tobacco farming. The chapter is structured as follows: an overview of global tobacco production is provided, followed by a more focused discussion of the history and development of tobacco production in Uganda. Tobacco market structures in the rural West Nile area and the possibilities for alternative crops in Uganda are also discussed.

2.2 Global production of tobacco leaf

Tobacco is grown in one hundred and twenty-five countries globally, on over forty million hectares of land, a quarter of which are in China (Eriksen, Mackay, & Ross, 2013). Over the past fifty years, tobacco cultivation has tended to shift from high-income countries to low-income countries, particularly in Asia and Africa (Hu & Lee, 2015). Figure 2.1 shows the tobacco production shares of Africa, Asia, Europe, and the Americas.

Asia's contribution to global tobacco production is the largest, followed by the Americas, Africa, and Europe in that order. In the past, the Americas, especially the United States, produced the bulk of the world's tobacco leaves. This changed when the United States stopped funding the buyout program that supported farmers (Hu & Lee, 2015). The decrease in US tobacco production may have also been related to tighter tobacco control policies. In the developing world, China, Brazil and India are the top three tobacco-producing countries.

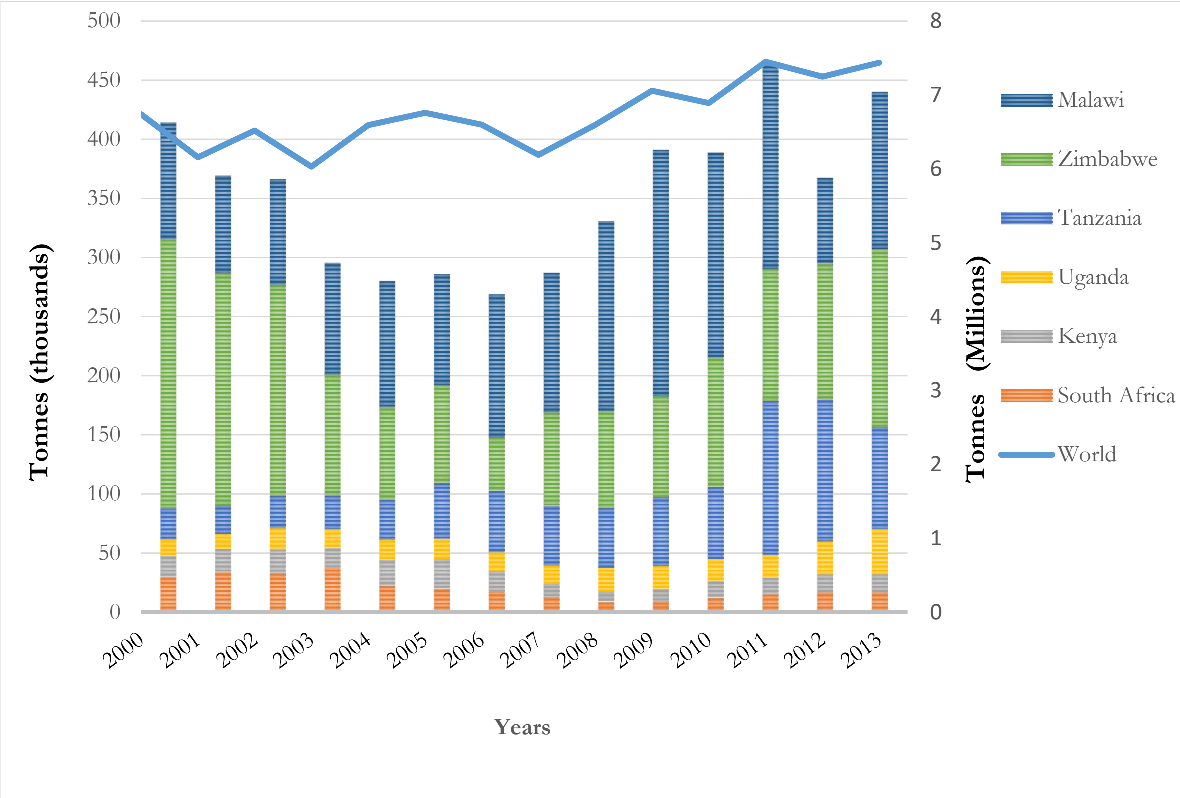


Source: FAO Tobacco Production Data, 2016

Figure 2-1: Tobacco production share by region

China produced 3.2 million tonnes of tobacco in 2013, followed by Brazil (850 000 tonnes) and India (830 000 tonnes) (FAOstat, 2016). Moreover, the acreage allotted to tobacco in China increased by 15% from 2005 to 2012 (FAOstat, 2016). Flue-cured tobacco is the predominant type of leaf produced in China, and demand is driven by the local production of cigarettes, with more than 80% of the tobacco leaves produced being used for domestic cigarette production (Eriksen et al., 2013). The State Tobacco Monopoly Association (STMA) in China controls many of the tobacco sales. Brazil produces tobacco varieties such as Virginia, Burley, and Comum (known as common) (FAO, 2003). Comum is sold mainly in the domestic markets for local consumption, but Brazil exports most of its tobacco (FAO, 2003). India produces mainly three types of tobacco: Virginia, Burley, and Oriental tobacco (FAO, 2003). These varieties are used in the production of cigarettes and bidis.

In Africa, 31 countries grow tobacco. Zimbabwe produces the most tobacco, followed by Malawi and Tanzania. South Africa, Zambia, Uganda, and Kenya have small but still significant shares of African tobacco produced (see Figure 2.2). Both farmers and governments see tobacco production as a source of household income and foreign exchange. Figure 2.2 shows tobacco produced in selected African countries compared to world production.



Source: FAO tobacco production data, 2016. The legend on the right-hand side shows world tobacco production.

Figure 2-2: Tobacco production in selected African countries

In 2013, Zimbabwe produced 150 000 tonnes of tobacco leaf, followed by Malawi with 133 000 tonnes, and Tanzania with 86 000 tonnes. Uganda produced 38 600 tonnes. Asian countries and the Americas drive global tobacco production but Africa has the highest number of smallholder farmers who depend on tobacco farming for their livelihoods (Hu & Lee, 2015). The following section describes tobacco production in Uganda in more detail, from the colonial period to 2012, and is followed by an examination of local tobacco marketing structures.

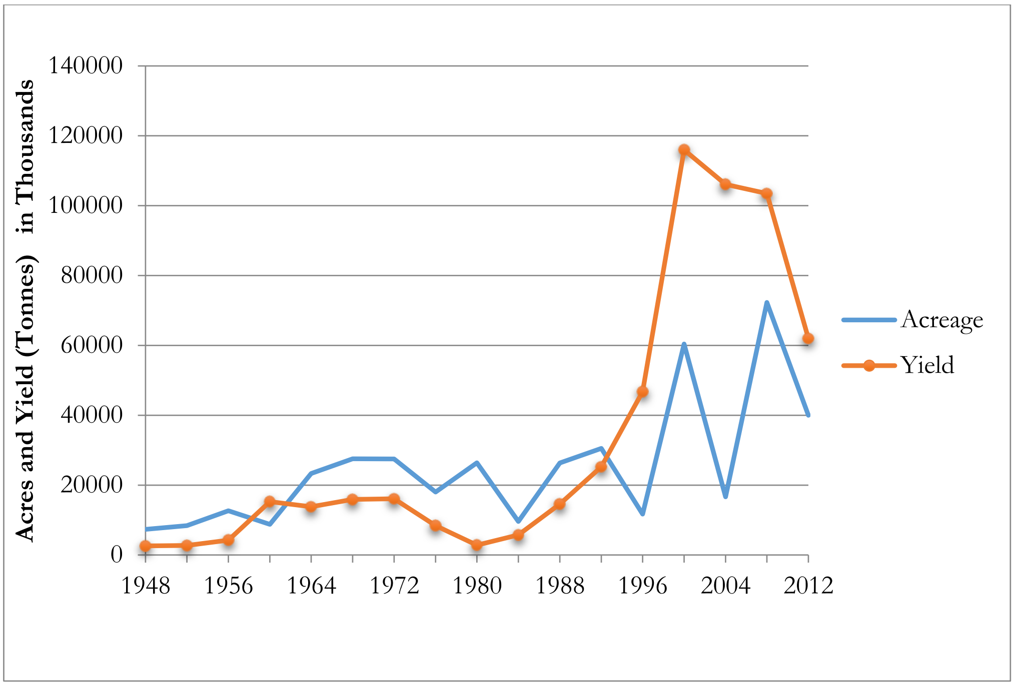
2.3 The geography of tobacco leaf production in Uganda

The establishment of Uganda as a British protectorate was recorded in the London Gazette in 1894 (Leggett, 2001; Sejjaaka, 2004b). In the early years of the British Administration, trade was mainly in ivory, but with the construction of the Uganda – Kenya railway in 1902, exports of bulky commodities like cotton and coffee became possible. Tobacco production in Uganda began in 1903 when a South African tobacco expert, Van Venhoff, was hired by the colonial administration of Uganda to carry out tobacco-farming experiments (Byrnes, 1992; Aliro, 1993). Twenty-five years later the colonial administration and British American Tobacco (BAT) started tobacco out-growers' schemes in parts of Kigezi, West Nile, Mubende, and the Middle North (Acholi, Lango and East Madi) (Middleton & Greenland, 1954).

In 1926, BAT constructed a tobacco-processing factory in Jinja (Sejjaaka, 2004a). The distribution of tobacco seedlings and the provision of extension services were largely governed by the Department of Agriculture and Colonial District Agricultural Officers. A flue-cured and fire-cured tobacco industry was not established until the early 1940s. In 1945, the Greek-owned East African Tobacco Company was reorganised and took over all government tobacco-farming schemes. Under the East African Tobacco Company, farmers were offered seedlings at the time of planting and the crop was purchased later in the season.

British American Tobacco took over tobacco activities from the East African Tobacco Company in 1947, buying the green leaf and curing it. At the time, only Kenya exported raw tobacco. Tobacco production increased under BAT, and by 1960, over 8 700 acres of land were under tobacco cultivation, with an estimated production of 15 000 tonnes (see Figure 2.3). The colonial era had a profound effect on Uganda's tobacco cultivation and on the livelihoods of farmers. The transport system, which included railway and road networks, eased the movement of tobacco from areas as distant as West Nile to Jinja for processing. Tobacco was integrated into a trading system that was shaped to meet the interests of the farmer and the country. These establishments were part of the meticulous governance of the colonial administration, which steadily increased tobacco production in Uganda.

For several years prior to independence, tobacco was one of Uganda's major foreign exchange earners, ranking fourth after coffee, cotton and tea (World Bank, 1970; Byrnes, 1992). In 1962, Uganda gained independence, with Sir Frederick Mutesa elected as its first president (Sejjaaka, 2004b). Unlike other East African countries, Ugandan independence was not characterised by violence, and the transition to independence was orderly and harmonious (Leggett, 2001). The president was a monarch from Buganda, who found it increasingly difficult to take orders from the national government, which was led by Milton Obote (a non-Muganda) (Sejjaaka, 2004b).



Source: FAO tobacco production data, 2016 and Uganda Department of Agriculture Annual Reports 1962, Entebbe

Figure 2-3: Tobacco acreage and yield in Uganda

Opposed to Uganda's monarchies, Obote sought to reverse the dominance of Buganda and established a socialist state (Arnold, 2005). Despite these internal conflicts, Uganda's commitment to tobacco production was vigorous, and the government was keen to involve more African farmers in tobacco cultivation. Acreage under tobacco cultivation increased from 9 000 acres in 1960 to 23 000 acres in 1964 (see Figure 2.3). In 1966, the government encouraged farmers to form cooperatives and take over the production and marketing of tobacco, and, in 1967, a tobacco produce marketing board was established.

Over the next two years, it was government policy to allocate a large measure of responsibility for the agricultural development programs to cooperatives, including tobacco cooperatives. This forced BAT to halt its tobacco production, and left the responsibility for production to cooperatives and the Department of Agriculture. BAT stopped farm operations, but the government still planned to expand tobacco production. In March 1968, the Government of Uganda asked the International Bank for Reconstruction and Development (the World Bank) to provide financial support for a multi-million-dollar tobacco project, in the three areas of West Nile, Middle North, and Kigezi. Tobacco cooperatives and tobacco growers received credit through the Department of Cooperative Development in the Ministry of Marketing and Cooperatives. Uganda at the time exported

7 thousand tonnes of flue-cured leaf to the United Kingdom, as Uganda's tobacco met the high quality standards of the British market (World Bank, 1970).

However, a series of internal and external shocks stopped the progress of tobacco production. These disturbances included political strife between President Obote and the Buganda monarchy, fluctuating commodity prices, mounting debt, and Uganda's involvement in regional conflicts. Ethnic tension during the rule of President Obote was replaced by an even worse political regime when General Idi Amin Dada came to power in early 1971. President Idi Amin remained in power until he was overthrown in 1979 (Sejjaaka, 2004b).

During his rule, BAT was forced out of Uganda when Amin nationalised the company and renamed it the National Tobacco Corporation. Many Asians who traded in small tobacco merchandise were expelled from the country. There were mass murders, and the economy was run into the ground (Byrnes, 1992; Aliro, 1993). Tobacco cooperatives were also mismanaged. The persistent political instability led to the collapse of the Ugandan tobacco industry. Tobacco production dropped from 16 000 tonnes per year between 1968 and 1971, to 500 tonnes in the 1980/81 farming season (FAOstat, 2016). Many tobacco farmers were drawn into the turmoil and some were killed in the conflict (Byrnes, 1992; Aliro, 1993).

The country's tobacco infrastructure, such as cooperatives and auction floors, was severely damaged by two decades of instability. Shortages of fuel made it very difficult to transport the produce, farmer morale plummeted, and many farmers were afraid to produce tobacco. Moreover, farmers from the West Nile region avoided producing tobacco because West Nile had provided the ethnic base for much of Idi Amin's earlier support and had enjoyed relative prosperity under his rule (Byrnes, 1992). In 1981, the area experienced extensive violence when anti-Amin solders avenged themselves on inhabitants of Amin's home region (West Nile) (Byrnes, 1992).

Uganda's leaf production plummeted to its lowest levels. The second Obote regime of 1981-1985 encouraged many exiles, both individuals and companies, to return to the country. BAT returned to Uganda and repossessed its former properties in 1984 (Sejjaaka, 2004a). BAT re-established its farm operations and collaborated with most of the tobacco cooperative unions to foster the development of tobacco.

In 1986, a new political party known as the National Resistance Movement came into power. This signalled the end of decades of internal conflict and turmoil. During the late 1980s, the government, through its Development Bank, introduced a series of fresh agricultural credits to local farmers, in addition to the credit from agricultural cooperatives. Tobacco production increased, and the country produced an average of 23 000 tonnes of tobacco between 1989 and 1992. For the next five years, however, tobacco production was hit by complaints from farmers about cooperatives not paying for their produce, the low producer prices set by government, and delayed payments (Byrnes, 1992).

This prompted many tobacco farmers to sell much of their crop illegally in neighbouring countries, and Uganda registered a shortfall in tobacco in 1996. During the late 1990s, producer prices increased steadily, and BAT intensified its operations and started contracting farmers to produce tobacco. In the early 2000s, tobacco received favourable support from the government, which encouraged several tobacco companies, such as Leaf Tobacco Uganda, to carry out tobacco-farming operations in the country. In 2003, tobacco production peaked at 116 000 tones. Volatile global tobacco prices affected production from 2004 to 2006, but it has nevertheless been steady.

Uganda's ratification of the WHO FCTC in 2007, and the tabling in 2012 of the Uganda Tobacco Control Bill, led to speculation that tobacco farming might be banned. Consequently, in 2014, BAT Uganda withdrew all its tobacco-farming operations from the country, citing the possibility of lower profits as a result of the proposed Tobacco Control Bill. Much of this speculation was false, but it had an impact on tobacco farming. A sharp decrease in tobacco acreage and production was registered between 2008 and 2013 (See Figure 2.3). Political events had an impact on tobacco production, but farmers continued to produce the crop. Tobacco control policies, on the other hand, have had an even stronger effect and the future of tobacco farming may be uncertain in Uganda.

2.3 Tobacco leaf marketing

The West Nile region produces most of Uganda's tobacco (TFI, 2000). Tobacco is sold through formal and informal markets. Before the political instability of the 1970s, much of the tobacco produced was sold through tobacco cooperatives, and few informal markets existed. The Master Growers' Scheme of 1961 was the formal marketing channel for many tobacco growers. Later, the Produce Marketing Board and BAT took over the scheme. The Produce Marketing Board governed all tobacco cooperatives. Farmers were authorised to sell their tobacco at a minimum price in a given marketing year. Tobacco auctions existed for a while, but ceased because of fraudulent grading systems which led to much frustration for farmers. The collapse of the formal tobacco industry in the 1970s had encouraged the rise of informal markets. The turbulent times meant that tobacco farmers could sell much of their crop to cross-border markets in the Democratic Republic of Congo (DRC) (former Zaire) and South Soudan (former Sudan).

Present day tobacco markets are not very different from those of the 1960s and 1970s. Tobacco companies, cooperatives and intermediaries, and informal traders all participate in present-day West Nile's tobacco markets. There are several types of formal markets. Tobacco companies have direct contracts with some farmers, using pre-season tobacco prices. Contracted farmers are then obliged to sell their produce to the tobacco company at the end of the season. Farmers also sell to intermediaries (the middlemen) who then sell to tobacco companies. Tobacco cooperatives form another, albeit less significant, formal market.

The marketing season often starts in late May for early harvesters, and for most farmers the market is open by June. Collection/receiving centres, owned by tobacco companies, are part of the tobacco supply chain. Here, the tobacco leaves are weighed and graded. Informal markets are more numerous and are closely connected with the parallel food markets and cross-border local markets. Retail traders and farmers from surrounding towns and villages, and wholesalers from distant areas, bring their tobacco to a market day in Arua (West Nile's main town), transforming the market from a local centre of exchange into a major distributive centre for tobacco.

Traders from as far away as the DRC bring their tobacco to market and purchase other goods brought in by shopkeepers and long-distance traders. These market days operate on a periodic cycle of two days per week. Tobacco sold in these markets is locally dried. Small packs of dried tobacco are sold in stalls and on the floors of the market. The grade of tobacco sold in these markets is not high and is for household consumption. Such informal tobacco sales have a relatively small market share in Uganda.

2.4 Alternative crops in Uganda

The introduction of tobacco control policies, coupled with political instability, has led to a decline in tobacco cultivation in Uganda, and further declines may follow. An appraisal of alternative livelihoods for tobacco-farming communities is thus clearly warranted. In Uganda, the government no longer provides agricultural services to tobacco farmers and a shift away from tobacco to alternative crops seems likely as farm households respond to the progressive withdrawal of government subsidies and services.

The discussion here focuses on the development of alternatives to tobacco-based farm enterprises, and avenues through which such alternatives can succeed. The term "alternative" signifies farm diversification - the introduction of a non-traditional or traditional source of income into the pre-existing farm business. Alternative farm enterprises could be encouraged in Uganda through two different policies. Firstly, the tobacco control policy of 2014 could support the development of alternative livelihoods. Secondly, the national agricultural policy of 2013 could be reformed to address the issue of agricultural support services for alternative crops.

Globally, the uptake of alternative livelihoods has been poor (Mataya & Tsonga, 2001). However, this is because alternative livelihood strategies have rarely been included as components of broader development efforts. Efforts to promote alternative livelihoods are often constructed as crop-substitution ventures. Felbab-Brown and Trinkunas (2017) suggest that alternative livelihood strategies that focus on crop substitution do not increase their acceptance. Providing economic conditions that allow a decent livelihood for farmers who stop growing tobacco is a more viable means of encouraging farmers to move into alternative livelihoods.

In West Nile, for example, tobacco cultivation is perceived to be more profitable than many other crops, yet there are farmers who choose to farm non-tobacco crops. The key point here is that possibilities for alternative livelihoods exist in Uganda, but in order to succeed there must be economic conditions that allow farmers to make a decent living other than by farming tobacco. This thesis therefore investigates whether (and if so how) market forces and production can improve the integration and adoption of alternative crops by the tobacco-farming communities of West Nile.

2.5 Concluding remarks

Tobacco is an important crop for many communities in Uganda. Uganda's history of political instability, and its more recently introduced tobacco-control policies, have led to changing trends in tobacco production. Alternative livelihoods for tobacco farming communities are an issue of real and current concern.

Chapter 3

Study area, research design, and methodology

3.1 Introduction

This chapter explains the research design and methodology of this thesis. The aim of the research design was to provide a guideline for obtaining accurate empirical data that informed the empirical analysis.

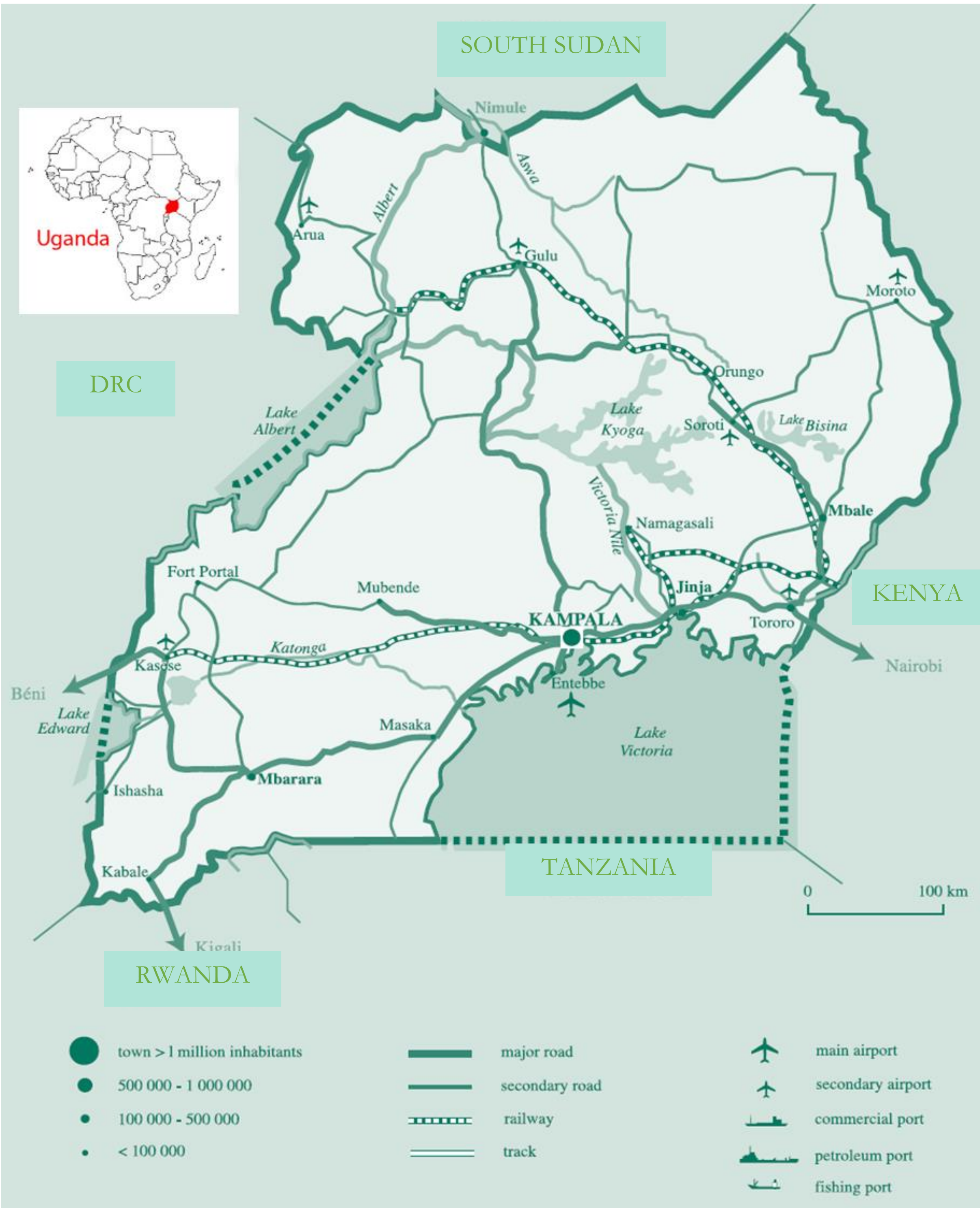
The chapter describes the location and climatic conditions of the study area, and identifies the specific study site. The philosophical basis of the research design and methodology is also discussed, along with a description of the research strategy. Details of the sampling design, data collection design, and methods of data analysis are given, and the ethical considerations relevant to the study are presented.

3.2 The country – Uganda

A reader familiar with Uganda can omit this section without loss of meaning. The section discusses the climatic conditions, economic outlook of the country and the study area.

3.2.1 Location and climatic conditions

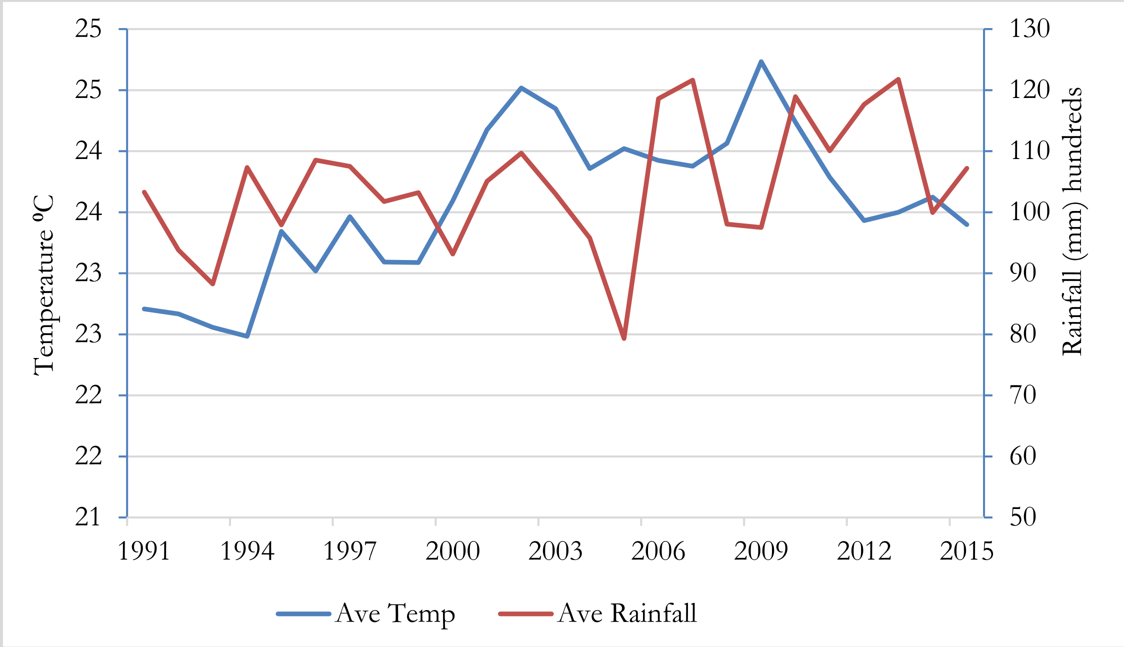
The Republic of Uganda lies across the equator in Eastern Africa. It is bordered by South Sudan to the north, the Democratic Republic of Congo to the west, Tanzania to the south, and Kenya to the east (see figure 3.1). It straddles the Equator, stretching from about 4 N to a little more than 1 S, and from approximately 29 E to nearly 35 E Longitude. It has a surface area of 241 550 km^2 of which 18% is open inland waters and wetlands and 37.8% is arable land. The country has regular rainfall, and irrigated agricultural land only makes up 0.073% of total agricultural land.



Source: African Economic Outlook Report, 2011. OECD Publications

Figure 3-1: Map of Uganda

Uganda has a tropical climate, with temperatures ranging from 21 to 25 Celsius, apart from the mountainous areas, such as the Rwenzori mountains in the west and Mount Elgon in the east, which are much cooler. Uganda receives most of its rain between March and June, and annual rainfall ranges between 500mm and 1 200mm. The rainy season typically provides enough water for crops and livestock. A time series from 1991 – 2015 of rainfall and air temperatures, extracted from crop-growing regions in Uganda, indicates that rainfall declined in 2005 and 2009. Figure 3.2 shows that lower precipitation is associated with higher temperatures.



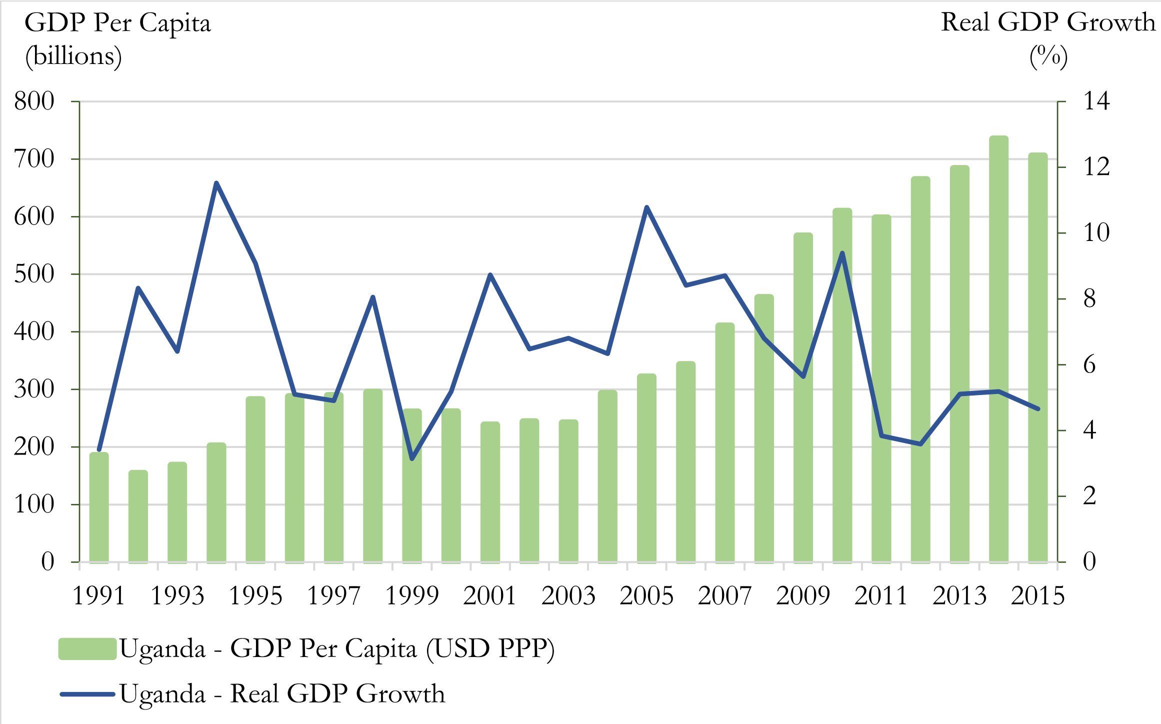
Source: World Bank development indicators data

Figure 3-2: Annual rainfall and air temperature time series

Between 2011 and 2013, the country received a significant amount of rain, which in 2014 decreased by about 18% on average. Air temperature data show that temperatures increased by approximately 3° C between 1991 and 2009, although a decline was recorded from 2009 to 2015.

3.2.2 The economy of the country

For the past two decades (see figure 3.3), Uganda has had one of the more successful economies in Africa, combining high growth and low inflation. Real GDP growth between 1991 and 2005 averaged 7% (World Bank, 2018). This strong economic performance is attributable to prudent macroeconomic management and bold structural reforms, which are supported by large inflows of overseas development assistance.

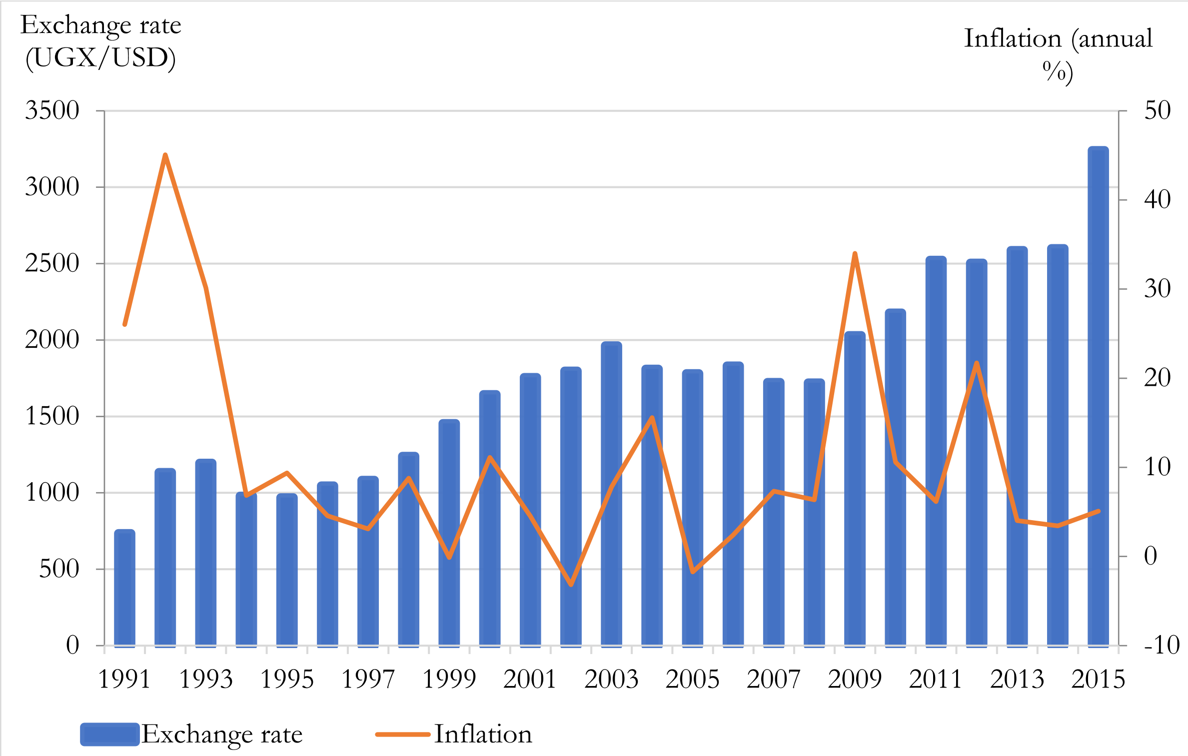


Source: World Bank and Bank of Uganda data, 2018

Figure 3-3: Real GDP growth and per capita GDP

After 2005, the inefficient use of public resources and sub-regional political instability caused a number of international donors to reassess their support for Uganda. The effects of the 2009 global financial crisis also had an impact on the economy. Between 2011 and 2015, growth decelerated by approximately 5%. The economy has been further negatively affected by declining commodity prices and the depreciation of the currency, which increased the prices of imported factors and stimulated inflation. Fiscal performance generally improved during the financial year 2013/2014 but the overall fiscal deficit amounted to -3.8% of GDP (World Bank, 2015).

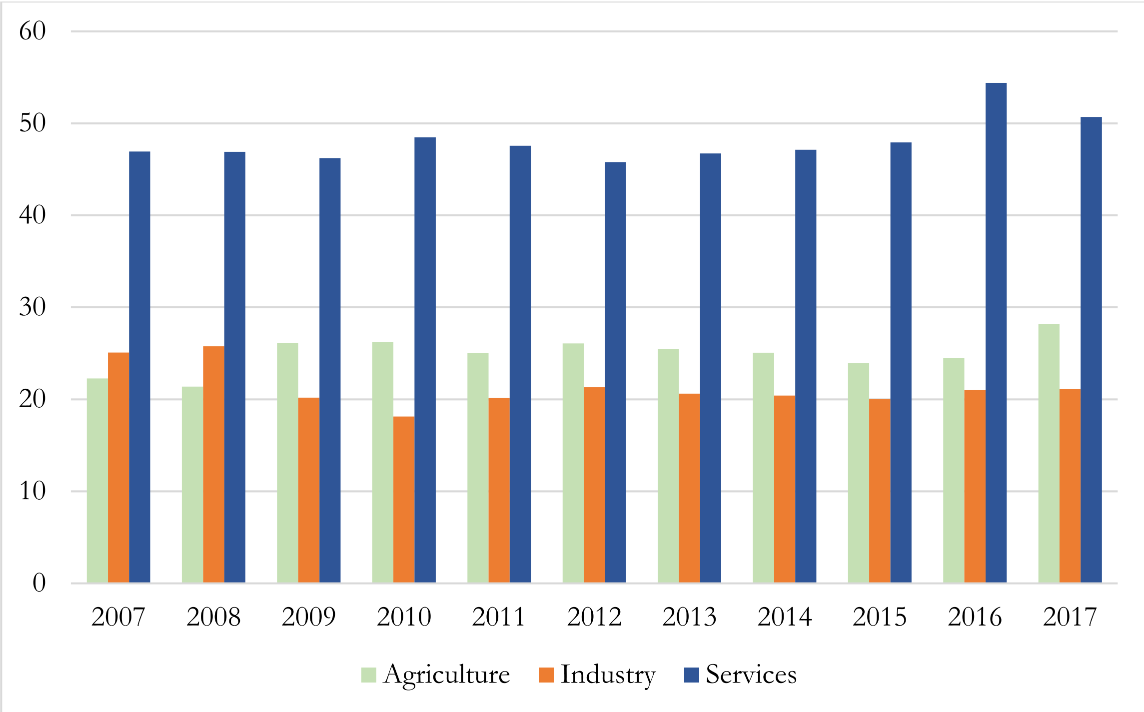
Inflation has largely been kept under control (see figure 3.4), except during 2008/2009, when inflationary pressures from the global financial crisis caused inflation to increase to approximately 27%. Over the past two decades, the Ugandan Shilling has depreciated substantially against the US dollar. Although a general depreciation trend is observed, it has not been characterised by much volatility, as the Bank of Uganda intervenes to reduce volatility.



Source: World Bank and Bank of Uganda data

Figure 3-4: USD/UGX exchange rate and inflation

Sectoral contribution to GDP growth has changed slightly in the past ten years, with agriculture overtaking industry. Figure 3.5 shows the distribution of GDP across economic sectors in Uganda from 2007 to 2017. In 2017, agriculture contributed 28.2% to the GDP, 21% came from the industry, and 51% from the services sector.



Source: World Bank and Bank of Uganda data

Figure 3-5: GDP composition by sector

The agricultural sector, therefore, remains important to the Ugandan economy. The sector employs over 72% of the economically active population. The main agricultural crops are coffee, cotton, tea, tobacco leaf, and sugarcane.

Table 3-1: Agricultural economic indicators

Selected indicators	2011	2013	2015
Agricultural value added (annual % growth)	3.11	1.86	2.35
Agricultural value added (% of GDP)	27.01	27.45	26.09
Agricultural labour force (% of total labour force)	75.4	74.2	73.0
Per capita cultivated land (ha)	0.25 (est.2012)		
Area equipped for irrigation (ha)	14 000 (est.2012)		
Per capita food supply (kcal/capita/day)	2273	2279	NA

Source: FAO and World Bank data. NA – not available

In 2013, agricultural growth declined by 1.25%, which nevertheless did not affect its contribution to GDP, but picked up in 2015 to 2.35%. As mentioned previously, irrigation systems are not generally necessary because rainfall is sufficient, and therefore only 14 000 ha of land is equipped for irrigation. The food supply remains stable with per capita supply approximately the same year on year.

3.2.3 Study area profile – West Nile sub-region

The study sites for this research are all within the West Nile sub-region, which is located in the north-western part of Uganda. The West Nile sub-region has eight districts: Arua, Maracha, Nebbi, Yumbe, Koboko, Adjumani, Moyo and Zondo. Arua and Maracha districts were chosen as study sites because tobacco is more intensively farmed there than in other districts in the region.

Farming is a mainstay of this region; virtually all families in the region are involved in farming. Mixed farming is most common, but many tobacco farmers practice mono-cropping. The household farming structure in West Nile is mainly founded on three types of fields, giving equitable access to a range of soil qualities. The *amvuakua* (home gardens) are used to grow vegetables.

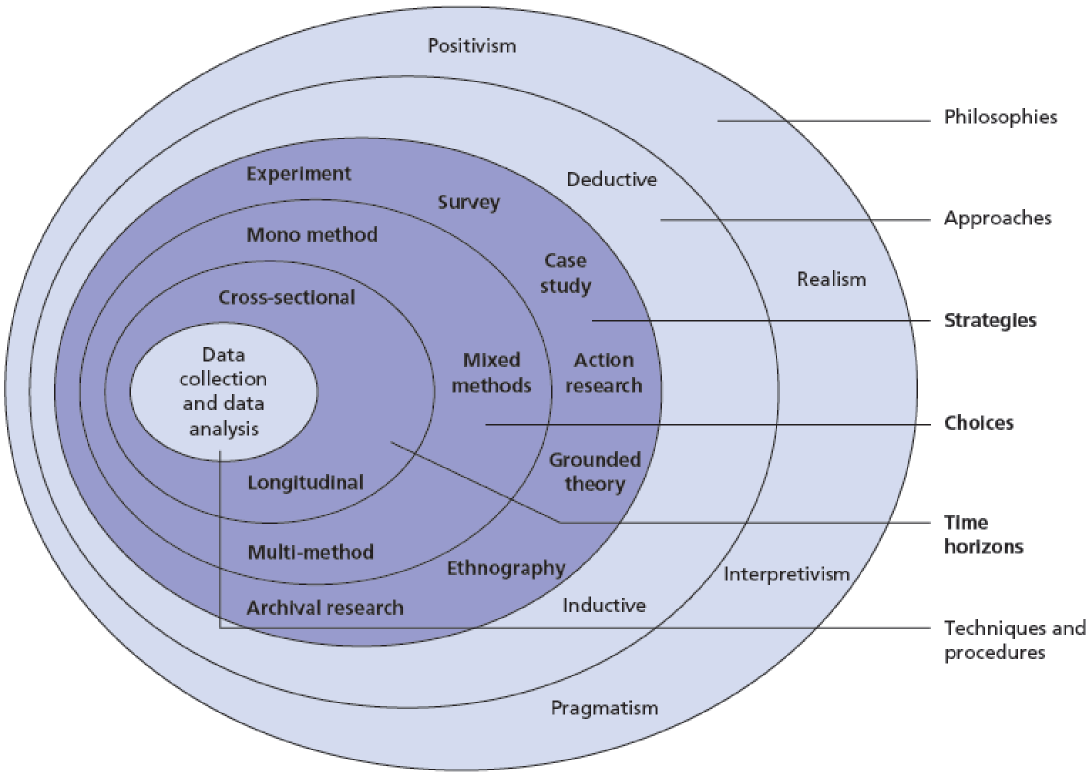
Close proximity to livestock stabling pens means that these fields are richly manured, making this soil better than the poor-quality soil found elsewhere. The *yimile* (riverine fields) are the most productive farm plots; they are relatively fertile and, as they are riparian, well-irrigated. They are used to grow staples such as sweet potatoes, cassava, beans and maize. These crops are sown in mixed farm plots, so that they are covered with vegetation for most of the growing season, which protects the soil from erosion. When necessary, land is left fallow for up to three years, by which time the soil quality is normally restored. The *amvuamve* (fields outside) are the fields in which most of the tobacco is cultivated.

Crops grown in West Nile include tobacco, cassava, coffee, maize, rice, sesame and sweet potatoes, with tobacco and cassava dominating in the region. Livestock holdings are minimal in the area, though some households do rear a few goats, sheep, and cattle. The bulk of labour is drawn from members of the family and neighbours.

3.3 Research philosophy and its application to this study

The theory of the agricultural household model as stipulated in Chapter 1 is only a set of assumptions about how farm households behave. The usefulness and test of that theory lies in its ability to predict. As long as it predicts adequately, the theoretical framework of the agricultural household model is preferred to any other complex theory. Because theories can be disproved but are not proved, they should be continuously tested and replaced by better ones as they become available. This thought pervades this thesis. To describe it as a philosophy may be a little pretentious but certainly the essence of the study's approach to modelling household production behaviour is simplification in representation of relationships and interpretation of the analysis. This is, of course, in no way unique to this thesis, as it is properly involved in most farm household analyses.

Different scholars naturally differ in what they regard as an appropriate philosophy. This study's own preferences, for example, with regard to data manipulation and the use of differential statistics is different from scholars who focus on the algebraic forms or realism of their research. Economic and social science literature show a distinction between philosophies, for instance the philosophies of positivism and interpretivism (Hughes & Sharrock, 2014; Bryman & Bell, 2015), although Saunders, Lewis, and Thornhill (2009) and other writers add realism and pragmatism to the economic and social science philosophy literature (see Figure 3.6).



Source: Adapted from Saunders et al. (2009)

Figure 3-6: The Research 'Onion'

Positivism adopts a quantitative approach, which has a number of advantages. The quantitative approach allows comparison between groups, as these can be measured for difference. In addition, the positivist approach attempts to identify relationships in the real world, which helps to predict other phenomena. This implies that studying a smaller group of respondents can actually provide a reliable indication of the views of a larger population. Ideally, from the positivist perspective, a researcher controls the research process by, for example, standardizing the survey and controlling for variables.

However, some critics have argued that focusing on measurement can lead to flaws in knowledge. Crossan (2003) argues that the positivist approach is not sufficient for an in-depth examination of human behaviour. Post-positivism emerged, in response to this criticism, as a refinement of positivism without rejecting positivism. Post-positivism assumes that reality is multiple, subjective, and mentally constructed by individuals (Crossan, 2003). The post-positivist approach usually adopts a qualitative approach to describe and explore phenomena. Although no theoretical perspective is ideal in all circumstances, the positivist approach is the most appropriate for the current study because it allows the measurement of data and helps to link the meaningful aspects of data to reality.

Studies of production behaviour in farm households frequently make use of surveys as they are an effective tool for obtaining data. Because there is limited data available on this topic, this study used a survey to collect data. The aim is to determine the best way to address the issues surrounding tobacco farming in Uganda. Comparisons can also be made between the findings in the present study and previous findings. Clearly, elements of other forms of philosophies can and indeed must be involved in household production analysis, but following a positivist philosophy would provide an explanation for intervening variables.

3.4 Research strategies

The research strategies chosen for a particular study direct the methods used to collect and analyse data (Bryman & Bell, 2015). The approach can be quantitative, qualitative or a mix. This section discusses the strengths and weaknesses of the two primary approaches.

3.4.1 Qualitative strategy

The qualitative research approach, which depends more on interpretation by the researcher, seeks to gain insight to, and understanding of, respondents' behaviour. Qualitative research is thus empirical research, where data are not numerical and the interpretation tends to be inductive rather than deductive. A deductive approach would move from data or known facts to theory, while an inductive approach is concerned with the context of specific events (Bryman & Bell, 2015). A qualitative study can be based on a small sample of respondents, but may require different types of data.

3.4.2 Quantitative strategy

A quantitative approach tends to be associated with positivism and seeks to collect factual data, study associations between facts, and relate these to theories (Fellows & Liu, 2015). Often the purpose of the quantitative approach is to test a theory rather than to develop one. Quantitative research involves reasoning deductively, and developing conceptual frameworks and theoretical structures prior to testing them by empirical observation (Gill & Johnson, 2010). In this approach, the researcher deduces a hypothesis by analysing and synthesising ideas and concepts already present in the literature. The researcher's hypotheses and questions are in this way grounded in theoretical frameworks developed by previous studies.

Robson and McCartan (2016) provide five sequential stages through which deductive research progresses: deducing a hypothesis from the theory, expressing the hypothesis in operational terms, testing the hypothesis, examining the specific outcome of the inquiry and modifying the theory in light of the findings as necessary. For example, in this thesis, the hypothesis on the technical efficiency of tobacco leaf is deduced from the theory of production. The deductive approach only requires the measurement of specific concepts in the hypothesis, in this case efficiency. In most cases, a hypothesis is tested by collecting quantitative data from a specific population sample. This does not mean that a deductive approach does not apply qualitative data as well (Saunders et al., 2009).

This thesis uses a quantitative research approach involving the collection and analysis of data using statistical procedures in order to test the hypotheses set out in chapter one. A survey is used as the most effective way of collecting data for this purpose, and a quantitative approach is preferred as it enables the researcher to make more general applications from the findings (Saunders et al., 2009; Robson & McCartan, 2016).

3.5 Research designs and methods

3.5.1 Research designs

There is a variety of ways of describing 'research design' or 'research strategy'. Bryman and Bell (2015) list five types of 'research designs': cross-sectional, experimental, comparative, longitudinal, and case study. Saunders et al. (2009), instead, speak of 'research strategies' using the concept of the research onion (see Figure 3.6), highlighting seven strategies: action research, survey, experiment, case study, grounded theory, ethnography, and archival analysis. All these designs use either deductive or inductive research approaches.

Similarly, writers such as Tan (2002) and Yin (2018) consider six and five types of research designs respectively. Tan (2002) suggests experiments, case studies, surveys, causal comparative research, co-relational research, and historical research as research designs. Yin drops from Tan's list causal comparative research and co-relational research, but includes archival analysis among the mainstream research designs. Yin (2018) cautions that no single research design is better than any other; each design has advantages and disadvantages depending on the type of research question, whether the focus is on contemporary or historical phenomena, and how much control the researcher has over respondent behaviour.

Saunders et al. (2009) also point out that no research strategy or design is inherently superior or inferior and that the choice of a design must be guided by the researcher's research questions, the extent of pre-existing knowledge on the subject, the time and resources available, and the philosophy underpinning the particular study. Yin (2018) suggests that each research design can be used for descriptive, exploratory and explanatory research, and therefore the benefits and shortcomings of each design may overlap.

Table 3-2: Research designs from literature

Research design	Description	Suitability	Research strategy	
			Qualitative	**Quantitative**
Survey design	Uses cross-sectional design which entails the collection of data from more than one respondent over a given time period. The data are quantifiable, with several variables of interest used.	It is suitable for descriptive, correlative, exploratory, and interpretative studies. Research questions with a survey design follow the form of *who*, *where*, *what*, *how much*, *how many*.	Survey methods would include interviews, focus group discussions, content analysis of a related set of documents, all at a single time.	Methods include survey questionnaire or structured observation of a sample at a single point in time. Content analysis is done on a sample of documents.
	The survey design also includes a longitudinal design where the selected sample is surveyed on more than one occasion.		Uses ethnographic research over a prolonged period of time, interviewing respondents on more than one occasion, and content analysis of documents over different time periods.	Uses a survey questionnaire on a single sample on more than one occasion (as in a cohort or panel study). Content analysis is done on documents relating to different time periods.
Experimental design	This design uses causal research although the number of variables that are studied are smaller and controllable.	This type of design is suitable for explanatory and exploratory research. The form of research question answered here consists of *how* and *why* questions.	There is no typical form of qualitative method that is used in an experimental research design.	Several research studies use an experimental design for purposes of comparison, such as between experimental and control groups with regard to specific variables.
Case study	This is an empirical inquiry that investigates contemporary phenomena in a real-life context, particularly if there are blurred boundaries between the context and the phenomenon.	Case studies are suitable for descriptive, exploratory, and explanatory studies. The forms of research questions covered by this design include *how*, *what* and *why* questions.	It focuses on a single case, using interviews or ethnography.	The methods include survey research on a single case with the intention of revealing critical features of the circumstances of that case.

Research design	Description	Suitability	Research strategy	
			Qualitative	Quantitative
Other designs	**Comparative**: endeavours to identify differences that occur between more than two groups.	It is suitable for explanatory research.	Uses ethnography and qualitative interviewing of more than two cases.	Uses survey research, in which there is a direct comparison of more than two cases, to conduct cross-cultural research.
	Grounded theory: empirically collects data in order to build a general theory that fits the data.	It is suitable for exploratory and explanatory research.	It involves in-depth focus group discussions and observations of specific cases.	n/a
	Ethnography: endeavours to study a particular phenomenon or cultural group.	It is suitable for exploratory and descriptive research.	Uses multiple methods, particularly unstructured interviewing and the observation of cases, events, and documents	n/a
	Archival analysis: endeavours to understand or deduce lessons from the past and apply them to present and future events.	It is suitable for exploratory and explanatory research.	Methods include the survey of historical data through archives or documents.	Document survey.

Source: Saunders et al. (2009), Bryman and Bell (2015) and Yin (2018)

Given that this thesis takes a positivist approach and has developed specific hypotheses to be tested, a survey research design was deemed most appropriate in this case. Tan (2002) defines a survey as a systematic method of collecting primary data based on a sample. Surveys and questionnaires are often used to collect economic research data (Saunders et al., 2009).

The purpose of a survey is not to consider a specific respondent but to capture the main characteristics of the population or monitor their characteristics over time (Tan, 2002). The *what*, *why* and *how* questions set out in chapter one are most suited to the use of a survey research design. This provides a basis for producing empirical models, generating findings that are representative of the population, and lowering the cost by using a representative sample (Saunders et al., 2009).

In addition, the data collected through surveys provide an opportunity for statistical analysis. The present study uses a cross-sectional survey, collecting one wave of data. This was adopted because it allowed the researcher to compare different variables at the same time and also because it was less costly. The cross-sectional design made it easier to identify respondents as belonging to particular groups, and it also increased the likelihood of participation, as it was only occurring once.

However, the cross-section design has its limitations. For example, the design does not permit the study of causal relationships (Fink, 2013). This is because the cross-sectional design offers a snapshot of a single moment in time and does not consider what happens before or after the snapshot is taken. Therefore, it is impossible to know for sure if price incentives to tobacco farming had any effect on tobacco leaf production. For this, a longitudinal study would be more appropriate. Longitudinal studies are good at determining effective patterns of variables over time and in developing trends. On the other hand, longitudinal studies require a significant amount of time and can be expensive compared to cross-sectional studies.

In general, survey designs are limited in a number of ways. The accuracy of the data may be affected by difficulties in understanding respondents, and progress is often delayed by dependency on respondents' information (Saunders et al., 2009). However, these kinds of weaknesses can be minimised when a survey is properly designed and administered. Subsequent sections will provide discussion on the sampling design and data collection design used in this thesis. Of the several survey research tools available, a questionnaire was adopted as the preferred method of data collection for this thesis, as is discussed further in section 3.7.

3.5.2 Research methods

The terminology 'research methods' and 'data collection techniques' are often used interchangeably in the literature, and several methods are described. These include interviews, observation techniques, the analysis of previous documents, and questionnaires. Some methods are better for obtaining quantitative data, and some for qualitative data. Fellows and Liu (2015) indicate that data collection methods that produce quantitative data include self-administered questionnaires, content analysis of documents, structured interviews, and structured observation. Qualitative methods include focus group interviews, content analysis of documents, respondent observation, and both structured and unstructured interviews. The choice of a method depends on the purpose of the study, the availability of resources, the skills of the researcher, and the appropriateness of the method.

This study used a survey questionnaire because it was the best option for collecting a significant amount of data quickly. Saunders et al. (2009) note that the use of a questionnaire has the advantages of being affordable, adaptable, and implementable in a variety of ways (Saunders et al., 2009; Gill & Johnson, 2010; Fink, 2013). Questionnaires can be classified by how they are administered: by telephone, by mail (email or postal), on the internet, or by the researcher in person (Fellows & Liu, 2015). They can also be administered collectively in a public space (Saunders et al., 2009). There are limitations to the use of a questionnaire, however, such as low response rates, self-selecting bias, limited opportunity for spontaneous responses, and limited opportunity for respondents to clarify issues.

3.6 Sampling design

3.6.1 Target population and sampling unit

The study's target population was tobacco farming communities in Uganda. The research examined two main farming groups: tobacco-leaf farmers and non-tobacco-leaf farmers. The aim was to examine farming production behaviour and efficiency in both groups. The farm household is the basic unit of analysis used in this study. This was because farm households are seen as the basic institutions within which resource sharing and exchange among household members take place (Haddad, Hoddinott, Alderman, & Ellis, 1997). While conducting fieldwork, it became apparent that the researcher needed to adapt to the local definition of a household member. For example, male heads of households who had two families and lived with these families intermittently were identified as household members. Conventionally, these members are not involved in the daily farm operations of the household. However, in Uganda, such members are still regarded as members of the household and in some cases are heads of households. In cases where the husband was not present, the questionnaire was administered to the wife.

3.6.2 Determining of the sample size

Surveys operate on the basis of statistical sampling and only in rare situations are complete population surveys possible, practical, or desirable (Fellows & Liu, 2015). Statistical sampling is used to secure a representative sample given limiting factors such as time and cost constraints, availability of household members in the target population, the degree of precision required for estimation, whether the findings are to be generalised and, if so, to what level of confidence (Hair Jr, Money, Samouel, & Page, 2007). There is always a trade-off between the constraints of cost and time and the benefits of a large sample size. Larger sample sizes involve more expenditure on collecting and analysing data. The present study had budget and time constraints particularly associated with a PhD project, and had to balance those against the advantages of a large sample.

With these considerations in mind, the researcher followed suggestions from Roscoe (1975) and Sekaran and Bougie (2016) about adequate sample sizes. They suggest that sample sizes of more than 30 and fewer than 500 respondents are appropriate for most research. If samples are to be disaggregated into sub-samples, for instance tobacco and non-tobacco farm households in the present context, a minimum sample size of 30 of each category is necessary. In multivariate research, the sample size should be several times the number of the variables in the study. Stutely (2003) recommends a minimum of 30 respondents for studies that are aligned to statistical inferences. Kent (2001) states that for any quantitative analysis, 100 respondents are sufficient, since that number would allow the researcher to get a sensible statistical inference[1].

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[1] The researcher further consulted with Ms. Katya Mauff, a statistical consultant employed in the Department of Statistical Sciences at the University of Cape Town. The consultant provided advice on power calculations.

Table 3.3 summarizes the parameters used in calculating the sample size. Tobacco-farming incidence figures were used to determine the sample size. The study group design is a one-sample study. The agricultural census of 2008/2009 indicated that about 60% to 70% of the general population of West Nile was involved in farming tobacco. Assuming a 70% incidence that West Nile farm households grow tobacco, a sample size of 181 participants gives an 80% ability to detect difference at a 95% level of significance.

Table 3-3: Sample size parameters

Study parameters	Estimates
Anticipated incidence, population (p_o)	60%
Anticipated incidence, study group (P_1)	70%
α, probability of type I error (usually 0.05)	0.05
β, probability of type II error (usually 0.2)	0.2
Power	0.8
$\boldsymbol{z_1}$, critical Z value for a given α or β	

Source: Author's calculations and estimates from UBOS, 2011

$$N = \frac{p_o q_o \left[z_1 - \alpha/2 + z_1 - \beta \sqrt{\frac{P_1 q_1}{p_0 q_0}} \right]^2}{(p_1 - p_0)^2}$$

$$N = \frac{0.6 * 0.4 \left[1.96 + 0.84 \sqrt{\frac{0.7*0.3}{0.6*0.4}} \right]^2}{(0.7 - 0.6)^2}$$

$$N = 181$$

where $q_o = 1 - p_0$ and $q_1 = 1 - p_1$.

3.6.3 Sampling method and procedure

The study used a sampling method that included a non-probability sampling technique because the study focus was on tobacco farming districts, hence the two districts where purposively selected. The first step involved identifying two leading tobacco-producing districts, Arua and Maracha districts, of the West Nile sub-region. The second step intentionally selected counties and sub-counties where tobacco leaf is widely grown. District Agricultural Officers (DAOs) in the selected districts provided specific information, such as farmers' contact names, the crops that they grew, and their cell phone numbers, on the basis of the sampling frame. The sampling frame consisted of 836 farmers of whom 629 were from tobacco-farming households and 209 produced other crops.

A systematic random sampling process was followed to select the required sample. In order to take non-response into account, the target sample size was increased to 185 farm households, assuming a household non-response rate of about 3%. With a sampling frame of 836 farm households, 185 farmers represented a sample of 22%, which corresponded to selecting approximately 1 in 4 farmers from the population. The researcher chose a number between 1 and 4 randomly, in this case number 4, and then went down the list taking every fourth farmer, so as to derive a sample list of 185 farm households.

Table 3-4: Distribution of the sampled farm households across the districts

Sub-counties	Arua district	Maracha district
Bileafe, Ajia, Arivu, Dadamu, Katrini, Oluko, Vurra, Pajulu and Aii - vu	84	–
Kijomoro, Maracha TC, Nyadri, Oleba, Oluffe, Oluvu, Tara and Yivu	–	101

Source: Field survey data, 2014

The sample composition included 119 tobacco farmers and 66 non-tobacco-producing farm households. As the sampling frame was organised randomly rather than alphabetically, picking in this systematic way did not introduce bias.

3.7 Data collection design

The farm household survey was chosen for administering the research questions, as the researcher was able to collect production and farm household demographics data from both tobacco and non-tobacco farm households. The purpose of the data collection was to determine the prevailing production choices and the determinants of those choices.

As the main objective of the study is to analyse production choices and the efficiency of smallholder farms, it was necessary to gather detailed information on several aspects of the production system for tobacco and alternative crops. The availability of farm records, particularly accounts, would have been an ideal source of information from which both physical and financial input and output data could be obtained. Unfortunately, neither farm records nor adequate disaggregated time-series data on inputs and outputs, particularly those related to smallholder tobacco farming, were available at the time.

To circumvent this issue, a field survey was developed by the researcher. Surveys are useful tools, particularly if the phenomenon to be studied involves variables which are measurable and can be aggregated. Variables such as resource use, production costs, and returns can be directly measured and quantified and thus basic information on these factors can be measured and quantified from a farm survey. In the following sections, the research setting and the development of the survey questionnaire are discussed, followed by a discussion of its pre-testing and implementation.

3.7.1 Development of the questionnaire

The survey questionnaire is a widely-used research tool that has a number of advantages: it reduces interviewer bias, collects significant quantities of data relatively quickly, and is fairly straightforward to analyse provided the questions are not open-ended. Questionnaires can be anonymous, and respondents can complete them at their leisure.

However, questionnaires also have shortcomings: response rates tend to be low, data quality can be affected by uncompleted questions, and people are less likely to complete a questionnaire if they do not see it as having personal relevance (Gillham, 2008). Simmons (2006) emphasises the appearance of the questionnaire, suggesting that this has a significant influence on whether respondents will complete it. For this reason, the questionnaire was produced in booklet format to give it a professional appearance and make it easier for respondents to turn pages, and to prevent pages from getting lost.

The front page emphasised that all responses would remain confidential and that it would take less than 45 minutes to complete the questionnaire. The document was eight pages long and questions were numbered. This made recording returned questionnaires easier. The ordering of the questionnaire was important; it began with general questions, which were followed by more specific questions about the farm. Although it has been suggested that demographic questions are sensitive and should be placed at the end of the questionnaire (Simmons, 2006), the researcher started the questionnaire with demographic questions because they were considered easier to answer and were less intimidating than questions on production, costs and profit. A note of thanks was included at the end of the questionnaire. The questionnaire was divided into seven sections, each section with a specific purpose:

Part 0: *General information* – This section covered the respondent's identity, plot number for the household, and the type of farmer. 'Type of farmer' required farmers to identify themselves as tobacco or non-tobacco farmers. In addition, the section also obtained disaggregated information on location such as district, sub-county and village.

Part 1: *Demographic information* – This section consisted of demographic data about the respondent's gender, age, level of education, and main occupation, as well as questions about farming experience, household size, and other sources of income.

Part 2: *Structure of land tenure and access to finance* – Thirteen questions were included in this section. Six questions dealt with the structure of land tenure and seven questions inquired about farmers' access to finance. Questions on land tenure included types of land ownership, the quantity of land owned, land rented, and how much land was used for farming. Questions on access to finance dealt with whether farmers had financial institutions in their community and how they financed their farm inputs. Farmers were asked to choose from a list of agricultural credit providers, which included tobacco companies. Farmers also explained their repayment terms and types of collateral that they provided lenders. In addition, questions about farmers' perceptions on whether agricultural credit would improve farmer crop production, and their experiences on default loans, were included.

Part 3: *Crop production and marketing* – This section was designed to capture information on the quantity of output and sales. The questions first dealt with cropping systems, size of area planted, quantity of seedlings used, quantity of crop harvested, and the unit price. The cropping system option needed farmers to select from mono-cropping, inter-cropping, mixed cropping and relay cropping. Questions on the classification of the tobacco leaf, that is, flue-cured or air-cured, were included.

Part 4: *Farm inputs and their costs (fixed and variable costs)* – A checklist was used for questions about farm inputs and their costs. Both fixed and variable inputs were included. The checklist further captured the type of input, quantity applied, the unit cost, and total cost.

Part 5: *Labour utilization* – Labour utilization is crucial, especially in tobacco-farming households. Farmers were asked if they used hired or family labour, and a list of farm activities was provided for farmers to select the number of labourers that each activity needed per crop produced. Labour was measured in man-days and a question on the rate paid per man-day was included. The question on family labour captured provision of labour from adult male and female respondents and children. Family labour was measured in man-days and a 'rate paid per day' query was included, but other forms of labour exchanges or donations were also included, since family labour involves family members who may not receive cash payments.

Part 6: *Technical support* – In this section, questions were designed to capture how farmers obtained technical support, agricultural training, and membership in farmer associations. Questions were asked about extension services and if respondents paid for them. Farmers were also asked to give their reasons for cultivating non-tobacco crops.

A copy of the questionnaire can be found in Appendix B.

3.7.2 Pre-testing of the questionnaire

The questionnaire was pre-tested with a group of fifteen farm households in Arua district. The aim of the pilot was to check the usability and acceptability of the questionnaire and to identify any ambiguous questions. The pre-test provided valuable feedback from farm households of the potential study population regarding the questionnaire's structure, flow, wording, design, timing, and content. After the pre-testing exercise, the researcher went through the questionnaires with the district agricultural officials to find out whether both respondents and the officials could understand the questions.

All unclear questions were either removed or reformulated to make them understandable without altering the meaning of the original questions. Some tobacco farmers requested questions on the value of tobacco production to be rephrased to remove references to the profit from tobacco production. Farmers also requested that the questionnaire be available in the local language. This could not be achieved, although the researcher and data collectors translated the questions into the local language during the survey so that it was easier to complete.

3.7.3 Farm household survey

Training of data collectors/enumerators

In May 2014, while in South Africa, the researcher contacted the district agricultural officials of Arua and Maracha in Uganda, to identify suitable local agricultural extension officers who would assist in data collection. Initially it was planned that four extension officers who had been involved in the agricultural census of 2008/2009 would be used as data enumerators in the household survey. However, this was not possible as these officials were required to attend in-service training at the time of the survey. With the help of district agricultural officials, the researcher found other field enumerators from the National Agricultural Advisory Services for the West Nile sub-region. These enumerators were selected on the basis of experience with collecting agricultural data, attainment of a senior high school certificate, fluency in spoken and written English, good knowledge of the local language, and a good reputation in the community. Thirteen fieldworkers were interviewed and three were selected.

The training, which took one day, involved explaining the goals and objectives of the study, and training in specific skills to be used when conducting face-to-face interviews with farmers to ensure that respondents were continuously motivated to answer the whole questionnaire. The training also involved a discussion with enumerators on what the questions were specifically asking, as respondents during the pre-testing of the questionnaire indicated the importance of translating the questionnaire into the local language. At the training, data enumerators were cautioned on the importance of confidentiality during the interviews. The researcher worked through the survey questionnaire with the enumerators.

The farm household survey

The main survey was conducted over a six-week period between July and August 2014 using the survey questionnaire. The researcher and data enumerators visited sampled farm households to administer the questionnaire in person. In some cases respondents completed their questionnaires under the supervision of the enumerator or researcher. In other cases the enumerator/researcher posed questions to the respondents and filled in the questionnaire. Farmers' crop fields were visited to take plot-level measurements and observations. A typical interview took forty-five minutes, and in most cases was attended by the head of the household (husband) and occasionally by other family members too.

Heads of households were the preferred survey respondents because they often make the decisions on farm inputs and the allocation of farm and household resources. Some respondents declined to be interviewed, citing the many surveys that they had been involved in without having seen any benefit.

Some respondents, especially tobacco farmers, wanted to know whether the tobacco company (BAT) had approved the survey because they were instructed not to speak to anyone concerning tobacco farming. A few respondents wanted to know if the survey was part of a government development program and if participation in the survey would imply their selection to participate in the program. It was explained to respondents that the survey was part of an academic study and not a baseline study in preparation for a government program. Respondents were promised that the findings and recommendations of the study would be made available to policy makers, once the thesis was completed. The policy makers might use the results for future development projects in the study area.

3.7.4 Survey response rate

Fellows and Liu (2015) contend that an adequate response rate is crucial in order to draw acceptable conclusions. The response rate is the percentage of respondents who respond and the number of responses obtained (Fellows & Liu, 2015). An alternative way to determine the response rate is to divide the number of eligible respondents who respond to the survey by the total number of eligible respondents approached (Fink, 2013). As shown in Table 3.5, 126 farmers filled out the questionnaire representing a response rate of 68%.

Table 3-5: Response rate by respondents

Parameters	Tobacco farm households	Non-tobacco farm households	Total
Number of questionnaires distributed	119	66	185
Rejection	46	13	59
Active sample size (number of questionnaires received)	73	53	126
Response rate (%)	61%	80%	68%

Source: Survey data, 2014

The highest response rate (80%) was recorded from non-tobacco farming households. The response rate was lower in tobacco-farming households because of the political sentiment that surrounded tobacco control and its effects on tobacco farming at the time. Other factors that affected the response rate are discussed in section 3.7.5.

3.7.5 Some challenges encountered during data collection

As mentioned above, some tobacco farmers had been told not to disclose any information concerning tobacco-leaf production. The survey was done at a time when Parliament had consultations at the local government level regarding the 2014 Tobacco Control Bill. Some farmers chose to remain silent as they feared stigmatization from the tobacco-farming community. This made it more difficult to obtain the desired number of farm households in the sample.

Another challenge involved questions that required the respondents to recall production input and output data for the farming season. These included questions on the quantity of output produced, quantity sold in the season, and especially the costs involved in procuring some farm inputs. The third problem was the translation of the questions from English into the local language. Though all data enumerators were thoroughly trained before starting the survey, consistent clarity could not be guaranteed.

3.8 Data analysis

Data collected through a farm household survey questionnaire were analysed using three separate quantitative techniques that are described in the subsequent sections.

3.8.1 Data analysis software

A number of computer software applications have been developed that assist with data analysis. Fielding, Lee, and Lee (1998), however, point out that caution should be used as each will have some limitations. One of the main advantages of software packages is the ability to handle and manipulate large volumes of data in a number of ways and very rapidly (Robson & McCartan, 2016). This provides credibility, reliability and validity in data analysis.

In this thesis, the analysis is based on three data analysis software packages because of their different advantages for specific tasks. The software applications used were the Statistical Package for Social Science (SPSS) version 23, the Data Envelopment Analysis Program (DEAP), and STATA version 14. The SPSS software was mainly used to analyse descriptive statistics, and the characterisation or classification of farm types. These are presented in Chapter 4. Principal component analysis and cluster analysis were executed using SPSS. STATA was mainly used to develop the limited dependent models presented in Chapter 5 (incentives to tobacco leaf production). In addition, STATA was used to develop the inefficiency models presented in Chapter 6. DEAP is written to conduct data envelopment analysis (DEA) which is non-parametric. The computer program can evaluate several models, such as the standard models that involve the calculation of technical and scale efficiencies. These methods are outlined in Chapter 6.

3.8.2 Analytical methods for testing the hypotheses

Farm diversity and profitability

The first hypothesis of the thesis relates to the profitability of crops and diversity. For farm diversity and profitability, the thesis develops a farm typology that identifies farm types based on their choices within the household model. The analysis captures the heterogeneity among farm households and clearly identifies the choices that each farm household makes. It also captures the resource allocation behaviour of a given farm type. The empirical models for examining farm diversification and profitability include factor analysis, cluster analysis, and profit margin analysis. The variables selected for the farm typology analysis were farm output, revenue, expenditure, and household factors similar to those described by Chavez, Berentsen, and Oude Lansink (2010), Usai et al. (2006) and Goswami, Chatterjee, and Prasad (2014).

The direct approach of developing a farm typology starts with a direct principal component analysis of the observed variables. The resulting principal components are further analysed, using cluster analysis, to determine farm groups. The empirical model of the cluster analysis uses the hierarchical Euclidean distance-clustering algorithm. This algorithm is implemented on the pertinent principal components from the factor analysis model. Mutually exclusive groups are obtained from the data set. To show that the cluster solution is meaningful, a discussion of the descriptive statistics, as well as non-parametric tests on the group means of the pertinent cluster groups, is conducted. Finally, to show the profit of each farm type, profit margins are calculated between the identified farm types in order to determine farm profitability. This analysis is performed in Chapter 4.

Incentives to supply tobacco

The second hypothesis of this thesis is that tobacco leaf production is explained by price and non-price factors. The analysis involves a two-step procedure. The first step examines the decision whether or not to farm tobacco. The second step analyses how much tobacco should be produced. These two processes require a two-stage analytical framework. The analysis tests different modelling frameworks to select the most appropriate one.

Farm efficiency analysis

The third hypothesis considers cost, allocative efficiency, and technical efficiency in tobacco and non-tobacco farming. The two principal methods of testing for farm level inefficiency are Data Envelopment Analysis (DEA) and stochastic frontier analysis. The former involves mathematical programming and the latter uses econometric methods. This thesis adopts the DEA method of linear programming methods to construct a non-parametric frontier over the data; the rationale for DEA and a comprehensive methodology are presented in Chapter 6.

Efficiency scores for each farm household were calculated from the constant returns to scale (CRS) DEA model. Scale efficiencies were obtained by conducting a variable returns to scale (VRS) DEA, and then decomposing the technical efficiency scores obtained from the CRS DEA into two components. After obtaining the efficiency scores, the follow-up procedure was to estimate factors affecting efficiency. This was achieved by using a censored model, a Tobit regression model, which uses the efficiency score as a dependent variable for each farm household against selected independent variables that are assumed to be sources of farm inefficiency.

3.9 Ethical considerations for the study

There are a number of ethical issues that need to be considered when conducting research at a farm-household level. Bryman and Bell (2015) consider the lack of informed consent, insufficient protection for participants from the repercussions of their comments being reported, invasion of privacy, and deception as important ethical issues. This thesis adopted several measures to address these issues and to ensure that the research was conducted in an ethical manner. The research is conducted in line with the University of Cape Town's ethical guidelines.

Ethics approval for the study was granted by the Faculty of Commerce Ethics Committee. This involved lodging with the committee a research ethics clearance application, together with the survey questionnaire and participant consent form that each respondent would be required to sign before the interview (a copy of the consent form can be found as Appendix B). Respondents were subsequently provided with a copy of the consent form to retain for their records. The main ethical considerations are detailed below.

Informed consent – All respondents sampled to participate in the study were given a letter that fully informed them about the study. They were asked to sign a consent form before completing the questionnaire. The information letter contained the researcher's telephone number and respondents were asked to contact the researcher if they had any questions. Respondents who consented to interviews were contacted by telephone and were interviewed at a mutually convenient location, which was often their place of residence. Before the interview commenced, the purpose of the interview was explained and respondents were encouraged to ask questions if they were unsure about the interview process. The interviews were recorded with the respondents' consent on the understanding that only the researcher and the supervisor would have access to the completed questionnaire.

Right to withdraw – Respondents who did not wish to take part in the survey were able to opt out of the study by completing a withdrawal form and returning the questionnaire so that they were not contacted again. Respondents were informed that they did not have to answer a question if they were uncomfortable with it, and they had the right to withdraw from the interview at any point.

Anonymity – Given that tobacco farmers are wary of the power and influence of the tobacco industry, anonymity was an important issue for the respondents. As the main investigator, the researcher was the only person to have access to the respondents' names and addresses provided by the district officials. In order to maintain anonymity, all questionnaires were identified only by a number.

Confidentiality – All completed questionnaires, the coding system information, and the consent forms were kept separately in a secure lockable filing cabinet to protect confidentiality. Respondents' names and addresses were held in a password-protected computerised database for record keeping and to enable respondents to be contacted again, should the need arise. The questionnaire responses were stored in a separate password-protected database that contained no personal details about the respondents.

Appropriate handling of respondents – Respondents had to be handled sensitively as the survey addressed tobacco issues. Some questionnaires were not fully completed if the respondent appeared to be uneasy or distressed.

Debriefing – At the end of the interview, the researcher spent on average ten minutes debriefing the respondent to ensure that she or he had not been distressed by answering the questions. The researcher further verified that the respondent had the researcher's contact number so that she or he could contact the researcher later with any further queries that might arise.

3.10 Concluding remarks

This chapter deals with the research philosophy, design and methodology of the study, and explains the reasons for adopting a quantitative research strategy. It explains how households were sampled, how data was collected and analysed, and discusses relevant ethical considerations for the study.

Chapter 4
Economic profile of farm households

4.1 Introduction

The research questions that the study investigates require a careful compilation of data. This chapter presents a descriptive analysis of tobacco and other crop production systems in the study area. The analysis includes a comparative analysis of farm profitability and diversity in West Nile.

The descriptive analysis provides insight into the demographic profiles of households, their labour patterns, the institutional profiles of the study area, and land use patterns. Farm size and land productivity relationships are also explored, providing insight into farm input use and output within crop enterprises. This is followed by an evaluation of the comparative gross margins of tobacco-leaf farms and of other crop enterprises. Finding feasible alternatives for tobacco leaf remains an important strategy for Article 17. The purpose of the profitability analysis is to evaluate the economic feasibility of tobacco leaf and consider its competitiveness with respect to possible alternatives.

Likewise, the results for profitable alternatives are essential to tobacco-leaf producers as reflecting on the perceived risk and uncertainty associated with growing tobacco leaf. The profitability results are followed by a sensitivity analysis that attempts to evaluate the possible effects of two assumptions on profit margins.

The research questions that guide the chapter are: do tobacco farms have a higher profit per unit than those farming non-tobacco crops? And are profits from non-tobacco crops more sensitive to input and output prices, and if so why? The chapter tests the hypothesis that: tobacco farms have higher profits per unit of output than farms that produce alternative crops. It is further expected that farm profits from tobacco farms are less sensitive to changes in factor and product prices than alternative crops. Farm diversity is discussed after the profitability analysis and the final section sums up the chapter's findings.

4.2 Household and farm characteristics

4.2.1 Demographic profiles

The conditions of farming tobacco and other crops in the rural areas are, to a considerable extent, reflected in the demographic profiles of farm households. These conditions in turn could affect the household's production behaviour. Usually the head of the household is responsible for the coordination of farm household activities and the procurement of farm inputs. In the demographic profile therefore, the variables reported relate to age and gender composition, educational status, household size and occupation, farming experience, and access to information, as reported by the heads of household.

Age and gender composition of the households

The age of the household head is considered a key factor in this study because age is a proxy for experience. It may also involve risk aversion - i.e. whether household decisions reflect the risk-taking attitude of a younger farmer. The average household head surveyed was 47 years of age.

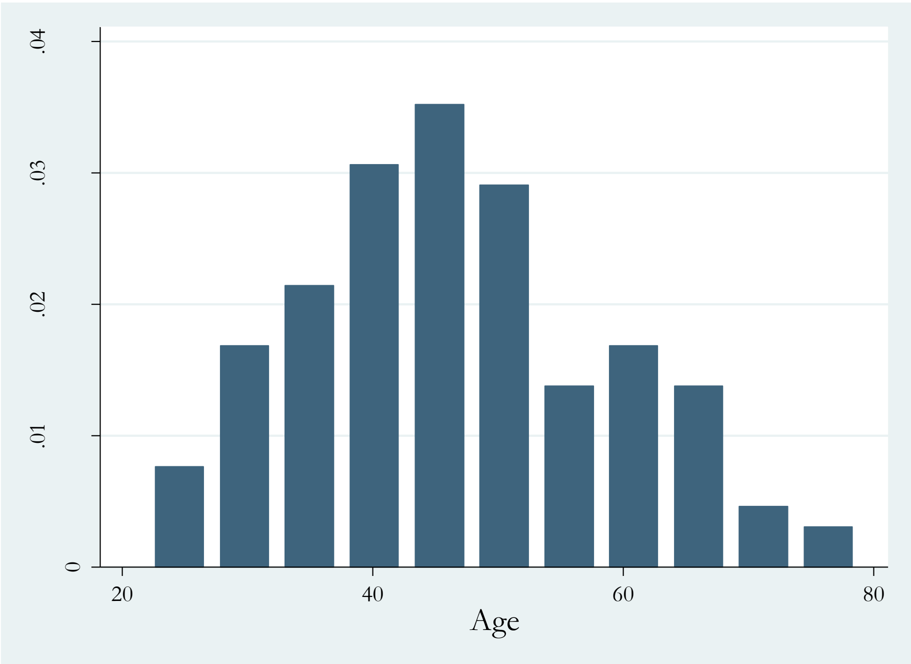


Figure 4-1: Age distribution of household heads in the sample

Figure 4.1 gives the age variable which shows a normal distribution with the mean almost at the centre of the range. The youngest head of household was 24, while the eldest was 79 years of age. Figure 4.2 presents the age and gender composition of an average farm household, and it shows that the sample had an overwhelmingly male representation, and that these were mainly between the ages of 40 and 60. Their female counterparts were within the 30 to 40 age category. Overall, 92% of the sample was represented by male respondents and the remainder (8%) were female.

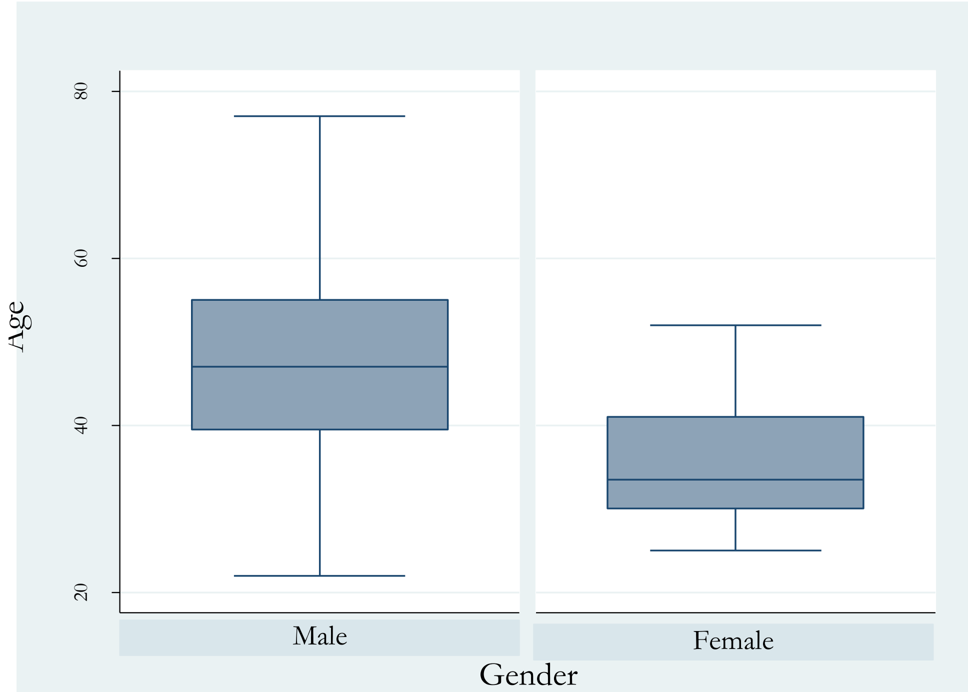


Figure 4-2: Age and gender composition of household heads within the sample

Table 4.1 shows the age and gender categories by district and the data indicates that 23% of male respondents were from Maracha district and ranged between 31 and 45 years of age. This was followed by the age category of 46 to 60 years, which represented 18%. The difference was minimal between Maracha and Arua districts. In the category of 'less than 30 years of age', Arua district had a 2.4% representation, which increased in the category of '31–45' to 14%, and to 18% for those between 46 and 60 years of age. Older farmers had a small representation (6%) in Arua district.

Table 4-1: Age categories and gender of household heads within in the sample

	Age and gender composition				
Districts	Percentage of male HH in sample by age group				**Size of sample**
	0 – 30	31 – 45	46 – 60	>60	(%)
Arua	2.4	13.5	17.5	5.5	49 (38.9)
Maracha	3.2	23.0	18.3	8.7	67 (53.2)
	Percentage of female HH in the sample by age group				
Arua	2.4	3.9	–	–	8 (6.3)
Maracha	–	0.79	0.79	–	2 (1.6)

Source: Field survey data, 2014.

Disaggregating the data into tobacco and non-tobacco farm households reveals that in a typical tobacco-farm household, the average age of tobacco farmers was 49 years, whilst the average age was 44 years in non-tobacco households. A t-test was used to compare the average age of the two groups. The independent t-test confirmed that a small difference between the average age of tobacco farming households and non-tobacco farming households was statistically significant (see test results under Appendix D). With respect to youth involvement, 2% of the sample is less than 25 years of age and not growing tobacco, while 1% is young and growing tobacco.

In farming, a key area of concern has been the extent to which women and men have different farm roles and the gender inequalities that exist. However, the data available only provide gender profiles for farmers. In the aggregated sample, female and male farmers are similar, as variations in individual characteristics are masked, although female respondents seemed to have attained a higher level of education.

Table 4-2: Gender differences by districts and farming household type

Gender *n=126*	**Arua district**		**Maracha district**	
	Tobacco HHs (%)	Non-tobacco HHs (%)	Tobacco HHs (%)	Non-tobacco HHs (%)
Male	23	16	33	20
Female	2	4	0	2

Source: Field survey data, 2014.

In terms of their gender roles in farming, the researcher had informal discussions in which farmers indicated that women were extensively involved in all farm labour activities, particularly in tobacco leaf production, but were not identified as responsible for production decisions. Female members of households were also involved in post-harvest processes, but the difference between the sexes lies in the management and control of finances and input use.

Educational attainment in the sample

Previous studies have reported mixed results in terms of the effect of education on crop adoption or managing farm risk (Mishra & El-Osta, 2002; Enjolras & Sentis, 2011). The likelihood that farmers will adopt new crops, access markets, or participate in high-value chains is positively associated with education (Läpple, Renwick, & Thorne, 2015). Feder, Just, and Zilberman (1985) mention that formal schooling plays an important role in determining the allocative ability of a farmer and also minimises errors in their subjective probability.

Weir (1999) found that farm operators' contributions to production were positively associated with their educational levels. In South America, Welch (1970) reported that education had no impact on productivity in farm areas that had traditional agricultural practices, but found a positive relationship in farm areas that were in the midst of modernisation. Because the aim of the thesis is to study household production behaviour, it is useful to examine the educational status of the sample farm households and the implication of it for households that could transition to alternative crops.

Table 4.3 shows that all respondents have formal education to primary, secondary, or tertiary level. Primary and secondary education is basic education. A tertiary level of education is higher education (beyond high school) and in this sample it involves a bachelor's degree (three years post-high school). Disaggregating the educational variable by districts shows that there were more farmers with only a primary level of education, both in Arua (23%) and Maracha districts (36%). This result suggests that 58% of interviewees (23% from Arua and 35.7% from Maracha) had only primary education, while a further 36% of respondents had gone to secondary school.

Table 4-3: Educational attainment of respondents

Districts	Age category	**Educational attainment**		
		Primary	Secondary	Tertiary
Arua	Less than 30	3	3	0
	31 – 45	6	16	0
	46 – 60	16	6	0
	More than 60	4	3	
Total		**29 (23%)**	**28 (22.2%)**	**0**
Maracha	Less than 30	2	2	0
	31 – 45	17	8	5
	46 – 60	17	6	1
	More than 60	9	1	1
Total		**45 (35.7%)**	**17 (13.5%)**	**7 (5.5%)**

Source: Field survey data, 2014.

Moreover, at least 35.7% of the sample had attained a secondary level educational status. This result is in line with the national population census survey statistics, which report 80% of persons aged 15 and above have completed at least primary and secondary level education

(UBoS, 2017). On the other hand, 5% of the sample respondents in Maracha district, most of them being between 31 and 60 years of age, had a tertiary education. Arua district, on the other hand, had no respondents with a tertiary education. No illiterate respondents were reported in the survey.

If the findings of Weir (1999) and Welch (1970) were applicable to the West Nile, then the transition to alternative crops in the study area should not be slow or difficult, especially if there were an effective extension support programme present. Table 4.4 further disaggregates the educational variable for tobacco and non-tobacco farming household heads. It shows little difference in their educational profiles.

Table 4-4: Educational attainment of heads of the household by crop type

Educational attainment	**Arua district**		**Maracha district**	
	Tobacco HHs	Non-tobacco HHs	Tobacco HHs	Non-tobacco HHs
Primary level	20	9	31	14
Secondary level	12	16	7	10
Tertiary level	0	0	3	4
Total	**32**	**25**	**41**	**28**

Source: Field survey data, 2014.

Household size (family size)

There is considerable debate as to whether household family size is associated with farm productivity and the economic well-being of farm households. It has been argued that within the social settings of less developed countries, such as Uganda, family members make a positive net economic contribution to their families, at least in the long run. In these circumstances, it is hypothesised that, *a priori*, families with many members should eventually be better off in terms of farm productivity and the provision of off-farm income than those with few members.

Family members' economic contributions may take the form of labour on the family farm, other *in situ* work activities, or the provision of income, in cash or kind, earned from employment elsewhere. The variable is therefore included as part of the analysis. Figure 4.3 below shows the distribution of family size in the sample.

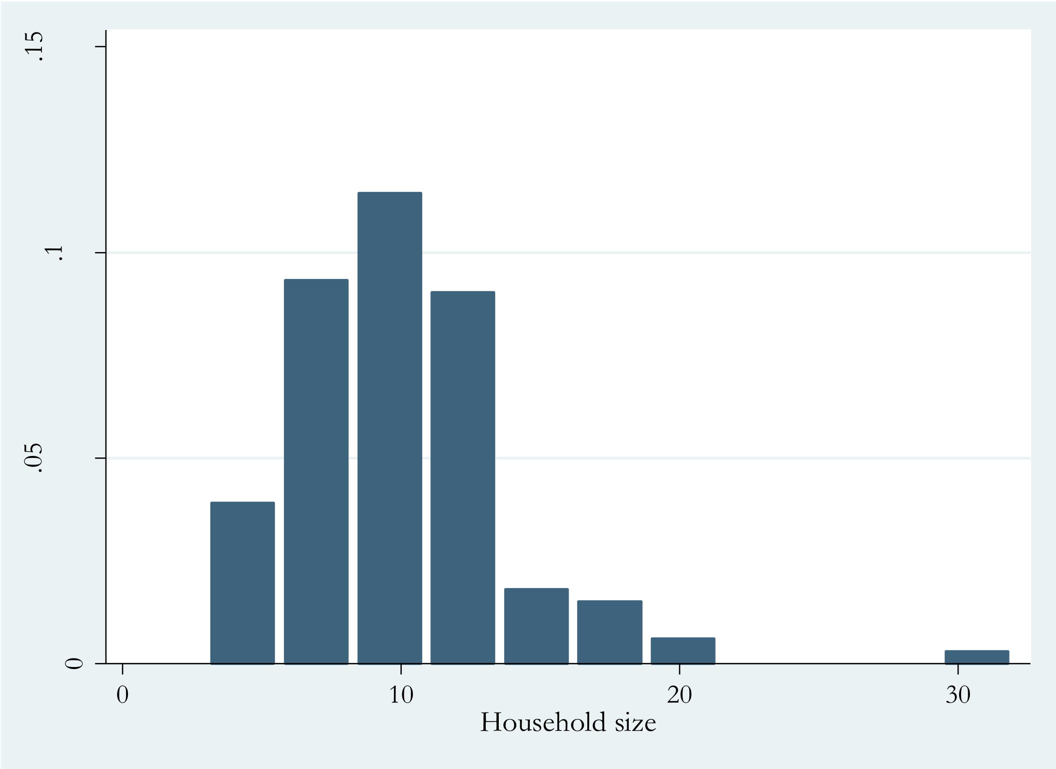


Figure 4-3: Family size of households within the sample

Households in this sample had relatively large families, with an average of 9.8 family members, the smallest having 3 and the largest 32 members. This sample mean is greater than the national average of 4.7 (UBoS, 2014). Mean family sizes varied slightly across the different farming activities. Table 4.5 and 4.6 present average family sizes amongst tobacco-leaf producing households and non-tobacco producing households respectively. The weighted mean family size of tobacco-farm households was 10.63 (*SD*=4.13) while that of households growing non-tobacco crops was 8.77 (*SD*=3.33). Table 4.5 shows that the average household size in a typical tobacco-farm household consists of approximately 6 adult members, with 5 children younger than 12 years. This was a common pattern for households in West Nile.

Table 4-5: Household size for tobacco farming households

Household size	Mean	Std Dev*	Minimum	Maximum
Adult members	5.82	2.02	2	13
Children<12 years	4.81	3.18	1	19
Combined	10.63	4.13	4	32

Source: Field survey data, 2014.

The differences in average family sizes between tobacco and non-tobacco households were statistically significant (t-test results are given in Appendix D). Perhaps the larger families in tobacco households are linked to the labour requirements for tobacco farming.

Table 4-6: Household size for non-tobacco farming households

Household size	Mean	Std Dev*	Minimum	Maximum
Adult members	4.67	1.86	2	8
Children<12 years	4.09	2.44	1	9
Combined	8.77	3.33	3	17

Source: Field survey data, 2014.

The household size variable was split into three groups: small families, medium-sized families, and large families to account for differences in family size as well as age, gender and education. The small category represented families with fewer than five family members, the medium-sized group had from 6 to 10 family members, and large families had eleven or more members. Table 4.7 shows that there were differences in family size along the three variables; for example, the likelihood of a larger family increased as the age of the respondent increased.

Table 4-7: Differences in family sizes by education, age and gender

Variables		Sizes of household		
		Small families n=13	Medium families n=69	Large families n=44
Age of family head	Less than 30	4	6	–
	31 – 45	6	39	7
	46 – 60	3	20	23
	More than 60	–	4	14
Gender of family head	Female	5	5	–
	Male	8	64	44
Education attainment of family head	Primary level	9	35	30
	Secondary level	4	29	12
	Tertiary level	–	5	2

Source: Field survey data, 2014.

Family heads who were older than 45 years of age had more medium and large families, and those in the age category 31 – 45 had families which were mainly medium or small. The relationship between family size and gender showed that female heads of households had smaller families than their male counterparts, whose families were typically medium and large. Differences were also apparent within the educational categories. For example, family heads with only a primary level of education were more than proportionately found heading medium and large families. Respondents with a tertiary education tended to have smaller families.

Primary and secondary sources of income (occupational profile)

In terms of the occupational profiles, 98% of sampled household heads gave farming as their primary occupation. Only two heads of households reported salaried employment as their primary source of income. In addition, over half of the respondents (54%) reported secondary sources of income, as is often the case in rural farming communities in Uganda. The secondary sources of income included running non-farm income generating enterprises (16%), salaried employment (11%), self-employment (6%), and the sale of household labour (21%). Table 4.8 presents the distribution of sources of income by family size. There is no difference in primary sources of income between family sizes, but differences are noticeable in the secondary sources of income.

Table 4-8: Frequency distribution of sources of income by family size categories

Sources of income		Family sizes		
		Small families	Medium families	Large families
Primary source	Farming	13	67	44
	Salaried employment	–	2	–
Secondary source	Self-employment	2	4	2
	Salaried employment	1	6	7
	Business-oriented Activities	2	15	3
	Casual labourer	1	14	11

Source: Field survey data, 2014.

Small families appeared relatively more creative and innovative in venturing into self-employment and business enterprises as their secondary income bases than large families. Medium-sized families mostly ventured into business and sold much of their household labour as casual labour. They also included civil servants who were employed as agricultural officers and teachers. In addition, some medium-sized families reported being self-employed (4 families). The sale of family labour as casual labour featured more in large families (11 families), followed by salaried employment (7 families), business activities (3 families) and self-employment (2 families). It is important to note that sample households were likely to have engaged in more than two economic activities as their primary and secondary sources of income.

Years involved in farming (farming experience)

Whether farming experience encourages the growing of tobacco leaf remains unclear in the existing literature on the economics of tobacco production, yet it is an essential concern for policy makers promoting alternative livelihoods in a tobacco farming area. The literature on the adoption of new agricultural production systems shows that as farmers accumulate experience over time, they progressively switch from traditional agricultural technologies to improved technologies on the basis of observed performance (Feder et al., 1985). In the case of tobacco farming, if research fails to develop a superior alternative crop, tobacco farmers are likely to continue growing tobacco.

There are two forms of farming experience mentioned in the adoption literature: experience in integrating agricultural technologies, which refers to the time a farmer spends on using an improved technology, and general farming experience, which refers to the time a farmer spends in farming and the degree to which farming is regarded as a calling rather than a mere occupation. This study focuses on general farming experience. Figure 4.4 presents years of farming experience in the sample and shows that the majority of farmers had spent a significant time, ranging from 9 to 13 years, in farming.

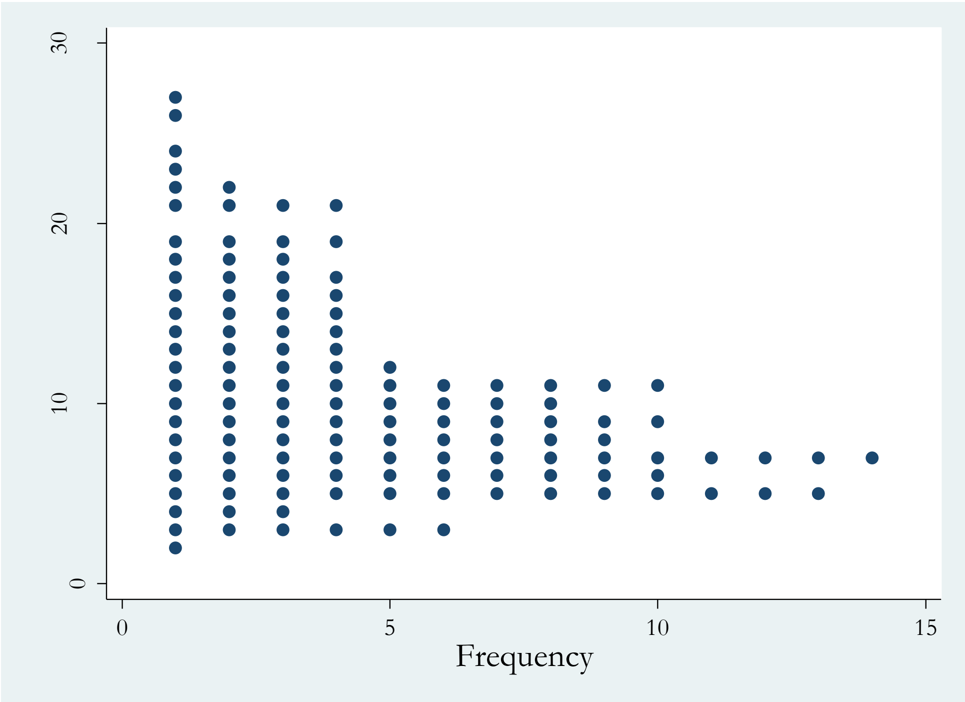


Figure 4-4: Farming experience distribution in the sample

The minimum number of years spent in farming amongst household heads was 2 years, and the maximum was 27 years; the average number of years was 10.5 years. Disaggregating the data into those that farmed tobacco and those that farmed non-tobacco crops, the differences in their mean years of farming experience was slight. Tobacco farmers had between 2 and 26 years of experience, with a mean of 11.67, while farmers that grew only non-tobacco crops had between 3 and 27 years with a mean of 8.92.

Table 4-9: Farming experience in sample households

Household type	**Farming experience (years)**			
	Mean	SD	Minimum	Maximum
Tobacco households	11.67	5.91	2	26
Non-tobacco farm households	8.92	4.62	3	27
Combined sampled	10.52	5.55	2	27

Source: Field survey data, 2014.

Figure 4.5 shows the age composition of farmers and their years spent in farming. A positive relationship is observed between the age of a farmer and the number of years spent in farming and is supported by a correlation test which shows a significance of r=0.7048. This could imply that farming in the study area is a generational income activity. The result further reaffirms the earlier result on the primary sources of income, which showed that farming was the main occupation for this sample, as it shows that farmers had been farming for much of their lives.

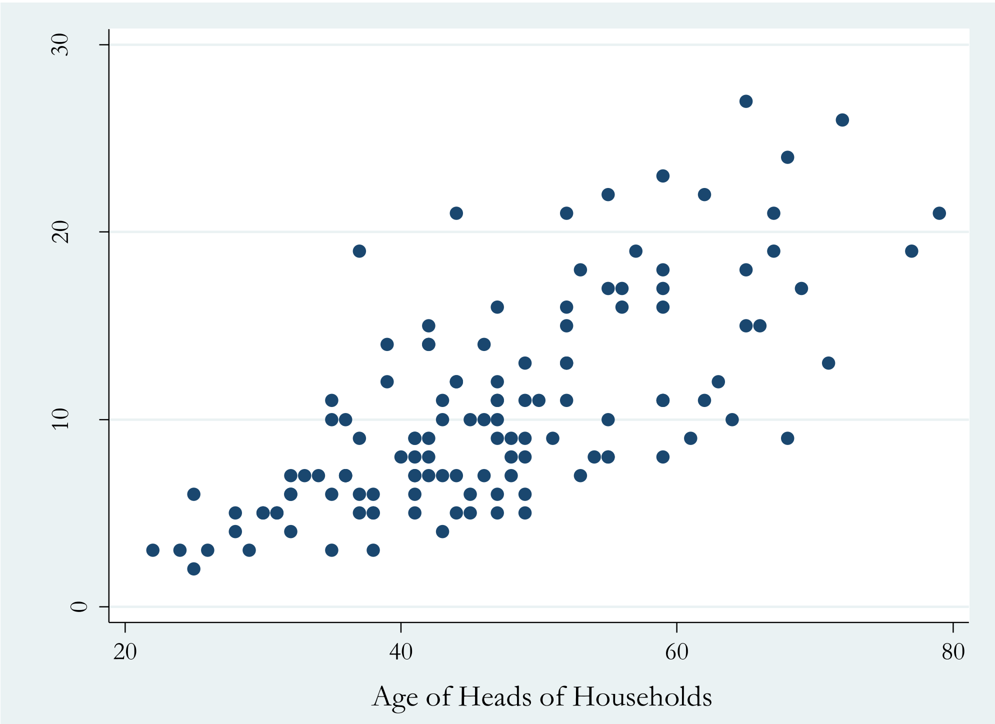


Figure 4-5: Composition of age and farming experience of heads of households

Time spent in farming appeared to vary inversely with educational attainment (see Figure 4.6), with a correlation test r = -0.212 ($p<0.000$). The majority of primary, secondary, and tertiary educated respondents had fewer than 10 years of farming experience. This could suggest that, in this sample, respondents spent much of their time in farming rather than in pursuing an education. Nevertheless, one respondent with a tertiary education level has spent 27 years in farming.

Figure 4-6: Composition of farming experience and educational status

Access to agricultural information

Information and knowledge matter in farming, with farmers continuously seeking information and sharing knowledge on new agricultural technologies. The literature shows that farmers have varying information needs, use different channels to communicate, and have knowledge embedded in their attitude, practice, and experience. Indeed, Aguilar-Gallegos, Muñoz-Rodríguez, Santoyo-Cortés, Aguilar-Ávila, and Klerkx (2015) argue that the lack of exchange of information and knowledge among and between farmers is a key issue in pro-poor agricultural development. Recognizing this, the National Agricultural Advisory Services for Uganda Act of 2001 encourages information exchange in order to build a robust and dynamic agricultural sector. Table 4.10 presents the different information channels that farm households reported using to access agricultural information.

Local radio stations were the main source of information for both tobacco and non-tobacco households. The importance of the use of radio stations to convey information was confirmed by 23% of tobacco-farming households in Arua and 27% in Maracha districts. The result is slightly higher (at 39% in Arua and 49% in Maracha) than the national statistics of 46% for Arua district and 44% for Maracha district (UBoS, 2014).

Table 4-10: Main sources of information

Sources of information	Arua district		Maracha district	
	Tobacco HH %	Non-tobacco HH %	Tobacco HH %	Non-tobacco HH %
Radio *(yes=1)*	23	16	27	22
Neighbours *(yes=1)*	20	15	27	21
Family members *(yes=1)*	15	11	24	16
Newspapers *(yes=1)*	5	2	5	6

Source: Field survey data, 2014.

Relying on neighbours as sources of information was also important, as both tobacco (47%) and non-tobacco (36%) farm households reported getting their information from neighbours. Family members were also considered important sources of information. Newspapers were not a popular source of information, and only 18% of respondents in both Arua and Maracha reported having obtained information from newspapers.

4.2.2 Labour use profiles

Farm labour as a farm input is likely to be higher on farm plots that tend to intensify with modern inputs and techniques, such as fertiliser, and improved farm practices that raise the productivity of land. Use of fertilisers increases output, but also the growth of weeds, thereby increasing the labour demanded per acre. Improved farm practices may also be labour-intensive. For example, the planting of crops in rows facilitates the weeding operation but increases labour input for weeding due to the spacing between plants. Similarly, adoption of the practice of seed treatment improves the probability of germination of the seed and consequent higher seedling survival rate, which in turn is likely to increase labour use per unit of cultivated land preparation in planting and threshing.

With regard to the relationship between farm size and labour, the literature, particularly in Africa (Mignouna, Mutabazi, Senkondo, & Manyong, 2010), shows that small farms have a higher labour input per acre. For small farms, dependent on family labour, the imputed cost of labour is below the rates paid by larger farms hiring labour at the market wage rate. Labour availability is often mentioned as one of the factors that affect farming decisions. Farm households in Uganda, as in any other subsistence-oriented farming country, rely heavily on household labour supply to carry out farming activities and other domestic activities. Family labour is by far the most important resource, particularly in a rain-fed agricultural region that is characterised by seasonality.

Occasionally, family labour resources cannot cope with the labour requirements of farm activities such as transplanting, weeding, and harvesting. In such instances, farmers tend to employ non-family labour. The types of non-family labour used in the survey areas included hired time. Farmers reported using exchange labour, which constitutes another form of labour supply in the study area but was not computed. Exchange labour is a practice where farm households make requests to extended families to come together and complete a specific piece of farm activity.

Farm labour used for several farm activities usually benefits the entire cropping system. For example, in a mono-cropping system, farm labour is related to the specific crop grown in a particular plot. But in the case where a farmer follows an intercropping system, most of the farm activities would benefit the entire farm system and a breakdown of labour use cannot be easily obtained. Tobacco-leaf farm plots were prevalently mono-cropping systems and labour use was therefore related to one specific crop. The same farming principle usually applied to sweet potatoes, cassava, and coffee.

Labour was computed as man-days and the calculation included the following factors: the number of farm labourers employed at the time of farm activity, the number of workdays spent in a farm activity, the conversion factor, which converts typical workdays into 8 hours, and the availability factor. Table 4.11 shows the allocation of hired labour to the various crop productions and it was clear that food-crop productions were provided with hired labour.

Table 4-11: Total hired labour per farm activity (man-days per farm season)

Crop enterprises	Land preparation	Transplanting/ planting	Weeding	Application of fertiliser	Harvesting	Post-harvest
Rice	-	-	-	-	-	-
Coffee	295	219	224	77	404	-
Cassava	-	410	325	191	653	33
Maize	-	-	-	-	-	-
Tobacco leaf	741	1178	734	170	1562	1223
Sweet potatoes	33	26	-	-	41	-
Sunflower	-	-	-	-	-	-
Beans	60	41	42	-	107	-
Sorghum	-	-	-	-	-	-

Source: Field survey data, 2014.

Data in the table show that almost all of the non-family labour usage was employed on five crop enterprises: tobacco, coffee, cassava, beans, and sweet potatoes. With the exception of other food crops such as maize, sorghum, and rice, more than 50% of the total non-family labour was used for transplanting or planting.

This is not surprising, particularly for tobacco production, because transplanting remains a manual activity which consumes many hours of labour and is essential for good tobacco-leaf harvests. The next most important farm operation for which hired labour was employed was harvesting, particularly in the case of cassava, coffee, and tobacco leaf. Post-harvest hired labour was not used in most crop productions, except for tobacco-leaf production (1223 man-days).

Table 4.12 shows the use of family labour for crop productions in the sampled households. Tobacco-leaf farming remained the highest consumer of family labour, with a total of 11 520 man-days per season for all major farm tasks. This was followed by coffee (4145 man-days), cassava (2920 man-days) and other food crops (1604 man-days). Much of the family labour was occupied in planting, harvesting, and post-harvest farm activities.

Planting tasks on tobacco farms usually involve transplanting seedlings from seedbeds. These tasks continue to be done by hand and it takes a farm household an average of 21 man-days to complete land preparation and planting. Harvesting tasks are still the most labour-intensive operations, averaging about a third of all labour required to grow and harvest the crop.

The tobacco and coffee harvesting phases are continuous processes and not a once-off process. It is estimated to take over a month to complete the harvesting of coffee cherries or tobacco leaf. Post-harvesting activities for stripped tobacco leaves include tasks such as curing, taking down, baling, loading, and hauling to the market.

Table 4-12: Total family labour per farm activity (man-days per farm season)

Crop enterprises	Land preparation	Transplanting/ planting	Weeding	Application of fertiliser	Harvesting	Post-harvest
Rice	107	78	71	-	172	-
Coffee	266	228	398	109	1546	1598
Cassava	375	588	536	397	896	128
Maize	36	60	45	18	71	-
Tobacco leaf	1475	1541	1502	531	3512	2959
Sweet potatoes	59	91	57	-	92	-
Sunflower	38	-	-	-	73	-
Beans	111	74	56	10	120	-
Sorghum	41	51	21	7	39	6

Source: Field survey data, 2014.

Similarly, coffee post-harvest activities included cherry sorting, pulping, and drying. The intensive use of labour in the weeding phase was also higher on tobacco farm plots and on average required 13 man-days in a farming season to maintain clear fields with no weed infestation. Weed infestation usually is correlated to a higher application of fertiliser to the farm plots.

4.2.3 Institutional profile of survey areas

Literature on farm household behaviour contains evidence of the influence of institutional factors, such as land ownership or tenancy arrangements and the availability of credit facilities, on the adoption of agricultural crops or technologies. To fulfil the objective of exploring these factors, the following subsection highlights the land tenancy and credit characteristics of the sample.

Land tenancy

The literature on farm household production behaviour is not unanimous regarding the effect of tenancy arrangements on farmer behaviour. Substantial gains from alternative crops, in the case of tobacco-farming communities, may require investment or changes in land-use patterns that upgrade the existing physical and chemical properties from tobacco farms. However, it is likely that land-use patterns, and types of investment made, depend on the relationship between a farmer and the land he/she cultivates, the share of benefits and costs, and the period of time over which benefits can be realised, i.e. on the nature of property rights.

Land-use patterns in the West Nile sub-region are likely to become increasingly important as agriculture intensifies in response to growing population pressures. Uganda reformed its land tenure systems with the 1998 Land Act (Government of Uganda, 1998), which recognised existing rights to land. The 1995 Constitution (Government of Uganda, 1995) and the 1998 Land Act recognise four different land tenure categories: freehold, customary, *mailo* land, and leasehold tenures.

The Constitution and the Land Act define freehold as a land tenure that bestows the right upon someone to own and manage land with full power of ownership. They can use it for any lawful purpose, such as selling, renting, leasing, or disposing of it willingly. The Land Act describes the customary or communal tenure as one in which land is owned communally by either a family, clan, or tribe. Customary land is governed by the rules accepted as binding by the given community.

Mailo land on the other hand provides permanent ownership of large plots of land to landlords, while at the same time tenants on the land are recognised and also have rights to live on and use the land. The *mailo* land system was introduced by the colonial administration in agreement with the Buganda Kingdom in 1900. The agreement gave the King and the landlords freehold rights over large plots of land, which are often occupied by poor subjects who become tenants. The *mailo* tenure system is prevalent in the Buganda, Toro, Ankole and Bunyoro, and Bugisu districts. Leasehold is as a tenure system where one party grants to another the right to exclusive possession of land for a specified period, usually in exchange for the payment of rent. Thereafter the land owner can grant the lease to another person.

The 2010 Statistical Abstract from the Ministry of Lands, Housing and Urban Development reports that 68.6% of households are on customary land, 18.6% on freehold, 9.2% on mailo, and 3.6% on leasehold (MLHUD, 2010). While the statistics from the National Development Plan reports that 45% of land in Uganda is under the customary tenure (Government of Uganda, 2010). Deininger and Castagnini (2006) report that customary tenure accounts for 59% of plots. Table 4.13 presents data from the two study districts. It shows that between 60% and 70% of the cultivated lands are owned by their operators through a customary tenure system.

Table 4-13: Tenancy classifications of cultivated land in the survey districts

Districts *n=126*	**Type of tenancy**	**% tenancy**	**Average land under the tenure (acres)**
Arua	Freehold	12.28	6
	Customary	70.18	5.59
	Leasehold	15.79	2.06
	Mailo	1.75	4.5
Maracha	Freehold	18.84	5.5
	Customary	66.67	5.85
	Leasehold	5.80	3.25
	Mailo	8.70	5.08

Source: Field survey data, 2014.

The evidence of land rentals (leasehold) in the survey districts (Arua = 16%; Maracha = 6%) suggested the presence of land markets in the West Nile sub-region. This evidence and the high percentage of customary lands are not surprising since statistics from the national census indicated that over 50% of land in West Nile is under a customary land tenure system. In view of the hypothesis that tenants are willing to invest in secure lands, it seems that there is potential for alternative crops in the West Nile sub-region if the initiatives of alternative livelihood development are community-driven. It is also evident that unregistered freehold (*mailo* land) is not as prevalent in the study areas as the freehold tenure system, which is to be expected as *mailo* land is predominantly found in Buganda.

Financing farm activities in the study areas

Three main factors that contribute to agricultural growth and decision-making are increased technological change, the use of agricultural inputs, and technical efficiency.

Technological change is the result of research and development efforts (Abdallah, 2016), while the technical efficiency with which new agricultural crops or technologies are adopted, or used more rationally, is affected by the flow of information and a better infrastructure. The use and better mix of inputs requires finance at the disposal of farmers. Finance could come either from farmers' own savings or through borrowing. In countries such as Uganda, where savings are negligible, particularly among smallholder farmers, agricultural credit seems to be an essential farm input. Agricultural credit capitalises farmers to undertake new investments or adopt new agricultural crops or technologies.

Earlier work by Binswanger, Khandker, and Rosenzweig (1993) showed that the presence of infrastructure and financial institutions does affect agricultural output and investment. They suggested that credit supports farm income-generating activities and is a strong factor in farmer decision-making, and that better credit facilities, by enabling the smoothing of consumption, may increase the willingness of farmers to take risks. This study also examines the relationship between farmer decisions, the nature of financial tools and institutions, and their effect on agricultural output. To this end, farm household heads were asked whether or not they had access to credit facilities and how they financed their farming activities. Farmers were not asked for details of debt or savings, or the structure of their debt.

In this sample, 83% of respondents reported having access to credit facilities and 17% did not have credit facilities in their vicinity. Village saving schemes, local commercial banks, and women savings groups were the most frequently-used local financial institutions. Other respondents mentioned post banks which are operated by post offices. It is important to note that the presence of credit institutions or access to them, does not necessarily imply that credit is taken. Table 4.14 shows how farm households finance their farm activities. Note that more than one source of funding may be used.

Table 4-14: How households finance their farm activities

Financing of inputs	%
a) Don't buy inputs	0.79
b) Own finances	34.13
c) Formal lenders *e.g. commercial banks*	10.32
d) Informal lenders *e.g. money brokers*	7.94
e) Tobacco leaf companies	46.83

Source: Field survey data, 2014.

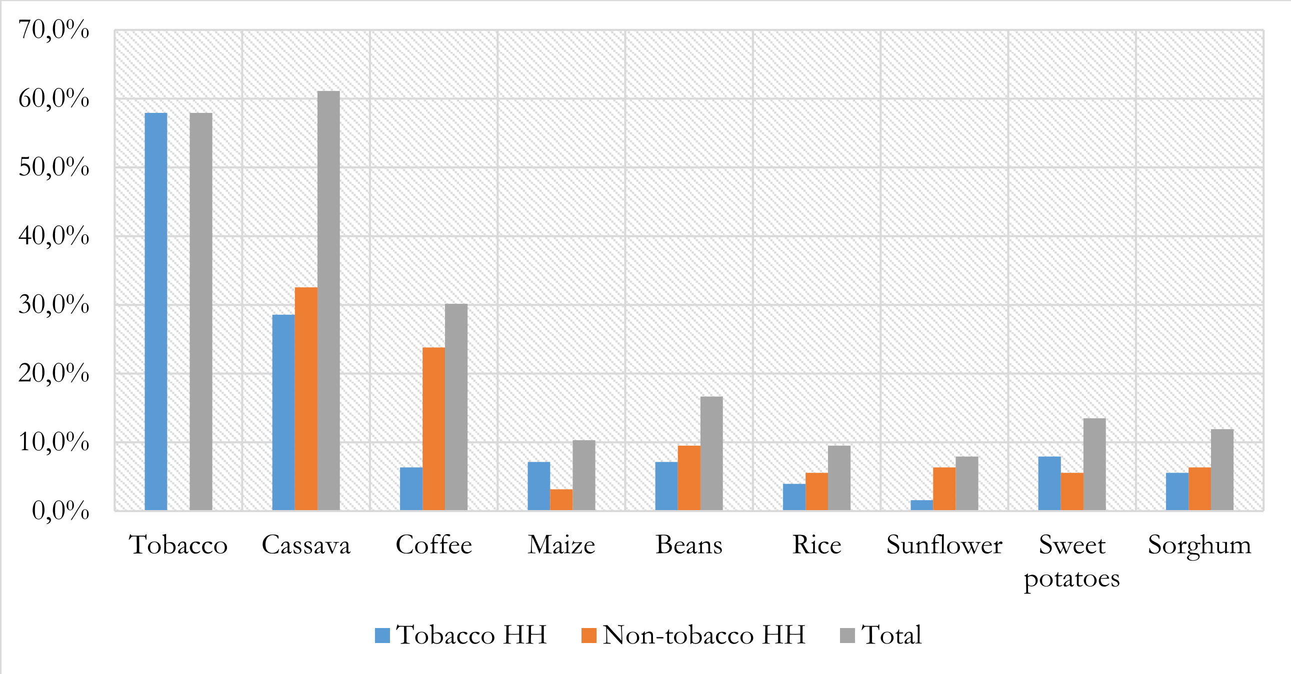
While 47% of farmers received financial support for their farm inputs from tobacco companies and 34% used their own capital, the proportions of farmers using formal credit facilities (10%) and informal lenders (8%) were relatively low. This could be because tobacco companies usually offer a complete farm-inputs package. The data also showed that some farmers defaulted on loans. 17 respondents reported having defaulted on their payments.

4.2.4 Landholding, land use and land characteristics

This section presents information on the farm activities of farmers in the sample in 2014 and discusses landholdings, the allocation to different crops, and the output obtained.

Land use patterns

Figure 4.7 presents the crops grown in the survey areas in the 2014 farming season. These include tobacco, cassava, coffee, maize, beans, rice, sunflowers, sweet potatoes, and sorghum. Cassava (61%) is the predominant staple crop in both tobacco-farming households and non-tobacco farming households. The majority of households (58%) reported farming tobacco leaf, followed by 30% for coffee farming.



Source: Field survey data, 2014. Note: Data generated from a multiple response question allowing the frequency to vary beyond 100%

Figure 4-7: Percentage of farm households that reported growing various crops

In terms of crop diversification, farm households also grow mainly cassava, maize, sweet potatoes, and beans. Coffee was predominantly produced by households that did not farm tobacco but some tobacco-farming households (8%) also farmed coffee. Coffee may have provided an alternative cash crop for some households that already farmed tobacco leaf, but was generally a principal cash crop in its own right. In the survey areas, beans were intercropped with either maize or sorghum. Intercropping is used as a hedge against crop failure and to increase the variety of food for a household.

Landholdings owned by farm households

The average landholding in the survey was 5.225 acres, larger than the national average of 2.1 acres (UBoS, 2014). Traditionally, it is assumed that households that farm tobacco leaf have larger farm areas and therefore experience economies of scales. In Table 4.15, the variable for land is disaggregated to represent the proportion of land owned by tobacco-farming households and non-tobacco farming households. There was a slight difference in the average size of farms, with households farming tobacco leaf having an average of 5.84 acres, compared to the 4.65 acres of non-tobacco farming households. Overall, this sample reported a total of 673.35 acres of cultivated land, 427 acres of which were growing tobacco and 246 acres were used for other crops.

Table 4-15: Total landholding in the sample by districts

Districts	Land owned by tobacco HH (acres)	Land owned by non-tobacco HH (acres)
Arua	160.5	128.35
Maracha	266.5	118
Combined sample	427	246.35

Source: Field survey data, 2014.

Fertiliser application practices

Inorganic fertilisers are multiple nutrient fertilisers with primary nutrients such as nitrogen, phosphorus, and potassium, and secondary nutrients such as calcium or magnesium. Examples of fertilisers given by farmers included NPK and LAN. Organic fertilisers included crop (green) manure, animal manure, and poultry manure. The Uganda census of agriculture for 2008/2009 indicated that 8 in 100 farm households used inorganic fertilisers, but 26 out of 100 farm households used organic fertilisers in crop production (UBoS, 2010). The agricultural census data further revealed that 50% of farm households did not use inorganic fertilisers because farmers perceived such fertilisers to be expensive (UBoS, 2010).

Table 4.16 presents the frequency distribution of crops that used the different types of fertiliser. It is important to note that not all farmers provided information about fertiliser application for all crops, particularly when intercropping legumes with sweet potatoes, sorghum, and sunflowers. Fertiliser application data for tobacco leaf, coffee, cassava, rice, and maize were available.

Fertiliser application results were in line with prior results from the agricultural census data. Other than tobacco farmers, not many farmers used inorganic fertilisers as supplementary nutrients for their crops in this sample. There was a slight difference in adoption rates among tobacco farmers, with 58 tobacco farmers reporting having applied inorganic fertilisers while 11 used organic manure on their fields. Keyser (2002) reported similar fertiliser consumption on Zimbabwean tobacco farms. Tobacco farms require intensive multi-nutrient soil supplements, particularly nitrogen. This may be the result of poor soil management practices, for instance the failure to rotate with crops such as legumes that assist in fixing nitrogen in the soil.

Table 4-16: Distribution of fertiliser use by type of fertiliser in some cultivated crops

Crop enterprises	Type of fertiliser applied		
	Inorganic fertiliser *(yes=1)*	Organic manure *(yes=1)*	Did not use fertiliser
Tobacco leaf	58	14	1
Cassava	19	17	30
Coffee	11	7	20
Maize	3	1	7
Rice	1	1	10
Beans	7	5	9
Sunflower	–	–	–
Sweet potatoes	2	3	12
Sorghum	3	2	2

Source: Field survey data, 2014.

The high application of fertiliser on tobacco farms could simply indicate that tobacco producers have economies of scale when purchasing fertilisers. They could be purchasing fertilisers in bulk at lower rates than smaller farmers. This will be examined further in the production costs section to see if there is a variation in the price of fertilisers. The most plausible explanation, however, is that much of the fertiliser was supplied by tobacco companies who enabled farmers to purchase fertiliser on credit. In fact, of the tobacco-farming households, 79% reported receiving fertiliser from tobacco companies, 5% purchased their fertiliser, and 15% used on-farm organic manures. Other crop producers applied less inorganic fertiliser and used mostly organic farm husbandry practices for their cropping systems.

Physical (harvested) output from the different crop enterprises

Table 4.17 presents the weighted average of the harvested output, amounts consumed and sold, and the percentage share of the total cultivated area. The data show that in the 2014 farming season, tobacco leaf had the highest weighted average of harvested output but the output share of harvested area was lower. Tobacco-farm households harvested an average of 1 755 kilograms of tobacco leaf during the season, with a household consumption of only 43 kgs. Farm households sold 1 712 kilograms of tobacco leaf.

It is evident that tobacco remains an important cash crop in West Nile. Out of the 427 acres of cultivatable land owned by tobacco-farming households, 73 tobacco-farm plots represented a 51% share of the total area. The weighted average of tobacco leaf production, however, was lower when compared to other crops, which was surprising because tobacco farms are equipped with more modern farm inputs than their non-tobacco counterparts.

Cassava farming, on 66 farm plots, produced an average of 941.39 kgs and households consumed an average of 84 kgs. Cassava farming ranked second after tobacco-leaf farming, occupying 12% of the reported farm land. Cassava is an important staple crop for West Nile farmers because it stores well in the soil as a famine reserve crop, withstands extreme weather conditions and performs well in marginal soils. Cassava farming seems to be evolving into a cash crop as 96% (912 kgs) of the average harvested output made it to the local food market.

Coffee farming ranked third, and 38 farm plots harvested an average of 835 kgs of coffee cherries, from average farm sizes of 1.16 acres. Coffee, however, only occupies 7% of the farmland reported in the sample. This is not surprising because much of Uganda's coffee is produced in the Central, Eastern, Western and South Western regions of the country. The emergent coffee farm plots in West Nile could either be a result of households diversifying their farmland or wanting to venture into farming a cash crop other than tobacco leaf.

Table 4-17: Weighted average of production (harvested, consumed and sold output)

Crops	Wt. Avg. production harvested (kg)	*Wt. Avg. consumed (kg)	Wt. Avg. production sold (kg)	No. farm plots	Average area harvested (acres)	% share of total cultivated area
Tobacco	1755	43	1712	73	2.97	50.75
Cassava	941	84	912	66	1.26	12.31
Coffee	835	–	835	38	1.16	6.54
Maize	443	140	833	11	1.43	2.34
Beans	509	62	533	21	1.41	4.4
Rice	495	178	519	12	0.83	1.48
Sunflower	689	11	678	10	0.69	1.02
Sweet potatoes	478	187	569	17	0.75	1.89
Sorghum	221	154	388	7	0.56	0.59

Source: Field survey data, 2014. *Wt. Avg. consumed is a representation for households that reported to have consumed some or all of their harvest.

All the coffee reported in the sample for the 2014 farming season was sold to the coffee market. Data on the types of coffee planted and harvested were not collected.

Sunflower farming had an average harvested output of 689 kgs, with much of the output (678 kg) being sold to the sunflower market. Only 11 farm plots were reported to have harvested sunflowers, with an average farm size of 0.69 acres and a 1% share of the reported farmland. Sunflower, like coffee, is an important cash crop for households that do not farm tobacco leaf.

Other crops such as maize, sweet potato, beans, rice, and sorghum reported an average harvested area of 4.98 acres and a harvested output of 2 146 kgs. These crops occupy small farm plots but have a high yielding capacity. Much of the harvested outputs from these crops is consumed at the household level as they are food staples in the study area. In the next section the focus is shifted to the relationship between farm size and the land productivity of crop enterprises.

4.3 Farm size and land productivity

Whether tobacco farms and other crop enterprises make efficient use of resources is particularly relevant for Uganda and other African countries as they consider the transition to alternative crops. Policy makers need to know what instruments to choose in order to modernise the farming sector from a subsistence-based to a market-driven rural economy. Farm size and productivity have not been extensively discussed in the context of small-scale tobacco production. A descriptive analysis of the relationship between farm size and productivity could provide insight on the extent to which tobacco and other crops enjoy economies of scale.

The analysis includes relationships between farm size, harvested output, value of production, and land productivity for each type of crop. Since the focus of this study is on crop farms, harvested acres are used to measure farm size and land productivity is measured as harvested output per unit of cultivated area. Farms were placed into three categories based on their size: small (less than 2 acres), medium (2 – 5 acres) and large (more than 5 acres). More tobacco farms were identified as 'large' than those farming other crops. Table 4.18 presents the relationship between farm size, harvested output, value of production, and productivity for tobacco farm plots.

Table 4-18: Farm size and productivity relationship in tobacco farm plots

Crop		Small farm plots	Medium farm plots	Large farm plots
Tobacco	Number of farms	28	33	12
	Average farm size (acres)	1.08	3.34	6.33
	Average harvested output (kgs/farm)	791	1916	3564
	Average value of production (USD)	874	1844	3029
	Average land productivity	849	651	570

Source: Field survey data, 2014.

Of the tobacco farm plots, 28 farms were characterised as small farm plots, 33 farm plots were medium-sized and 12 were large. The average farm sizes were 1.08 acres, 3.34 acres, and 6.33 acres respectively. Tobacco harvested output and sales increased monotonically with farm size, with the largest farms producing about four times more per cultivated area than the small farms. The harvested tobacco leaf output, together with the values of production, had a direct relationship with farm size. When descriptive statistics of land productivity by farm size are compared, the data suggest that there could be an inverse relationship between farm size under tobacco and land productivity. The data show that as farm size increases, land productivity declines, initially by 30% from small farms to medium farms, then slowed to 14% from medium to large farms.

This is a recurring finding in the literature on agricultural production and it is typically explained in one of two ways. The first is that larger farmers apply more than optimum amounts of certain inputs as a result of imperfections in the labour or land markets, or as a measurement error in farm size. Benjamin (1995) and Carletto, Savastano, and Zezza (2013) reported that errors in the reporting and measuring of farm sizes can cause a spurious negative correlation between farm size and productivity.

In this study, crop acreage was accurately measured and farmers also knew the sizes of their farm plots, but a certain margin of error cannot be ruled out, as indicated by Gourlay, Kilic, and Lobell (2017) who use GPS data but still find errors in their data. A more important explanation of an inverse relationship in tobacco farms is that tobacco farms may be characterised by diseconomies of scale for several reasons, such as imperfections in factor or output markets or a Pareto inefficient resource allocation.

Table 4-19: Farm size and productivity relationship in other crops

Crop	Small farm plots					Medium farm plots				
	Number of farms	Average farm size	Ave. harvested output	Average value of production	Average productivity	Number of farms	Average farm size	Ave. harvested output	Average value of production	Average productivity
Cassava	49	0.93	734	235	831	17	2.20	1 538	485	682
Coffee	28	0.7	489	897	691	10	2.45	1 803	3 533	731
Maize	7	0.68	194	112	324	4	2.75	877	401	251
Sweet potatoes	16	0.64	408	128	632	1	2.50	1 600	754	640
Beans	14	0.97	358	314	370	7	2.28	810	727	360
Rice	11	0.72	454	376	652	1	2	950	688	475
Sunflower	10	0.69	689	273	–	–	–	–	–	–
Sorghum	7	0.56	221	182	–	–	–	–	–	–

Source: Field survey data, 2014.

The presence of diseconomies of scale or constant costs would suggest the inability of such farms to lower costs of production while increasing production. Considering the entire distribution of land productivity, the results suggest an inverse – direct relationship across all the crop types, except coffee and sweet potato farms. An inverse relationship between farm size and land productivity also exists for cassava, maize, beans, rice, sunflower, and sorghum farms, as shown in Table 4.19, and a direct relationship was apparent in coffee and sweet potato farms.

This descriptive result is similar to the result of a direct – inverse – direct relationship that Savastano and Scandizzo (2017) report in Ethiopia. Their results further showed that less productive farms exhibited an inverted U shape relationship between farm size and productivity, while more productive farms were characterised by a U-shaped relationship. Overall the descriptive result of an inverse relationship, particularly on some alternative farms, suggest that farm size should be considered in efforts to promote alternative crop development in West Nile.

4.4 Comparative farm economic performance of crop enterprises

This section presents the comparative profitability of tobacco farms and alternative crops. The value of this section lies in the fact that it allows one to compare profitability between farm types which can, in turn, be used to motivate people to transition away from tobacco farming to other forms of farming. Tobacco farming can earn more on a per hectare basis than alternative cropping systems (Keyser, 2004).

This section explores and tests hypothesis 1: *tobacco farms have higher profits per unit of output than farms that produce non-tobacco crops.* The hypothesis is studied using calculations of gross profit per unit of harvested output across crop enterprises. The gross profit measure for crop enterprises was obtained by deducting total direct production expenditure from gross farm revenue. Gross profit margin was calculated as gross profit divided by total revenue. Gross profit margins where expressed in percentages. Due to some missing data on the use of inputs, a restricted gross profit measure was used. Farm profits are interpreted to mean gross revenue from all individual crop enterprises less total expenditure on available inputs.

Although this is not an exact accurate measure of gross profit (farm income), it was considered as a good approximation to a precise gross profit measure since, for some farmers, inputs such as fertiliser were not purchased. Net profits could not be computed because data on annualised investment costs and/or fixed costs were not available. The detailed crop enterprise budgets are given in Appendix C.

4.4.1 Farm production costs (expenditure)

As shown in Table 4.20, the cost of farming various crops forms a significant part of their total production costs, especially for tobacco leaf, coffee, and cassava farms. Table 4.20 shows the relative contributions of several variable costs to farm expenditure. Production costs typically include seedling/seed/cuttings costs, wages, fertiliser costs, chemicals (insecticides/pesticides), transport costs, firewood, jute twine, fuel pipes, cost of packaging material, and storage costs. Labour was classified as a variable cost because casual labourers in West Nile are not permanently employed.

Production costs were computed based on two measures, that is, pre-harvest and post-harvest costs. Pre-harvest costs are input costs incurred before harvesting of the crop, and include expenditure on seedlings/seeds, fertiliser, wages, and agro-chemicals. Post-harvest costs include wages (for example, for curing of tobacco leaf or sorting of coffee cherries and drying), transport costs, cash purchases for jute twine, and firewood.

The cost of farm labour was computed using the reported wage rate which varied across farm activities, perhaps because of differences in the opportunity cost of farm labour. For instance, ploughing, applying fertiliser, or harvesting had different wage rates per man-day. Farm households reported paid and unpaid family labour, but all labour was costed to the market wage rate.

The costs associated with farming tobacco leaf amounted to 54 925 USD compared to a total of 19 370 USD from all the other crops. The large quantities of fertiliser required in tobacco-leaf farming led to an increased farm expenditure volume and contributed 17% of their total farm expenditure. In addition, tobacco-leaf seedlings, usually purchased from tobacco companies and other growers, are the highest contributor to farm expenditure in tobacco farms, amounting to 52% of overall expenditure. The tobacco farms' wage bill contributes 20% of farm expenditure on tobacco farms.

Table 4-20: Contributions of various inputs to farm expenditure

Crop enterprise	Seed/seedlings /cuttings (%)	Fertiliser (%)	Chemicals (%)	Labour (%)	Others (%)
Tobacco	52.08	16.75	3.88	20.17	7.09
Cassava	20.04	31.79	9.66	32.14	6.36
Coffee	29.74	14.91	4.01	50.01	1.34
Maize	6.52	33.14	15.41	19.23	25.69
Beans	11.34	31.17	11.71	21.69	24.09
Sweet potatoes	53.26	14.43	0	32.30	0
Rice	6.67	49.66	7.97	35.69	22.09
Sunflower	79.64	0	0	20.36	0
Sorghum	3.96	70.84	6.81	18.38	0

Source: Field survey data, 2014.

A similar result was reported by Keyser (2002) in Zimbabwe. Keyser (2002) suggested that tobacco not only demands a heavy application of fertilisers, but that the crop used intensive pesticides and herbicides, and other special costs, which demanded greater cash expenditure before harvest than almost every crop enterprise they had analysed.

Transplanting and weeding in tobacco farming increased labour hours and this increased man-days and raised pre-harvest costs for tobacco-leaf farms. Pre-harvest costs were higher in tobacco-leaf farms because of other purchases, such as insecticides or pesticides, which contributed 4% of farm expenditure. According to these results, pre-harvest costs (the sum of all costs before harvesting the crop) were 89% of total farm expenditure for tobacco-leaf farms. Post-harvest costs contributed the remaining 11% in the form of significant unique costs. Farm expenditure per unit of output on tobacco-leaf farms was 0.43 USD.

Cassava production also experienced higher farm expenditures than other crops, particularly in fertiliser expenses (32%) and labour (32%). These two inputs drive most of the increases in the average production costs for cassava farms, although, as expected, labour in man-days remains lower than for tobacco. The use of fertilisers on cassava farm plots could be because cassava is mostly produced by tobacco farmers, who may be more likely to believe that higher fertiliser application provides better yields. In the case of cassava, using high inorganic fertilisers may not pay, because the output prices for cassava do not offset the much-needed margins for reducing the average production costs on cassava farms. Farm expenditure per unit of cassava output was 0.13 USD which is much lower than the 0.43USD from tobacco farms.

Total farm expenses from coffee farms were lower (6 594 USD) than for other crops such as cassava and tobacco leaf. Coffee farms had lower costs, especially for fertiliser. The greater use of manure and compost, rather than inorganic fertilisers, reduced farm expenditure. The unit cost of coffee seedlings is relatively low compared to tobacco leaf seedlings, contributing 30% to total farm expenditure. Wages contribute the most to farm expenditure on coffee farms, probably because of the post-harvest labour required for cherry sorting, pulping, and drying. Overall, coffee production had low production costs compared to other enterprises. Farm expenditure per unit of coffee output was 0.21 USD which was much lower than tobacco, but higher than cassava.

Smaller crop enterprises, such as maize, beans, sunflower, sorghum, rice, and sweet potatoes had varying farm expenditure. Sunflower farms did not report the use of fertiliser and data on family labour were also not reported. Results on sunflower farms should be viewed with caution. Maize, sweet potatoes, and rice had relatively lower farm expenses, particularly because of their low levels of application of inorganic fertiliser, which cost on average 43 USD per 20 kg bag.

Sweet potato farms only applied 3 bags of inorganic fertiliser and the rest used manure or compost. Sorghum farms had missing labour data, thus the conclusion that these farms had the lowest farm expenditure per unit of output may be incorrect. On the basis of a production cost assessment of all the crop enterprises, sunflower (0.05 USD), sweet potato (0.09 USD), maize (0.15 USD) and rice (0.13 USD) had the lowest farm expenditure per unit of harvested output.

4.4.2 Comparative profit performance of crop enterprises

The gross value of production for farms is the sum of the value of production of all farms. The value of production is the quantity of harvested output multiplied by the unit price of output. Table 4.21 presents the gross value of production (gross revenue) for the various crops. Tobacco farms had the highest gross revenue with a value of 130 209 USD. This was followed by coffee, cassava, beans, rice, maize, sunflower, sweet potato, and sorghum farms. An advantage of high harvested output is that it improves the value of crop enterprises; however, the most significant factor is the positive effect some crops experience with a higher output price. For example, cassava had a higher harvested output than coffee, but coffee had a higher value of production due to its higher output price.

Table 4-21: Comparative farm profitability across sample crops

Crop enterprises	Farm profitability indicators				
	Harvested output (Kgs)	Farm expenditure	Gross revenue	Gross profit	Gross profit margins (%)
Tobacco	128126	54925	130209	75284	57.82
Cassava	62132	7798	20397	12599	61.77
Coffee	31725	6594	56657	50062	88.36
Maize	4870	711	3750	3039	81.04
Beans	10027	1764	8881	7117	80.14
Sweet potatoes	8130	780	2691	1912	71.03
Rice	5943	775	4953	4177	84.34
Sunflower	6890	344	3158	2814	89.11
Sorghum	1547	604	1323	719	54.34

Source: Field survey data, 2014. All values in USD using the 2014 exchange rate: 1USD = 2760 UGX, except output. Total output was measured in kgs

The gross profit for crop enterprises is the sum of all gross profits for individual enterprises, as shown in Table 4.21. The profitability of tobacco farms was negatively affected by the high farm expenditure and perhaps also the low harvested output of tobacco leaf. Also, tobacco leaf commodity prices were high enough to offset its production costs.

Cassava farms had an average performance, with a gross profit margin of 62%, which was enough to cover farm expenditures. The cassava cropping system had a gross profit margin of 12 599 USD, which was negatively affected by lower output prices. Farm profits from coffee farms were positive for most individual farms owing to the high output prices. Moreover, farm input expenditure on coffee farms was only 11% of gross farm profit, much lower than that of other crops, particularly cassava and tobacco leaf. In these cases, coffee production seems to be economically attractive from a farmer's point of view.

Other small farms, for example maize, sweet potato, sunflower, sorghum, and rice farms, all had higher margins, but these should be interpreted with caution because costing of family labour was incomplete, as the cost of paid family labour was unavailable, which could affect the accuracy of the profit margins. The highest gross profit margins (89%) came from sunflower farms and the lowest ones from sorghum farms (54%). The farm performance on these farms was mainly influenced by lower harvested output coupled with lower market prices. Nevertheless, 21 farms producing beans had a gross profit margin of 7 117 USD with a farm input expenditure of only 1 764 USD. The lower costs of farming beans contributed to relatively higher gross profit margins of 80%.

The profit indicators, as presented in Table 4.21, demonstrate that tobacco leaf, with the available data on production costs and output, was unable to produce a positive profit for all farmers.

4.4.3 Sensitivity analysis on farm gross margins

As discussed in the previous section, the economic performance of crop enterprises (e.g. farm expenditure and gross profit margins) can be determined once certain factors such as farm inputs and harvested output are identified. However, the effects of these factors on the economic viability of the crops are also of importance. A sensitivity analysis which involves measuring the relative magnitudes of these effects is performed in this section.

Several studies use econometric specifications or mathematical programming models to test farmers' responses to changes in input and output factors. This section, however, uses an enterprise budget model to determine profit margins. The econometric specification for tobacco leaf supply is estimated in Chapter 5. Here, the analysis assesses how input and output prices in particular influence the economics of growing tobacco leaf and alternative crops.

The analysis simulates their variation within a reasonable range. This analysis provides information for the subsequent analysis in other chapters, for example in the estimation of the supply response of tobacco leaf in Chapter 5. A sensitivity analysis in this instance should, however, allow the study of the factors in which farmer uncertainty can affect farming decisions.

The results are presented in Tables 4.22 and 4.23 for input price and output price scenarios respectively. All crop enterprises were tested, apart from sunflower, which had no fertiliser data. For this reason the sensitivity analysis of the sunflower profit margin with changes in input prices was not computed.

Input price scenarios

Inorganic fertiliser, labour, and seedlings were strong contributors to total farm expenditure. However, among the different crops, fertiliser costs were strongly linked and contributed from 5% to 15% of the total production costs (see Appendix C). Fluctuations in fertiliser prices were selected as an important factor that needed to be assessed for their possible effect on farm profitability, given that Uganda is a net importer of fertilisers, including all its potassium requirements.

Conceptually, the effect of input prices on farm profit margins is ambiguous. For instance, the direct effect of the reduction in fertiliser use as a result of an increase in the fertiliser price is likely to be negative for tobacco leaf output, which directly affects tobacco-leaf farm profits. However, with an increase in the fertiliser price, land with low tobacco-leaf productivity can be left for alternative crops, which may increase the production of alternative crops in the country. The effect of an increase in the fertiliser price on tobacco-farm profit margins could be negative, incentivising farmers to switch to crops that require less fertiliser in order to save on input costs (for example, from tobacco to coffee).

Table 4-22: Sensitivity of farm profit margins to changes in the fertiliser price

Crop enterprise	% change in the fertiliser price			
	Typical profit Margins (%)	(±) 10% change	(±)15% change	(±)20% change
Tobacco	57.82	0.71	1.06	1.42
Cassava	61.77	1.23	1.84	2.45
Coffee	88.36	0.17	0.26	0.35
Maize	81.04	0.62	0.94	1.25
Beans	80.14	0.62	0.93	1.24
Sweet potatoes	71.05	0.41	0.62	0.83
Rice	84.34	0.78	1.16	1.55
*Sunflower	89.11	–	–	–
Sorghum	54.34	3.24	4.85	6.47

Source: Field survey data, 2014. *Fertiliser data not available

In this descriptive analysis, the aim is to explain the possible reasons for the different scales at which a change in an input price distorts farm profit margins. Table 4.22 illustrates the sensitivity of farm profit margins to several assumptions made. The farm profit margins are affected by changes in the price of fertiliser in ranges of 10%, 15% and 20%. In this instance, the farm profit margins of coffee and sweet potato are somewhat less sensitive to changes in the fertiliser price. This is because the two crops have a lower fertiliser application rate than other crops.

The profit margin of coffee and sweet potato would change by 0.17% and 0.41% respectively if there was a 10% change in the price of fertiliser. The farm expenditure differential works against the profit margins of sorghum, cassava, tobacco, and rice, but beans and maize have moderate changes in their profit margins.

A 20% increase in fertiliser price would decrease the farm profit margins of tobacco farms by 1.42%, cassava by 2.45%, maize by 1.25%, beans by 1.24%, rice by 1.55%, and sorghum by 6.47%. One other possible explanation for such varying distortions in the profit margins relates to the output price. If the crop's output price is sufficient to cover the related farm expenses, then changes in an input price have minimal effect on profit margins. Alternatively, if input prices increase disproportionately (too small in comparison) relative to market price for the crop the effect on the margins could be slight. This is reflected in coffee production, which had small changes to its profit margins because of the high price it fetches in the market.

Farm output price scenarios

Any deviations in the output price are reflected in the value of production of a crop, which consequently affects farm profitability. For example, an increase in the output price of a crop can be expected to increase the acreage devoted to that crop because farmers would have an incentive to switch acreage from other land uses to that crop.

The effect of the *expected* output price on farm profit margins can be conceptually ambiguous. On the one hand, all things held constant, an increase in the expected output price could lead farmers to increase their farm input use and adopt more productive farm management practices and crop varieties (Feng & Babcock, 2010), which increases the output of this crop and improves farm profit margins. On the other hand, the increase in the output price could also lead to greater increases in farm input expenditure, which can negatively affect farm profit margins.

In the case of this descriptive analysis, the assumption is that all farm expenditure remains constant at current prices and all output prices are influenced by external factors, such as international prices which are determined by demand and supply. Thus, an increase in the output price should have a positive effect on farm profit margins albeit to varying degrees.

Given that Uganda is a net exporter of unmanufactured tobacco leaf and coffee beans, the two crops could have strong variations in their profit margins. Enterprise budgets were analysed with the average price as the theoretical price, which was computed from seasonal prices reported by farmers. The analysis follows similar assumptions for the sensitivity analysis of farm profit margins to changes in input prices, namely 10%, 15% and 20%. Table 4.23 shows the changes in profit margins caused by output price increases, with all other factors held constant.

Table 4-23: Sensitivity analysis of farm profit margins with changes in output price

Crop enterprises	**% change in commodity prices**			
	Typical farm profit Margins (%)	(±) 10% change	(±) 15% change	(±) 20% change
Tobacco	57.82	3.83	5.5	7.03
Cassava	61.77	3.47	4.98	6.37
Coffee	88.36	1.06	1.52	1.94
Maize	81.04	1.73	2.48	3.16
Beans	80.14	1.81	2.59	3.31
Sweet potatoes	71.03	2.64	3.78	4.83
Rice	84.34	1.43	2.04	2.61
Sunflower	89.11	0.99	1.42	1.81
Sorghum	54.34	4.15	5.95	7.61

Source: Field survey data, 2014.

Farm profitability is highly sensitive to changes in output prices for most of the crops. Coffee and sunflower profit margins are somewhat less vulnerable to output price changes. This could be because of their higher harvested output per cultivated area, which allows changes in farm expenditure to be spread over a larger portion of harvested output per harvested area.

The coffee and sunflower profit margins would change by 1.94% and 1.81% if there was a 20% change in their output prices. The profit margins of sorghum, tobacco leaf, cassava, sweet potatoes, rice, maize, and beans are able to take advantage of high output prices but could also be vulnerable to low output prices. Changes in output prices do have strong effects on the profit margins of, in particular, sorghum, tobacco leaf, cassava, and sweet potatoes. If there was a 20% decrease in output prices, sorghum, tobacco leaf, cassava, and sweet potatoes would incur a drop in profit margins of 7.61%, 7.03%, 6.37% and 4.81% respectively.

The sensitivity analysis effectively captures the wider consequences of possible changes in input and output prices on farm profitability. The expected impact of changes in these two factors is suggestive and severe for crops that are mainly produced for food. In food crop productions, the high sensitivity could be attributed to the crops' lower commodity prices, which are unable to offset farm expenditure, meaning that any changes in factor or output prices can ultimately have a severe impact on farm profit. However, tobacco-leaf production does not generate sufficient gross value of production and profit margins under current prices to produce a positive profit for most tobacco-leaf farms.

The simulation further demonstrates that even in the case where the tobacco price is increased by 20%, its gross margin increases to only 65%, which is an insufficient margin to produce a positive profit for most farmers. While tobacco leaf prices can be increased by 20%, value of production seems to be suppressed at a certain level, not only because there are high costs in tobacco-leaf production but also because tobacco farms do not harvest a large enough output. The most competitive land use favours alternative crops such as maize, coffee, sunflowers, and possibly sweet potatoes. The survey found that cassava is a favoured food crop, particularly for farm households growing tobacco leaf, and could act as a complement crop.

4.5 Analysing farm households' differences and farm diversity

The first four sections have presented the results of farm households as homogeneous groups, yet farm heterogeneity exists in West Nile in several characteristics. In order to capture diversity among these farms, a farm classification which summarises farm diversity was developed (Tittonell et al., 2010; Alvarez et al., 2018; Kansiime, van Asten, & Sneyers, 2018). The purpose of this was to classify the surveyed West Nile farm households and differentiate them on the basis of their most distinguishing characteristics of farm structure. It was hypothesised that in order to determine farm diversity, the surveyed farms could be grouped according to their farm endowments and performance, highlighting variability in farm structure, crop choices, and adoption of inputs.

4.5.1 Multivariate analysis

Descriptive statistics, particularly ANOVA, were used to summarise the selected variables which were important in the characterisation of farms. For the survey dataset, the analysis used a multivariate approach which involved principal component and cluster analysis (Kuivanen et al., 2016; Alvarez et al., 2018). Principal Component Analysis was used to reduce the dataset into a few synthetic variables known as principal components. This was followed by two clustering approaches: hierarchical (Agglomerative Hierarchical Clustering) and non-hierarchical (*k*-means or partitioning). The combined clustering procedure allowed the analysis to benefit from the advantages associated with both hierarchical and *k*-means methods (Iraizoz, Gorton, & Davidova, 2007).

Clustering was applied to the outcomes of the PCA (factor scores) in order to identify clusters. The algorithm used in the hierarchical technique followed the Ward's method with squared Euclidean distance applied as a distance measure. The cluster centres (as starting values) from the hierarchical results were then clustered using the *k*-means method. Using the *k*-means algorithm on a case-by-case basis made it possible to produce the number of clusters that seemed most meaningful, as a final solution. The F-test statistic was used to evaluate differences in the principal factors between clusters in order to deduce the general farm diversification strategies and key indicators for distinguishing between farm types.

The variables used in PCA included farm household attributes (farm size, rented land, and access to finance), the costs associated with various farm inputs (seedlings, seeds, labour, and other inputs), crop output, and gross revenue. As part of the PCA results, the Kaiser criterion was 0.73, which meant that the data matrix used had sufficient correlation to justify the application of principal component analysis. The Bartlett's test of sphericity was used to check the strength of the relationship among the principal components. The Bartlett's test of sphericity was significant, meaning the hypothesis that the correlation matrix is the identity matrix can be rejected. This allowed for the conclusion that the set of variables used in principal component analysis was appropriate.

Of the seven principal components, the first three components explained between 27% and 51% of the variability in the survey dataset. The first component (factor 1) was most strongly correlated to variables related to modern inputs and labour use. These farmers used hired labour during the ploughing, planting, weeding, and harvesting phases of production. Some of the hired labour was used for the curing of tobacco leaf. The component represented a farmer who applied fertiliser in his/her fields as "a modern farmer who was labour oriented". In the context of this study a "modern farmer" is a farmer who has a significant input expenditure. The correlation with inputs such as jute twine, firewood, and fuel pipes shows that this component could represent a tobacco farmer, because such inputs are used in the curing and processing of tobacco leaf. Therefore, this component is named a *commercially-oriented tobacco farmer*.

Component two represented a farmer with a large household size, who had access to a moderately large farm land, and did not rent extra land. This type of farmer did not apply inorganic fertilisers but rather used compost and moderately applied pesticides. This farmer further did not hire non-family labour but entrusted members of the household to provide family labour to his/her farm. His/her crop output was good and positively impacted farm revenue. This component attributes 10.82% to the variation contained in variables included in the analysis. This description represents *a traditional farmer*. Component three represented a farmer who grew more than one crop on his/her farm. The farmer's crop output was good and positively correlated with farm revenue. This factor contributes 9.67% to the variation contained in variables included in the analysis. Factor 3 can be said to represent a farmer who practises *farm diversification* on his/her farm.

Cluster analysis for the West Nile farmers produced the following results: N=126, cluster 1=43, cluster 2=37 and cluster 3=59. The means were compared across farm types, using an F-test to establish whether farm differences across clusters were statistically significant. Cluster 1 contained 43 farms (35% of the total), Cluster 2 had 53 farms (43%) and Cluster 3 had 27 farms (22%). There were four main differences between the three farm types identified here. These included differences in their household structure, their crop choices, their farm endowment, input uptake, output, and their per-acre profitability. The F-test statistic for the characteristics showed significant differences across a number of variables within farm types. This implies that the farm types were significantly different from each other and hence that the indicators that were used for differentiation were appropriate.

4.5.2 Analysing farm diversity in the study area

Variability in household structure

From Table 4.24, it is apparent that these farm types do not significantly vary by age of household head. Farmers are overwhelmingly men in their forties, who are married, are heads of households, and are Lugbara speaking. Virtually all these farmers mentioned that farming is their main occupation and the vast majority of households rely entirely on agriculture for income. This confirms the descriptive analysis in the earlier sections. The average household size is nine to ten people, of which half are adults and half are children below the age of twelve. This suggests that household labour is likely to be important.

Table 4-24: Farm and farmer differences across clusters (ANOVA)

Cluster description	Diversified farms *n=43*	Traditional tobacco farms *n=53*	Specialised farms *n=27*	F-statistic
Household attributes				
Age of household head (years)	49	46	43	1.87^{ns}
% farmers who are head of household	95	92	93	0.18^{ns}
% farmers who are men	98	91	85	1.85^{ns}
% farmers, working as farmers	100	98	96	0.72^{ns}
% farmers with only primary education	65	64	41	2.53*
Size of household	10.2	9.8	9.0	0.80^{ns}
% households with off-farm income	14.0	7.5	7.4	0.65^{ns}
Selected farm endowments				
Farm (acres)	7.3	4.2	4	12.46***
Land under crops (acres)	3.26	3.15	3.93	1.72^{ns}
% farms on clan / family land	72	55	85	4.29**
% farms using tobacco company credit	44	64	19	8.45***
% farms using bank loans	40	13	56	9.42***
Crop choices				
% of farms growing each crop				
Tobacco	47	75	22	12.89***
Cassava	53	42	74	3.96**
Sweet potatoes	26	26	48	2.45*
Maize	35	43	48	0.66^{ns}
Coffee	9	2	19	3.48**
% of farms practicing mono cropping	42	45	22	2.13†

Source: Field survey data, 2014. *** signifies p ≤0.001 ** signifies ≤0.05, * signifies ≤ 0.10, †signifies ≤0.15, ^{NS} signifies Not Significant

The percentage of households with off-farm income varies between 7% and 14%. The only household characteristic which varies significantly across cluster membership is the percentage of respondents who have primary education only. This was 65% and 64% respectively for clusters 1 (diversified farms) and cluster 2 (traditional tobacco farms), and just 41% for cluster 3 (specialised farms). Although the majority of the variables comprising the household profile do not vary significantly across cluster membership, cluster 2 represents younger farmers and farmers in cluster 3 are more likely to be female, and better educated.

Household profiles already predict how each of these homogeneous groupings of farmers are likely to engage with the wider world. On the one hand, one would expect that households who already have one member working in an off-farm occupation would have better networks in the outside world. Links to the wider world may make such households more likely to experiment with modern inputs, find it easier to source and pay for modern inputs, and perhaps to have the strongest relationships with tobacco companies. On the other hand, one could say the same for members of cluster 3, who should be more likely to practice modern farming because they are better educated and thus more informed. In summary, these household profiles suggest that cluster 2 is likely to contain the most traditional farm operators.

Variability in farm endowments

In the previous section, it was argued that certain household profiles predict a greater likelihood of engaging in modern agriculture. In this section, systematic differences in farm endowments are examined for the same purpose. Farm endowments are complex. The aspects focused on (shown in Table 4.24) are farm size, tenure system, type of production system, and access to credit.

Farm size includes both owned and rented land. Renting is a common phenomenon, with most operations renting roughly half their total cultivated area. The tenure system can be communal, freehold, or clan land. Since the majority of the respondents indicated that they obtained their land through inheritance, a dummy variable was constructed where 1 = operate on clan or family land and 0 = otherwise. The majority of farmers indicated that they use credit to finance farm inputs. The two main sources of credit were own capital and advances made by tobacco companies. Two dummy variables were therefore constructed to capture whether a farmer accessed either of these two sources of credit.

Whereas there was almost no difference in household profiles across clusters, all aspects of farm endowment considered here varied significantly across clusters. Cluster 1 operates on almost double the farm size of Clusters 2 and 3, which have similar farm sizes. About three-quarters of the larger farms are on clan land. In Cluster 2, almost half of the farms are not on clan land, while in Cluster 3 the vast majority are on clan land. There is some evidence here that cluster 2 farmers might be more oriented towards modern farming, as they are not bound by clanship ties or possibly by tradition.

It is clear from the data in Table 4.25 that company credit and bank loans are complementary. Between 70% and 80% of respondents use one of these sources as the main way of financing their next crop. The proportions were similar for Cluster 1. 44% indicated that they use company credit and 40% indicated that they use bank loans. Cluster 2 farmers depend on company credit rather than bank loans, while Cluster 3 farmers are more likely to depend on bank loans than any of the other groups, perhaps because they do not have access to company credit. Company credit is only available for tobacco growing. While it is normal to think of farm endowments determining crop choices, here crop choices might determine a landholder's access to resources. The next section investigates this by examining differences in crop choice.

Coffee and tobacco are specialised cash crops in the West Nile. They also seem to be mutually exclusive on most farms, as only seven farms grew both in 2014. Coffee-growing is less prevalent than cassava cultivation in the region. Cassava has become an increasingly popular cash crop, making Uganda the sixth largest producer of the crop in Africa. In addition, farmers grow maize, sweet potatoes, beans, and rice, some for market and the rest for home consumption.

Nearly three-quarters of farmers in Cluster 1 grew tobacco in 2014. There is no clear correlation between tobacco-growing and the choice of any other crop, except cassava. Cassava-growing is negatively correlated with tobacco-growing ($r = -0.3457, p = 0.0232$). This suggests that although certain diversified farms predominantly grow tobacco, they should not be described as tobacco growers. These farms also grow coffee, rice, and sunflowers. Cassava production was positively correlated with the production of sweet potatoes ($r=0.3330, p = 0.0291$), but uncorrelated with maize-growing (r = 0.0023, p = 0.9884). It is possible that, within this group, farmers specialise in either tobacco or cassava to generate cash income.

In Cluster 2 (tobacco farms), three in four farmers grew tobacco in 2014. No other crop had this uptake and tobacco production is uncorrelated with the production of any other crop. Within Cluster 2, the production of one staple crop is associated with the production of other staples. Maize production was significantly positively correlated with cassava production (*r = 0.3340, p = 0.0117*) and sweet potato growing (*r = 0.2525, p = 0.0681*), whilst cassava production was highly correlated with sweet potato growing (*r = 0.5375, p = 0.0000*). Here the impression is that tobacco is the only cash crop of note, whilst cassava and sweet potatoes are cultivated for subsistence purposes only. It is likely that these farmers reserve their outlying fields for tobacco (and not maize) while their staples are cultivated on riparian land.

In Cluster 3 (specialised farms), there are three tobacco growers, eight coffee growers, and fifteen farmers who grow cassava. In this group, the production of staples is positively correlated with the production of other staples; maize production is correlated with the production of cassava (*r =0.401, p = 0.038*) and bananas (*r = 0.367, p = 0.059)*, while cassava-growing is correlated with sweet potato growing (*r =0.401, p = 0.038*). Tobacco production is negatively correlated with the production of all other crops, and significantly so with the production of maize (*r = -0.336, p = 0.086*), which again suggests that outlying fields are reserved for tobacco rather than maize growing. Coffee production is marginally positively correlated with sweet potato (*r = 0.304, p = 0.123*) and cassava (*r = 0.2820, p = 0.1541*) production, which suggest that these farms might have better access to reliable water sources.

Variability in crop choices and input uptake

Table 4.25 shows differences between clusters in the uptake of modern inputs such as fertilisers and pesticides, in output, and in per acre profitability. There are significant differences in the uptake of fertiliser and pesticide across clusters. In Cluster 1, 49% of farmers apply inorganic fertilisers, 16% use animal and poultry manure, while the rest (35%) do not fertilise their fields. Fertiliser expenditure varies significantly across clusters, with Cluster 2 farmers, who mainly produce tobacco, spending more on fertilisers but, interestingly, posting low crop outputs. Pesticide uptake also varies significantly across clusters, with 75% of farmers in Cluster 2 applying pesticides, 47% in Cluster 1, and only 22% in Cluster 3using pesticides.

In terms of crop output, Cluster 1 performs well compared to the other two clusters. The average crop output that farmers from Cluster 1 harvested in 2014 was 2 101 kilograms, which is significantly higher than the 1 865 kilograms of Cluster 3 and 1 386 kilograms of Cluster 2. As mentioned, Cluster 2 farmers use more fertilisers and pesticides than those in Cluster 1 and 3, which supports the argument that consumption of fertilisers in tobacco farms was higher than for other crop enterprises.

Farms in Cluster 1 are diversified farms which mainly grow tobacco leaf and may be currently experiencing a decline in their crop output, perhaps due to the lack of crop rotation or a build-up of diseases in their fields. Cluster 3, with a preponderance of cassava and coffee growers, posted a higher unit profit per acre (US$ 157) than Cluster 2 (US$ 120) or Cluster 1 (US$ 86). A lower use of fertiliser, labour, and pesticides, which translates into lower production costs, shows that the two crops (coffee and cassava) are feasible alternatives to tobacco. Cluster 2, composed mainly of tobacco farms, had a substantially higher cost of production, possibly because tobacco-leaf farming is labour-intensive and requires continuous fertilisation of the soil.

The farm classifications presented here reaffirm some of the characteristics presented earlier, but its importance is its central role in the systematic understanding and prediction of farm dynamics in tobacco-farming areas. Literature that guides the implementation of Article 17 requires a logically developed and empirically supported representation that gives a clear picture of tobacco and alternative farming systems. For the policy maker interested in promoting alternative cropping systems, questions such as: Who are tobacco farmers? Are tobacco farmers different from non-tobacco farmers? Why do tobacco farmers farm tobacco leaf? Do tobacco farmers diversify their farms? are answered by a farm classification. The classifications developed here attempt to address some of these questions. In particular, the classifications aid with (a) identifying farm types by their unique farming styles; (b) validating the farm classification with farm data; and (c) profiling the characteristics of the farm types obtained.

However, it would be foolhardy to claim that this farm classification system addresses the preceding questions in a definitive manner. Rather, the farm classification is considered an initial step towards methodical research into the focal questions that need to guide implementation of Article 17. This classification complements previous research on the behavioural differences of farmers in different farming systems (Schulman & Garrett, 1990; Chavez et al., 2010; Chavez, Berentsen, & Oude Lansink, 2012, 2014) and provides additional empirical evidence to support the existing farm classifications in Uganda (Kansiime et al., 2018).

Table 4-25: Differences in input uptake and per acre profitability

Cluster description	Diversified farms *n=43*	Traditional tobacco farms *n=53*	Specialised farms *n=27*	F-statistic
Modern Input uptake				
Fertilisers	65	83	44	6.84***
% NPK, CAN	49	53	22	
% animal manure	12	30	18	
% poultry manure	4	0	4	
Pesticides	47	75	22	12.89***
Land holdings				
Farm size (acres)	7	4	4	12.24***
Renting land (acres)	5	3	3	6.27***
Total (acre)	**12**	**7**	**7**	
Physical output (kg)				
Harvested output1	1672	1103	1272	2.60*
Harvested output2	95	209	478	30.84***
Harvested output3	334	74	115	2.01NS
Ave total	2101	1386	1865	
Harvested output (kg/ac)	175	198	266	
Gross income (US$)				
Gross income1	1184	981	892	0.69NS
Gross income2	49	96	282	45.36***
Gross income3	124	48	72	1.98NS
Ave total income	1357	1125	1246	
Unit gross income(US$/ac)	113	160	178	
Farm input expenditure (cost of production (US$))				
Seedlings	197	268	171	1.43NS
Seeds	4	10	13	9.50***
Plant cuttings	2	3	5	1.58NS
Fertiliser	53	85	24	3.34**
Pesticides	6	11	3	10.37***
Jute twine	2	5	1	10.02***
Fuel pipes	6	21	3	14.34***
Fuel-wood	10	22	5	8.01***
Hired labour	29.39	32.70	13.26	
Family labour	13	28	9	7.43***
Ave total cost of production	322.39	485.70	247.30	
Unit cost of production (US$ / ac)	27	40.48	20.61	
Unit profit (US$ / ac)	86	119.52	157.39	

Source: Field survey data, 2014. NS Not Significant; * $p<0.1$; ** $p<0.05$; *** $p<0.01$; *Notes*[2] Exchange rate: 1 US$ = 2760 UGX, 1 ZAR = 230 UGX in August 2014

In line with previous research, the results reported here suggest the presence of three farm types with distinct farming styles. With all the significant differences between farm types, the conclusion that tobacco farmers are inherently different from farmers producing non-tobacco crops, in terms of their farm endowment, crop choices, harvested output, and per acre profitability, is clear.

In terms of their household profiles, however, the differences are not clear, other than the division into diversified farms, traditional tobacco farms, and specialised farms. Farm diversification was identified and could be used as a strategy to combat risk and uncertainty, but farmers also follow farm specialisation, possibly as a strategy for sustaining farm income.

Diversified farms are more thoughtful and creative in their crop choices than other farm types. Diversified farms do not rely as heavily on fertiliser, yet they post better outputs than traditional tobacco farms. Furthermore, and similarly, they tend not to have high farm expenses. A distinctive feature of production systems in West Nile is that farms are relatively small, and households that have access to the area's fertile resources are able to farm cash-oriented crops to meet their farm household income targets.

4.6 Concluding remarks

This chapter investigated the nature of tobacco leaf and other crop production systems. Households' profiles were found to be similar across farm types, but there were slight differences in their educational attainment and household sizes. The differences in family size reflect the need for family labour and perhaps the sale of labour too. These households are also often tobacco-farming households. Productivity differences across farm sizes were reflected in the analysis. The descriptive results show the presence of an inverse relationship between farm size and productivity in most crop enterprises, while coffee and sweet potato production systems had a direct relationship between farm size and productivity. Farm heterogeneity exists in West Nile. As tobacco farmers tend to exhibit different individual characteristics relative to other crop producers, it is important that farm policy and efforts to assist farmers take this into account.

The results of farm economic performance are intriguing. Results on the profitability of tobacco-leaf farms are especially interesting for two reasons. First, tobacco-leaf farming is traditionally thought of as the area of crop farming with the most inherent economies of scale in the sense that unit costs of production are supposed to be lower. Secondly, tobacco farmers are usually contract farmers, and one would expect that such producers have the most information on the costs and benefits of the vertical integration for tobacco-leaf farming.

In West Nile, however, farmers who farmed non-tobacco crops actually made more profit per unit than tobacco farmers, with the costing of family labour included. It is important to keep in mind that profits were computed on the basis of what farmers had reported at the time of the survey. In most cases, coffee production performed better in terms of profit per kilogram of output than most other crop enterprises, though profit per unit made by other non-tobacco crops was not far behind. Furthermore, the sensitivity analysis showed the viability of non-tobacco crops in scenarios where shocks were applied to the gross profit margins.

Hence, hypothesis one of Chapter 1 is not supported: there is no basis in the data for the view that tobacco farms make higher per unit profits than do farms producing non-tobacco crops, as long as all farm labour (family and hired labour) is costed at market wage rates. The pattern of a better performance for non-tobacco farms versus tobacco farms was encouraging but needs to be kept in perspective. Despite the better performance by farms that do not specialise in tobacco leaf, tobacco-leaf farms are still able to compete with producers of non-tobacco crops if tobacco-producing farms are more efficient users of farm resources. Nonetheless, the conclusion from the profitability results was that alternative crops in West Nile could actually be more competitive for both informal (low end) and formal (high end) markets, since informal markets have recently expanded (particularly for cassava), which in turn allows producers of non-tobacco crops to expand rapidly.

Chapter 5

A double – hurdle model for tobacco-leaf supply response

5.1 Introduction

Tobacco leaf is produced by a significant number of farm households in Uganda, but there is an increasing number of farm households who do not produce tobacco. An understanding of the price elasticity and other non-price parameters that influence the supply of leaf tobacco will provide valuable information to policymakers looking to develop alternative livelihoods for tobacco farmers. However, estimating these parameters, particularly the elasticity of supply, is complicated by the presence of zero values in micro-level production survey data. This chapter compares different estimation methods for modelling tobacco-leaf supply with 'zero' observations, using the predictors of farm resources, an input price, farm output and relative price variables.

'Zero' tobacco production can occur for three distinct reasons. First, a farm household may be willing to produce tobacco, but economic factors, such as a price that is below that household's threshold price, and a shortage of resources to start tobacco production, mean that they cannot participate in farming tobacco. In this case, a higher output price or higher revenue would enable production.

Secondly, a farm household may conscientiously refuse to farm tobacco for social or religious reasons. This farm household would not farm tobacco even if the output price was high. Finally, because cross-sectional production surveys typically record production data over a short time-period, households producing tobacco infrequently may be unobserved in the farm tobacco survey. These reasons need to be considered in the analysis, and the purpose of this chapter is to examine more thoroughly and more quantitatively the direction and magnitude of farmer responses to the incentives mentioned.

The major hypothesis set forth in this chapter is that tobacco farm households, when given the opportunity, do respond to both price and non-price incentives. The research questions addressed include: what incentives determine the supply of tobacco leaf? How do tobacco farmers respond to the price of an alternative cash crop and a food crop in relation to the tobacco price? Other than price, do tobacco farmers also respond to non-price incentives, such as the output of alternative crops, resources, and possibly demographic factors?

This chapter makes two contributions to the existing literature. First, the study provides a modelling framework for using farm survey data that is often masked with zero observations. Second, this chapter more accurately identifies the characteristics associated with the supply of tobacco. The remainder of the chapter is organised as follows: the chapter discusses the existing literature on incentives to agricultural supply, before reviewing the literature on consumption, which often has the same problem of 'zero' observations, although for different reasons. It then discusses the methodological techniques used in the literature in more detail. The chapter finds that the estimate of tobacco supply response is fairly stable across model specifications, except for the Tobit model. Finally, the implications of these findings are discussed and conclusions are drawn.

5.2 Literature review

Agricultural supply response represents the response of farm output to either a change in crop price or, more generally, to agricultural incentives (Mamingi, 1996). Farm supply response can be analysed from the perspective of aggregate output, sub-sectoral output, and the production of individual crops (in this case, tobacco, coffee, and cassava). There are some issues in the specification of supply models that are not sufficiently highlighted in the literature. The emphasis in this review is on the impact of incentives on output supplied, and model specification. The first issue concerns the impact of price and non-price incentives on agricultural supply response. The second issue concerns the most suitable methodology to analyse the current data set.

5.2.1 Incentives to agricultural supply response

The literature on agricultural supply response to price and non-price parameters is vast. Important contributions in the general agricultural context include Nerlove (1958), Krishna (1963), Falcon (1964), Nerlove (1979), Askari and Cummings (1977), Barnum and Squire (1980), Bond (1983), Lee and Helmberger (1985), De Janvry and Subbarao (1986), Diebold and Lamb (1997), Rosegrant, Kasryno, and Perez (1998), Kanwar (2006), Magrini, Balié, and Morales-Opazo (2018), among others. Studies that have a focus on tobacco leaf supply include Dean (1966), Adesimi (1970), Leaver (2004), and Shahzad, Jan, Ali, and Ullah (2018).

In particular, Kanwar (2006) presents evidence using a panel dataset of six food grains and concludes that prices matter but input availability, especially of irrigation, fertiliser, and seeds, is vital. On the other hand, Rosegrant et al. (1998) analyse the effects of prices, technology, and investment on output growth for rice, cassava, corn, and soybean in Indonesia and report substantial impacts from extension and public investment.

Mamingi (1996) reviews the literature dealing with the impact of prices and other macroeconomic policies on agricultural supply, particularly in Africa, and concludes that farmers are rational and expand their production as output prices increase. Mamingi's review highlights the fact that agricultural supply is affected by a host of factors, such as the level of technology, climate, and soil quality. Mamingi (1996) also points out that for individual crops, such as tobacco leaf, the short-run own-price elasticity is smaller than the long-run elasticity. This is because factors of production are fixed in the short run and vary in the long run.

Mackay, Morrissey, and Valliant (1999) estimated the supply response of agricultural output in Tanzania and concluded that the long-run price elasticity of aggregate crop supply was unity, while the short-run price elasticity was inelastic at 0.35. Magrini et al. (2018) examine a cross-country supply response for major staple crops in Sub-Saharan African countries over a period of 10 years. Their results show that farmers respond to changes in crop prices although the magnitude of response is small and is often affected by other factors. They further find that the supply response is explained less by cross-prices for competing commodities than by the cost of inputs.

A few studies have estimated the supply response of tobacco leaf, using price and non-price parameters. Dean (1966)'s study of supply response focused on Malawian tobacco growing. He found that tobacco farmers did respond to economic opportunities, particularly for cash crops. Adesimi (1970) examined the tobacco supply response in Nigeria, measuring acreage supply response. Adesimi found that tobacco farmers responded to price incentives. Adesimi further showed that extension services were crucial to an expansion in tobacco output.

Leaver (2004) used a Nerlovian model to estimate tobacco supply in Zimbabwe. Leaver reported that the short-run and long-run elasticities of tobacco were inelastic—at 0.34 and 0.81, respectively—implying that Zimbabwean tobacco farmers are relatively unresponsive to output prices. Shahzad et al. (2018) used the autoregressive distributed lag approach to test the supply response of tobacco leaf, and their results were in line with Leaver (2004)'s results. The authors reported that tobacco output in Pakistan was price inelastic in the short run (0.55) and price elastic in the long run (1.15) (Shahzad et al., 2018).

Their findings on crops competing with tobacco indicated that any increases in the price of competitive crops led to a decrease in tobacco output. The reason that the findings of Ademini (1970) differ from those of Leaver (2004) or Shahzad et al. (2018) could be that the tobacco industry has a substantial presence in the agricultural sectors of Zimbabwe and Pakistan, but not in Nigeria.

There are determinants other than price incentives that affect farmers' decisions concerning crop supply, the omission of which in any econometric estimation of crop supply brings about omitted variable bias. One such set of factors is household characteristics, which include the age, gender, educational status, farming experience of the head of the household, and household size. In addition, farm resources, such as farmland and access to extension services, are cited in the literature as essential.

Mignouna, Manyong, Mutabazi, and Senkondo (2011) used a double-hurdle model to analyse the determinants of adopting a particular maize variety. Their results indicated that the age of the household head, household size, and access to extension services positively influence farmers' decisions to adopt a particular maize variety. Turner (2014) found that, in Mozambique, farmers' cropping decisions were also impacted by the size of the household, which is often regarded as a proxy for labour. Wood, Jina, Jain, Kristjanson, and DeFries (2014) found that social interactions, education, household size, and gender affected farmers' decisions. Katchova and Miranda (2004) reported that the educational level of the household head was the only household variable likely to influence farm decisions; educated farmers were more likely to choose a more stable and predictable form of income, such as a contract.

Some studies consider the characteristics of households to be less important in farmer decision-making. For example, Mbaye, Lagat, and Mulungu (2014) examined household factors (such as household size, gender and farming experience) in Kenya, and reported that these factors were not necessarily strong predictors of farm household behaviour. In addition, Wu, Adams, Kling, and Tanaka (2004) observed that household attributes had no effect on farmers' decisions in the Gulf of Mexico. Kurukulasuriya and Mendelsohn (2007), using data from eleven African countries, reported that resources, such as land and extension services, had a greater effect on farm decisions than household characteristics such as gender and age.

In addition to household characteristics, farm resources, support, and prices of agricultural inputs and outputs, agricultural supply is further influenced by factors such as possible physical output, input costs, and credit. The response of crops to costs and credit factors has been widely studied, but there is a gap in the literature on the effects of physical outputs of alternative crops on tobacco supply response.

This chapter will thus expand the existing literature by testing whether physical outputs of alternative crops relative to the tobacco output can influence the supply response of tobacco. Of course, the value of the output is important and hence this assumption is tested for both a cash crop and food crop. This may seem a narrow view but the viability of alternative crops is crucially important for the transition to alternative farming. If tobacco producers are not price or input-cost responsive, then planting decisions can be influenced by crop yields or harvested output of other crops relative to tobacco output. The inclusion of physical outputs of one crop relative to other crops brings into question farmers' supply responses to other crops in the absence of institutional or structural changes in their farming communities.

5.2.2 Approach to modelling agricultural supply responses with zero observations

So far, the discussion has focused on the determinants of agricultural supply, which assumes a complete dataset. This chapter would benefit from the estimation of simultaneous supply equations for tobacco leaf and alternative products, but the absence of a complete dataset limits the modelling options available. In addition, censoring, non-normality, and heteroscedasticity, which are characteristics of cross-sectional production data, further narrow the types of models that can be used.

The presence of 'zero' observations in the current dataset is not unusual. Studies of labour supply, for example, frequently show 'zero' for the number of hours worked. The literature on tobacco consumption and expenditure also has 'zero' observations. As with tobacco leaf supply, some of these zeros in tobacco consumption arise because a household is a non-smoking household. Similarly, in the labour supply literature, the zeros arise because the wage offered to people is below the reservation wage or because some people do not want to work. Both examples are analogous to the present research on the supply of tobacco leaf.

The following literature review focuses on addressing the current data issues using limited dependent variable models, which are conventionally applied in decisions about household consumption or labour supply. The model approach is based on a double-hurdle model used in a number of studies (Cragg, 1971; Jones, 1989; Su & Yen, 1996; Yen & Jensen, 1996; Jones & Yen, 2000; Aristei & Pieroni, 2008). These studies have shown the value of variants of the double-hurdle approach for microeconomic analysis. A special feature of the double-hurdle approach is that it does not require the assumption that the determinants of whether to produce are the same as the determinants of how much to produce. The double hurdle model provides a useful framework for examining the separate effects of variables on participation and the level of production. A detailed description of the double hurdle is provided in the next section entitled 'analytical framework'.

Although the use of a double-hurdle model is justified for certain problems, such as the infrequent farming of certain crops, in the case of tobacco there may be other behavioural factors, such as religious beliefs, that cause farmers to choose not to farm tobacco. Typically, the 'zero' observations are associated with non-normality and heteroscedasticity. These require appropriate treatment to avoid biased and inconsistent estimates (Amemiya, 1984, 1985). Several empirical studies, such as those by García and Labeaga (1996) and Yen and Jensen (1996), have shown the inadequacy of the standard Tobit model (Tobin, 1958) in cross-sectional analysis. The weakness of the Tobit model in this kind of analysis is connected with its failure to account for differences in the generation of 'zero' observations.

Yen and Jensen (1996) construct a double-hurdle model to analyse the determinants of alcohol demand and to allow for zeros, whilst accounting for heteroscedasticity and non-normality. The dependent variable is transformed using the inverse hyperbolic sine (IHS) transformation. The transformation is similar to taking the log of the dependent variable, but with the IHS the zero is defined. The authors compare the Tobit to the double-hurdle model and find that, in some cases, the differences in the elasticities estimated by these two different approaches is large. Jones and Yen (2000) use the double hurdle model and extend it by incorporating the Box-Cox transformation. The model, which is used to estimate beef consumption in the US, nests a range of popular limited dependent variable models. The authors' estimates in the Box-Cox specification outperform other restrictive models, implying that the Box-Cox specification provides better estimates when correcting for non-normality.

Moffatt (2005) applied the Box-Cox double hurdle model to loan default data, and found that the value of the double-hurdle approach was confirmed since the effects of certain key explanatory variables on the dependent variable were significantly different between the two hurdles. Aristei and Pieroni (2008) model tobacco consumption using several double-hurdle models. As in Newman, Henchion, and Matthews (2003), the error terms in each double hurdle are assumed to be independent of each other. Aristei and Pieroni (2008) correct for non-normality and heteroscedasticity and confirm that a Box-Cox double-hurdle outperforms all other hurdle models. This shows the advantage of the double-hurdle over the Tobit model, which would restrict the model in displaying the different directions of signs for both participation and consumption. In fact, the authors reject the Tobit model in favour of the double-hurdle model.

5.3 Analytical framework

Cross-sectional data often have peculiar characteristics that require special consideration when using the data in regression analysis. These characteristics arise from the respondents' behavioural responses or from the design of the survey. They may result in many 'zeros' being reported for the variables included in the survey. Specifically, many activities are likely to be reported by a relatively small proportion of the sample although a far larger proportion of the population engages in the activities occasionally. For example, non-tobacco growing households reported zero harvested tobacco leaf output while the rest reported positive levels of tobacco output, yet non-tobacco farming households are part of the population or sample. In other words, the sample has a mixture of observations with 'zero' and positive values. These types of variables are often regarded as censored variables (Wooldridge, 2010).

For the most part, censored variables require censored regression models, which can be of two kinds. In the first case, the variable y^* is censored above or below some value, meaning that it is not observable for part of the population. The second kind of censored regression models is when y^* is an observable choice or outcome which takes on the value 'zero' with a positive probability, but is a continuous random variable over strictly positive values (Wooldridge, 2010). For example, the amount of tobacco leaf grown by a tobacco-growing farm household is positive, with 'zero' values for farm households that do not farm tobacco. In this case, the optimal choice will be the corner solution, y. The outcome variable in this analysis does not imply a censored variable but rather a corner solution variable. It is important to note that, for corner solution applications, the issue is not data observability but the features of the distribution of y given x, such as $E(y|x)$ and $P(y>0|x)$ (Wooldridge, 2010).

As alluded to in the previous sub-section, a double-hurdle model is used to analyse farm household production behaviour in tobacco farms. Because of the existence of 'zero' observations in the dependent variable, the standard Tobit and Heckman selection models were tested for purposes of comparison with the double-hurdle model. However, as was alluded to earlier, and as will be shown subsequently, these two approaches were eventually discarded because they yielded theoretically and empirically inferior results to the double-hurdle approach.

Traditionally, a standard Tobit regression model is used to deal with censored data (Tobin, 1958). The Tobit model permits the use of all observations, including those censored at 'zero', without considering the sources of the zeros. This restriction ignores the 'zero' observations, regarding them as non-participation decisions. Using the Tobit model, therefore, imposes the assumption that all the zeros arise from other mechanisms, such as demographic characteristics of the households (Newman et al., 2003; Martínez-Espiñeira, 2006).

Heckman (1979) proposed a model that addressed the problem associated with the 'zero' observations generated by non-participation decisions, arguing that an estimation of a selected subsample, that is, the censored estimation, results in sample-selection bias. The Heckman selection model overcomes this problem by undertaking a two-step estimation procedure in which a full sample estimation is followed by a censored estimation carried out on the selected subsample.

The first step estimates the probability of observing a positive outcome, also known as the selection or participation equation. The second step estimates the level of participation, conditional on observing non-zero values (known as the conditional equation) (Dow & Norton, 2003). The Heckman model assumes that, unlike the Tobit model, different sets of variables can be used in the two equations that comprise the model. Heckman assumes that 'zero' observations arise from respondents' self-selection, which implies that all zeros are generated by the respondents' deliberate choices. As a result, the Heckman selection model is viewed as a generalised version of the Tobit model.

Like Heckman (1979), Cragg (1971) modified the Tobit model to overcome the restrictive assumption that the same probability mechanism generates both the 'zeros' and the positive values. Cragg suggested the double-hurdle model to cope with the problem of many 'zeros' in the survey data by giving special treatment to the participation decision.

The double-hurdle model assumes that observed positive values must overcome two hurdles. Cragg sets out the double-hurdle model in terms of the acquisition of durable goods: first, a household has to purchase products (not specifically durable goods) and secondly, there have to be favourable circumstances to realise this positive expenditure on durable goods.

In terms of tobacco production behaviour, this can be interpreted as follows. A non-zero tobacco production output can be observed if, first, a decision whether to farm tobacco leaf or an alternative crop is made (first hurdle), and secondly, circumstances permit the production of tobacco leaf (second hurdle). In principle, the first hurdle refers to the participation decision and the second to the level or quantity of tobacco grown (amount decision).

The Tobit model differs from the Heckman selection model and the double-hurdle in two ways. The Heckman selection and double-hurdle models recognize the process to be a two-stage decision and the two models also recognise that outcome variables are determined by selection and the amount decisions. It is also possible in these models to estimate the first and second stage equations using different sets of explanatory variables. However, the Heckman selection model, as opposed to the double-hurdle model, assumes that there are no 'zero' observations in the second step once the first-step selection is successful. In contrast, the double hurdle considers the possibility of 'zero' outcomes arising in the second hurdle from the household's deliberate choices or random circumstances. This is the main difference between the double-hurdle and Heckman selection models.

The difference between the Heckman selection model and the double-hurdle model can be best illustrated using the following example of tobacco leaf production. According to the Heckman selection model, only non-tobacco farming households can report 'zero' tobacco leaf output. The model further assumes that households farming tobacco leaf cannot report 'zero' values at all. On the other hand, the double-hurdle model assumes that 'zero' values can be reported at both decision stages. The 'zeros' reported in the first stage arise because the household produced crops other than tobacco, and those in the second stage because the household deliberately, or because of random circumstances, decided not to grow tobacco. In this regard, the double-hurdle model is an improvement on both the standard Tobit and generalised Tobit (Heckman selection) models.

In this analysis, two specifications were applied to the farm households' production of tobacco. The likelihood ratio and non-nested testing procedures were used to distinguish between the models (see Table 5.2). The double-hurdle model is found to be the most appropriate approach to modelling the production behaviour of tobacco-farm households and therefore is the only model structure outlined in this chapter.

5.3.1 The Double Hurdle – the empirical model

In the context of tobacco production analysis, the first hurdle involves the decision whether or not to grow tobacco (*participation decision*) and the second decision concerns the quantity of tobacco leaf produced (*production or amount decision*). Both hurdles of the two-stage process are assumed to be linear in their parameters (α, β), with disturbance terms v_i and u_i randomly distributed with a bivariate normal distribution. The matrices w_i and x_i represent the variables that are assumed to influence the participation and production decisions respectively. Conceptually, following Aristei and Pieroni (2008), Moffatt (2005), Jones (1989) and Pudney (1989), the bivariate model can be written as:

$y_{i1}^* = w_i\alpha + v_i$ *Participation decision*

$y_{i2}^* = x_i\beta + u_i$ *Production decision*

$y_i = x_i\beta + v_i$ if $y_{i1}^* > 0$ and $y_{i2}^* > 0$

$y_i = 0$ otherwise (5.1)

where y_{i1}^* is a latent variable that describes the farm household's participation decision (i.e. to farm tobacco), y_{i2}^* is a latent variable that describes the farm household's production decision (i.e. how much tobacco leaf to farm), y_i is the observed dependent variable (tobacco leaf output), w_i is a set of household characteristics explaining the participation decision, x_i is a set of variables explaining the production decision, and v_i and u_i are the error terms.

The positive level of tobacco leaf output y_i is observed only if the household is a tobacco-farming household and actually produces tobacco leaf (y_{i2}^*). For this reason, the double-hurdle model, unlike the Heckman selection model (Heckman, 1979) in which 'zeros' are not affected by the production decision, observed 'zero' tobacco leaf outputs as a result of either participation or production decisions. Potential tobacco-farming households may have 'zero' tobacco leaf outputs. The log likelihood function for the double-hurdle model is given as follows:

$$LL = \sum_0 ln\left[I - \Phi(w_i\alpha)\Phi\left[\frac{x_i\beta}{\sigma_i}\right]\right] + \sum_+ ln\left[\Phi(w_i\alpha)\frac{1}{\sigma_i}\phi\left(\frac{y_i - x_i\beta}{\sigma_i}\right)\right] \quad (5.2)$$

where $\Phi(.)$ and $\phi(.)$ refer to the standard normal probability and density functions, respectively. The first term corresponds to the contribution of all the observations with an observed 'zero'. It indicates that the 'zero' observations originate not only from the participation decisions but also from the production decisions. The second term accounts for the contribution of all observations with non-zero tobacco output. The probability in the second term is the product of the conditional probability distribution and the density function, which come respectively from the selection (participation) rule and from observing non-zero values (Fabiosa, 2006).

Assuming independency of the error terms, the log-likelihood function of the double-hurdle model (equation 5.2) is equivalent to the sum of the log-likelihoods of a truncated regression model and a univariate Probit model (McDowell, 2003; Martínez-Espiñeira, 2006; Aristei & Pieroni, 2008). This is in cases where the Probit model is used for the first hurdle on all observations, which is followed by the truncated regression on the non-zero observations (Jones, 1989; McDowell, 2003).

5.3.2 Model specification issues

In this chapter, different double-hurdle models are used to analyse farm household tobacco-production behaviour, with particular attention to the specification of the stochastic structure of the model. The analysis tests whether the assumption of bivariate normality, homoscedasticity, and independence of the error terms across the participation and production equations is acceptable. In the double-hurdle model, it is important to study how departures from the homoscedasticity and normality assumptions affect the estimated partial derivatives of the conditional mean functions.

Independence of errors. If the assumption of independence of error terms does not hold, it means that the participation decision dominates the production decision. This implies that no farm household is observed at a standard corner solution. If the first hurdle is successful, the standard Tobit censoring is no longer relevant, since no household would have 'zero' production level. All 'zeros' would be generated from the participation decision.

The assumption of correlated error terms allows for the possibility that participation and production decisions are taken simultaneously, which implies dependence of the error terms. If the error terms u_i and v_i are independent, the errors are assumed to be distributed as: $u_i \sim N(0,1)$ and $v_i \sim N(0, \sigma^2)$. If both decisions are made jointly (in the dependent double-hurdle model) the error term can be defined as $(u_i, v_i) \sim \mathrm{BV}N(0, \Upsilon)$

$$\Upsilon = \begin{pmatrix} 1 & \sigma\rho \\ \sigma\rho & \sigma^2 \end{pmatrix} \tag{5.3}$$

and ρ is the correlation coefficient. In other words, the conditional distribution of the latent variable is bivariate normal. The model is considered a dependent model if there is a relationship between the decision to grow tobacco leaf and the stated amount of tobacco leaf y_i. As mentioned in chapter one, the statement of theory assumes that farm household decisions are jointly modelled. In the present analysis, the error terms are assumed to be distributed bivariate normal. Economic literature often assumes that the error terms are independent, as in equation 5.2.

In this chapter, an *a priori* assumption is *not* taken on the correlation structure of the error terms. This differs from other studies (Yen & Jensen, 1996; Newman et al., 2003; Moffatt, 2005; Aristei & Pieroni, 2008). The independence of the error terms is not assumed as a maintained hypothesis. The statement of theory in chapter one assumes that farm households jointly or simultaneously make farm decisions, which implies that a double-hurdle model with dependent errors is appropriate. However, after the parameters have been estimated, a likelihood ratio test is performed to indicate the appropriateness of a model with dependent errors or one with independent errors.

Heteroscedasticity of errors. The consistency of maximum-likelihood estimates further depends on the assumption of homoscedasticity. Heteroscedasticity was suspected because weights were not introduced during the survey and so the probability of a farm household being sampled is not the same for all households. To account for the presence of heteroscedasticity, the variance of the error terms is specified as a function of a set of continuous variables:

$$\sigma_i = \exp(z_i', h) \tag{5.4}$$

where z_i' is a vector of continuous variables and h is a conformable vector of coefficients (Yen, 1993; Yen & Jensen, 1996; Newman et al., 2003; Aristei & Pieroni, 2008). The log-likelihood function for the double-hurdle model with heteroscedasticity correction and dependent error terms is written as follows:

$$LL = \sum_0 [1 - \Phi(z_i'\alpha, x_i'\beta, \rho] +$$
$$\sum_+ \left[\Phi\left[\left(z_i'\alpha + \frac{\rho}{\sigma_i}(y_i - x_i'\beta)\right)/\sqrt{1-\rho^2}\right]\frac{1}{\sigma_i}\phi(y_i - x_i'\beta/\sigma_i)\right] \quad (5.5)$$

where Φ represents the standard normal cumulative distribution function and ϕ is the univariate standard normal probability distribution function. This model hypothesises that participation and production decisions are made jointly (Atkinson, Gomulka, & Stern, 1984; Deaton & Irish, 1984; Blaylock & Blisard, 1992).

Non-normal error structure. The limitation of the standard double-hurdle model is that it is built on the assumption of bivariate normality of the unobserved error terms (Jones, 1989; Jones & Yen, 2000). If the normality assumption is violated, the maximum-likelihood estimates of the model are inconsistent (Jones & Yen, 2000; Aristei & Pieroni, 2008). This may be particularly relevant when the model is applied to a dependent variable with a highly skewed distribution, as is often the case with survey data. As suggested by Jones and Yen (2000) and Yen (1993), and as applied in Aristei and Pieroni (2008) and Moffatt (2005), one way to correct for non-normality of the error terms is to apply a Box-Cox transformation to the dependent variable which gives:

$$y_i^T = \frac{y_i^\lambda - 1}{\lambda}, \quad \text{with } 0 < \lambda \leq 1 \quad (5.6)$$

where λ is an unknown parameter. Note that the Box-Cox transformation includes, as special cases, a straightforward linear transformation $(\lambda = 1)$ and the logarithmic transformation $(\lambda \rightarrow 0)$, but normally it is expected that parameter λ lies between the two limits (Moffatt, 2005). The transformation applied to the dependent variable in the double-hurdle model creates the Box-Cox double-hurdle. The Box-Cox double-hurdle model implies the following relationship between the transformed dependent variable and the latent variables, y_{i1}^* and y_{i2}^*:

$$y_i^T = \binom{y_i^*}{0} \quad \text{if } y_{i1}^* > {}^{-1}/_{\lambda} \text{ and } y_{i2}^* > 0 \quad (5.7)$$

where y_{i1}^* and y_{i2}^* are defined as in equation 5.1. This specification relaxes the normality assumption on the conditional distribution of y_i and allows stochastic independence between the error terms of participation and production equations. The likelihood function for the Box-Cox heteroscedastic double-hurdle model with independent error terms is:

$$LL = \sum_0 ln\left[1 - \Phi(w_i', \alpha)\Phi\left(\frac{x_i'\beta + 1/_\lambda}{\sigma_i}\right)\right] + \sum_+ ln\left[\Phi(w_i', \alpha) y_i^{\lambda-1} \frac{1}{\sigma_i}\phi\left(\frac{y_i^T - x_i'\beta}{\sigma_i}\right)\right] \quad (5.8)$$

Note that equation 5.8 is not very different from the log likelihood function of the double-hurdle model (5.2). One important difference is that the use of y_i^T in place of y_i in the final term requires a Jacobian term $y_i^{\lambda-1}$ to be included (Moffatt, 2005).

5.3.3 Marginal effects in the Box-Cox model

Estimation of double-hurdle models is usually not the final stage of the analysis. This chapter seeks to determine the properties of the true model rather than those of the estimated model, and, from that, to make inferences about the true parameters. The economic interpretation of the double-hurdle model estimates focuses on the analysis of the marginal effects of regressors on the expected value of y_i (Jones & Yen, 2000), which can be decomposed into an effect on the probability of choosing to farm tobacco leaf and an effect on the conditional level of tobacco leaf production.[2] The unconditional mean of y_i in the Box-Cox double-hurdle model can be written as:

$$E(y_i) = P(y_i > 0)\, E(y_i|y_i > 0) \quad (5.9)$$

The conditional expectation of y_i is as follows:

$$E(y_i|y_i > 0) = E(y_i|y_{i1}^* > -w_i'\alpha . y_{i2}^* - x_i'\beta - \tfrac{1}{\lambda}) \quad (5.10)$$

Assuming independence between the error terms of participation and production,[3] the conditional mean is written as:

$$E(y_i|y_i > 0) = \left[\Phi\left(\frac{x_i'\beta + 1/\lambda}{\sigma_i}\right)\right]^{-1} \int_0^x \frac{y_i^\lambda}{\sigma_i}\phi\left(\frac{y_i^T - x_i'\beta}{\sigma_i}\right) dy_i \quad (5.11)$$

Given independence of the error terms, the probability of a positive production level is:

$$P(y_i > 0) = \Phi(w_i')\Phi\left(\frac{x_i'\beta + 1/\lambda}{\sigma_i}\right) \quad (5.12)$$

Marginal effects are then obtained by differentiating equations 5.10, 5.11 and 5.12 with respect to each explanatory variable.[4] From these marginal effects, elasticities are

[2] This decomposition follows the method suggested by McDonald and Moffitt (1980) for the decomposition of the unconditional mean of the dependent variable in the Tobit model.
[3] For simplicity, the notation of marginal effects is focused on the independent Box-Cox double hurdle. Jones and Yen (2000) provide the derivation of the conditional mean for the Box-Cox double hurdle with dependent errors.

derived. In particular, taking equation 5.9, the elasticity of the conditional mean with respect to regressor x_i is written as:

$$e_j = \frac{\partial E(y_i)}{\partial x_{ij}} \frac{x_{ij}}{E(y_i)} = \frac{\partial P(y_i > 0)}{\partial x_{ij}} \frac{x_{ij}}{P(y_i > 0)} + \frac{\partial E(y_i | y_i > 0)}{\partial x_{ij}} \frac{x_{ij}}{E(y_i | y_i > 0)} \quad (5.13)$$

where the two addends are the elasticity of the probability of observing a positive tobacco output level. Elasticities for categorical variables are computed as percentage changes in probability, and conditional and unconditional levels when the value of the variable moves from zero to one, holding all other variables constant (Newman et al., 2003; Aristei & Pieroni, 2008). For continuous variables, the elasticities are computed at the sample means.

5.4 Data and specifying the models

The analysis in this chapter uses tobacco physical output as the dependent variable and includes two of the most popular crops in West Nile, coffee and cassava, one a cash crop and the other a food crop. Table 5.1 displays summary statistics for the variables considered in the analysis. Variables were represented as three categories, that is, household attributes, relative physical outputs and resources, and relative prices.

5.4.1 Data construction of price and output variables

Because of the 'zero' observations as noted in the literature, there are cases of 'zero' crop outputs and prices in the current farm survey dataset. These 'zeros' are problematic for two reasons. Firstly, the 'zero' crop outputs lead to missing values after taking logs, which raises the practical problem of how to handle missing values, particularly when calculating output ratios. Secondly, the ML estimator would not allow specifications with 'zero' values. The plausible solution was to construct data and replace the 'zero' observations. Data for price ratios and output ratios were constructed for the purpose of empirically investigating the research question raised in the chapter.

To address the 'zero' observation data, an assumption is made that if a farmer in 2014 produced a given crop, the farmer would have at least produced a harvested output which is equivalent to the weighted mean of the other farmers in the sample. As such a weighted mean output is calculated in each selected crop enterprise and assign it to the 'zero' data. This approach is similar to that adopted by Anderson, Wang, and Zhao (2012)

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[4] Jones and Yen (2000) and Yen (1993) provide a detailed analytical derivation of the conditional and unconditional marginal effects for the Box-Cox double-hurdle model.

and Timmins (2006), who dealt with 'zero' crop shares in their studies. The aim is to estimate the opportunity cost of producing a crop. The resulting weighted mean for each crop output is used to replace 'zero' data for each crop output variable. For example, in the tobacco sample, the weighted mean of 1 755 kg is used to replace the 'zero' values in the tobacco output variable in cases where a relative output ratio is to be calculated. However, during estimation, the 'zero' data in the tobacco dependent variable is handled with truncation in the double hurdle.

After 'zero' observations had been treated with the weighted mean, the relative output of cassava and coffee to tobacco is then calculated, and these were expressed as the ratio of cassava or coffee to tobacco output. Other approaches were also tested. For example, the sensitivity of the crop output was explored by dropping 'zero' observations altogether. However, this produced substantially lower degrees of freedom compared to the weighted mean option. From the constructed harvested output ratio variables, it is expected that an increase in the relative outputs of the other two crops (i.e. coffee and cassava) will decrease the likelihood of growing tobacco.

In constructing the relative price variables for cassava and coffee, at least three simulation approaches were followed to test the sensitivity of the price variables[5]. These include the use of (1) a weighted mean price, (2) dummy variables, and (3) the percentile prices. Using the weighted average price follows a similar principle to that used in constructing the output ratios. In the dummy variable approach, a dummy variable was constructed for each price variable, that is to say, one would represent a household's response to a price, and 'zero' would indicate no response. The dummy approach was problematic because when the dependent variable of the first hurdle is a dummy, the tobacco dummy gets eliminated from the estimation process. In addition, this approach does not work well because the analysis uses relative prices and not absolute prices, and so the dummy approach was nullified.

Thirdly, the percentile approach used three percentile prices which included the 10th, 25th, and 50th percentiles to test the sensitivity of the results. Each percentile was tested separately. The 10th percentile price produced meaningful results, unlike the 25th and 50th percentile prices, which skewed the data, creating large variations in prices. In addition,

[5] It is important to note the price differences reported by households. This is because of differences in quality. Tobacco leaf particularly is graded from 1 to 4, each with a given price. The same applies to coffee beans. The cassava price had a small variation.

comparing the results of the 10th percentile approach to the weighted mean and dummy approaches, the 10th percentile produced a model of good fit and was therefore selected for further analysis. The relative prices of cassava and coffee were expressed as a cassava-tobacco price ratio and a coffee-tobacco price ratio. The fertiliser price variable had few 'zero' values, but the weighted mean price for fertiliser was nonetheless used for the 'zero' data. Overall, the results remained robust to these different approaches. The price variable constructs and fertiliser are hypothesised to have a negative association with the likelihood of growing tobacco leaf. To facilitate interpretation, variables are transformed into logs prior to estimation.

5.4.2 Household attributes

A long-standing debate in the farm household literature concerns the effect that household attributes may have on farming decisions. The literature does not offer any consensus on the effects of household factors. However, ignoring these effects may create bias in the model. Household factors are therefore included as control variables in all models. The household attributes estimated are: gender of the head of the household, age of the head of the household, household (family) size, and the educational level of the head of the household.

The gender variable is coded *1=male*, using female as the reference group. The majority of households in this sample are male-headed households, and the gender variable is expected to increase the likelihood of growing tobacco. This expectation is supported in studies by Carr (2008) and Peterman, Quisumbing, Behrman, and Nkonya (2011). The educational variable is categorical and is coded *1=primary*, *2=secondary* and *3=tertiary*.

There is no *a priori* expectations for the education variable, but respondents with more than a primary-level education could be less likely to grow tobacco. Level of education reflects the individual's social class and may help to explain how tobacco-production decisions vary among different social groups. Underlying the inclusion of household size in the analysis is the local preference for larger households and the perception that larger families are a source of family labour, which enables households to grow more than one crop. Moreover, family labour can be used as a resource for non-farm activities, in order to generate additional household income. Rahman (2008) and Seo and Mendelsohn (2008) find that an increase in farm household size increases farm output. *A* *priori*, household size should positively affect the decision to grow tobacco since growing tobacco is labour-intensive.

Table 5-1: Descriptive Statistics – selected variables in estimation

Variables	**Continuous variables**				**Dummy/categorical variables**
	Mean	Standard deviation	Min	Max	Percentage of farmers with dummy=1
Tobacco output (kgs)	956.43	1448.70	0	9080	
Predictor variables					
Price ratio – coffee	1.80	0.60	0.67	4.22	
Price ratio – cassava	0.37	0.11	0.16	1.00	
Output ratio – coffee	0.59	0.56	0.02	3.43	
Output ratio – cassava	0.75	0.83	0.04	4.58	
Fertiliser price (USD)	40.82	3.68	27.34	44.23	
Farm size (acres)	5.23	3.99	0.3	25	
Household size	9.85	3.92	3	32	
Farming experience	10.29	5.36	2	27	
Age head of HH	47	12.05	22	79	
Value of production (USD)	1177	1516	40.78	12243	
Gender (*male=1*)					92
Extension services (*yes=1*)					91
Educational level					
Primary					59
Secondary					36
Tertiary					5

Source: Field survey data, 2014.

Household size and age variables are continuous variables, and are included in the analysis as a control variable. Age is expected to have an effect on farm decisions. In the case of tobacco, one would expect older farmers to choose tobacco-farming over other crops, because of the long tradition of tobacco-farming in the region.

5.4.3 Farm resources variables

Resources include the availability of extension services and farmland. An increase in farm size is hypothesised to increase the likelihood of growing tobacco. The average farm size is 5.23 acres with a standard deviation of 3.99. Access to extension services is a dummy variable; it is assumed that greater access to these services will increase the likelihood of growing tobacco. Information from extension officials could have a spill-over effect to other household farming projects.

5.4.4 Model specification

One objective of this chapter is to test whether bivariate models are adequate for analysing the tobacco-production behaviour of farm households in Uganda. All double-hurdle models discussed in section 5.4 are estimated by maximizing the logarithm of the likelihood functions 5.2, 5.5 and 5.8. In addition, to test for sample selection bias that may occur in the double-hurdle model, the analysis includes the Heckman selection model. One parameter estimation challenge with double-hurdle models concerns the choice of covariates for the participation and production equations. The covariates chosen for inclusion in the two-hurdle equations do not depend on any *a priori* theory and the covariates were selected arbitrarily.

As the addition of the same set of regressors in each hurdle makes parameter identification difficult, exclusion restrictions are imposed. In estimating the double-hurdle model, the analysis starts with a specification that includes all regressors in both hurdles. Variables that were insignificant were systematically dropped, with exclusion restrictions giving higher identification reliability (Aristei & Pieroni, 2008). In empirical applications of the double-hurdle model, the first regression is assumed to be a function of demographic and social factors affecting the household's tobacco-farming decision, and so economic and resource factors are excluded from the first equation (Newman et al., 2003). The exclusion of economic and resource factors is motivated by the discrete random preference theory, in which sample selection is determined exclusively by non-economic factors (Pudney, 1989; Yen, 2005a) mentioned in Aristei and Pieroni (2008).

Economic variables are included in the participation equation. The explanatory variables considered are intended to encompass the determinants of both the participation decision to farm tobacco leaf and the production-outcome decision. The choice of these variables is based on suggestions taken from the empirical literature (Yen, 1993; Jones & Yen, 2000; Fabiosa, 2006; Alene et al., 2008; Langyintuo & Mungoma, 2008; Amare, Asfaw, & Shiferaw, 2012; Sheahan, Ariga, & Jayne, 2016; Verkaart, Munyua, Mausch, & Michler, 2017).

The inclusion of a variable in either the participation or outcome equations is justified by demographic, social, and economic incentives. In this chapter, it is postulated that the participation decisions are influenced by the number of individuals within the household (family size), the gender, age, and educational level of the household head, access to agricultural extension services, and a farmer's farming experience (number of years spent in farming).

Specific variables accounting for economic conditions and resource use are introduced in the production equation. The relative prices of coffee and cassava to tobacco are included as proxies for calculating the farm household's responsiveness to changes in other prices, as suggested by Sheahan et al. (2016). Further, household output of alternative crops is included as a proxy to verify the presence of substitution relationships with household production of tobacco leaf. A variable indicating the value of tobacco production is included in the model. This postulates that households would farm tobacco, or at least would attempt to farm tobacco, when the revenue from tobacco is high.

5.5 Interpreting results

In presenting the results, particular attention is given to the choice of the most appropriate model and to the analysis of the marginal effects of explanatory variables.

Marginal effects show the change in supply that would be induced by a marginal change in the exogenous variables, holding all other factors constant. They summarise the information given by the participation and production variables by including cases where these have opposite signs, allowing the researcher to quantify the effect of different variables. For the participation model, a number of different marginal effects can be derived, which differ in interpretation (McDonald & Moffitt, 1980).

The marginal effects include: (a) the marginal change in the probability of participating in producing tobacco leaf, as derived from the participation equation; (b) the change in desired tobacco leaf quantities, derived directly from the estimated variables in the production equation; (c) the conditional marginal effects; that is, given participation in tobacco farming, using information only for those farmers already farming tobacco leaf; and (d) the unconditional marginal effects. The unconditional elasticities of supply are derived for the entire sample (as opposed to only for those who farmed tobacco leaf) and they show the effects of variables on the observed quantities. Unconditional effects also refer to the expected change in actual quantities produced on tobacco farms and are of key policy interest and the focus of this chapter. The next section presents the initial tests for model selection after which the results are provided.

5.5.1 Model selection tests

In order to analyse the determinants of tobacco production correctly and to model household tobacco-farming behaviour, each bivariate or univariate model discussed in section 5.4 was estimated and tested against its restricted specifications by means of likelihood ratio tests (Vuong, 1989). The validity of the likelihood ratio tests strongly relies on the assumptions of homoscedasticity and normality. The distribution assumptions are also crucial for analysing double-hurdle models, since the maximum-likelihood estimator can lead to inconsistent results if normality and homoscedasticity assumptions are violated (Maddala, 1986). For these reasons, preliminary tests for the validity of the distribution assumptions are necessary (Aristei & Pieroni, 2008). The normality assumption of the residuals is tested using both the probability plots and test statistics, as presented in Figures 5.1 and 5.2 and in Table 5.2.

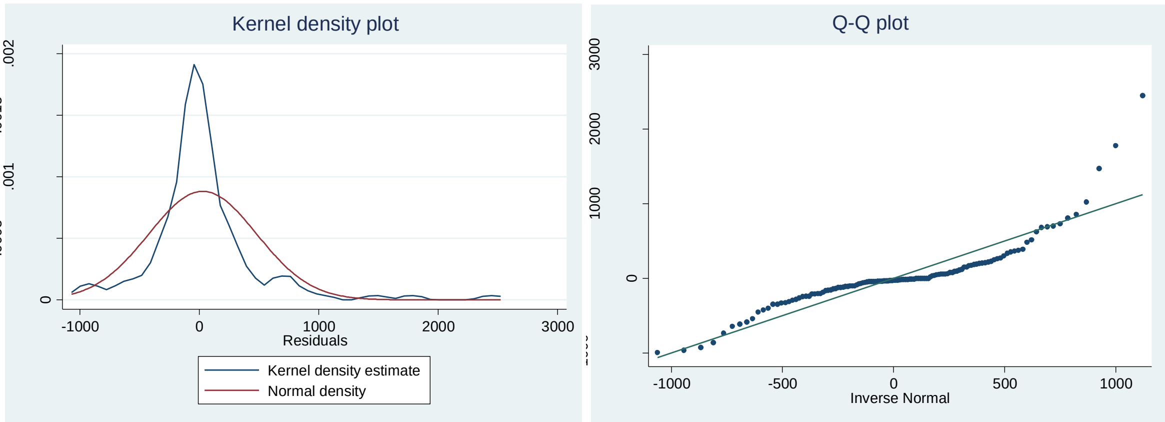

Figure 5-1: Distribution of the error term - untransformed dependent variable

As expected, the residuals from the untransformed dependent variable show a strong skewness to the left. The tail to the left, as evident from the Kernel density and quantile plots (Figure 5.1), causes us to doubt the validity of the normality assumption regarding the error terms. The null hypothesis that the disturbances in the models have a normal distribution is further tested with a Lagrange multiplier (LM) test (Cameron & Trivedi, 2010).

The LM test is supplemented by a conditional moment test (Drukker, 2002). The outcome of the two tests gives a strong rejection of the normality hypothesis. Test statistics in Table 5.3 show that both equations present the problem of non-normality, with the test statistics well above the relevant critical values in both the Tobit and double-hurdle models.

Table 5-2: Diagnostic tests

Test type	Tobit	Double Hurdle
Normality	χ^2= 44.65	χ^2= 52.39
Critical values	χ^2 (0.001,14) =36.12	
Decision	Reject H_o: Normality	Reject H_o: Normality
Homoscedasticity	χ^2= 57.43	χ^2= 52.74
Critical values	χ^2 (0.001,14) =36.12	χ^2 (0.001,7) =24.32
Decision	Reject H_o: Homoscedasticity	Reject H_o: Homoscedasticity

Source: Author's computation (2018)

The results in Table 5.2 confirm that the normality hypothesis, assumed in the standard Tobit and double-hurdle models, fails to hold for this data, which makes a non-normal generalisation of these models necessary. The results of the Tobit and double-hurdle specifications with the untransformed variable are in Appendix E. As previously discussed in section 5.4, following Yen (1993) and Yen and Jones (1996, 2000), a Box-Cox transformation of the dependent variable, relaxing the normality assumption on the conditional distribution of y_i and as special cases on linear and logarithmic transformations, is performed. As expected, the transformation reduced the skewness in the distribution of the error terms. Figure 5.2 presents the distribution of the residuals from the transformed dependent variable, showing an improvement in the skewness of residuals compared to the previous plots. Some outliers are still visible.

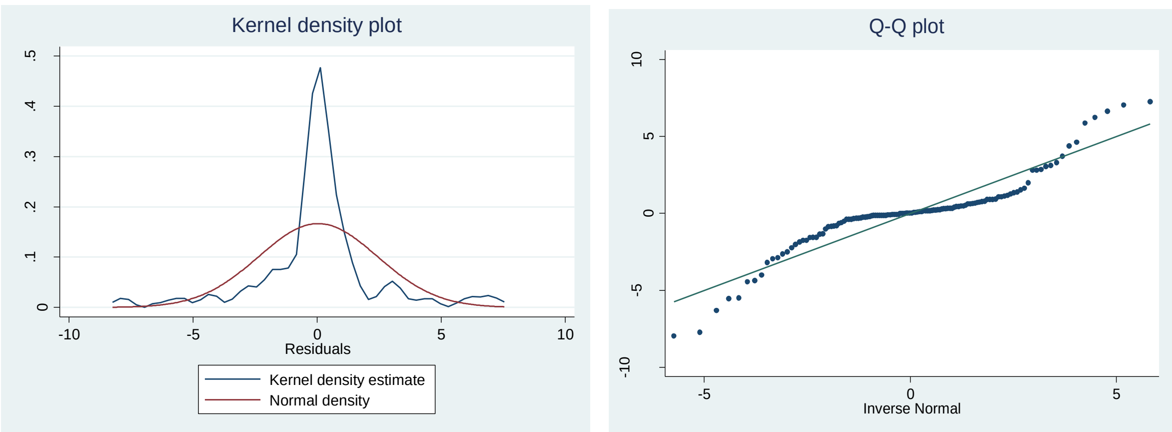

Figure 5-2: Distribution of the error term - transformed dependent variable

Aside from correcting for non-normality in the error terms, the Likelihood Ratio (LR) tests, which compare the restricted Tobit model with the double-hurdle, are carried out on both the Tobit and double-hurdle specifications. The results of the homoscedasticity tests reveal that there is heteroscedasticity, with the relevant test statistics significantly above the critical values in both the Tobit and double-hurdle models. This result violates the homoscedasticity assumption and requires its relaxation by specifying the standard deviation as a function of continuous variables in the models, as shown in equation 5.4. For this reason, all models considered in the remainder of the discussion are adjusted for heteroscedasticity and non-normality, whereas a Box-Cox transformation accounts only for non-normality.

Once the diagnostic tests of the models have been analysed, the most appropriate model can be chosen. The specification tests carried out are presented in Table 5.3. The first test analyses the hypothesis of independent error terms between the participation and production equations. The LR test ($\chi_6^2 = 20.28$ with a *p*-value of 0.210) indicates that dependency of the error terms is not important. This result is similar to the findings of Jones (1989), Blaylock and Blisard (1992), García and Labeaga (1996) and Aristei and Pieroni (2008). These authors demonstrate that the independent Box-Cox double-hurdle model is an acceptable alternative to the dependent model.

In fact, Smith (2003) explains that the relevance of the dependent double-hurdle model has little statistical information to support the estimation of dependency even when dependency is truly present. This implies that the decision to participate in tobacco farming is independent of the decision as to how much tobacco leaf can be produced.

Table 5-3: Specification tests

Models	Test type	Test statistic (χ^2)	Critical values	Decision
Box-Cox dependent double-hurdle vs. Box-Cox independent double-hurdle	LR	20.28	18.54	Reject
Box-Cox Tobit vs. Box-Cox independent double-hurdle	Vuong	256.41	36.12	Reject
Box-Cox independent double-hurdle vs. independent double-hurdle	Vuong	976.05	24.32	Do not reject
Tobit vs. Independent double hurdle	Vuong	353.96	36.12	Reject

Source: Author's computation (2018)

When the restricted Tobit model is compared to the unrestricted double-hurdle model, the likelihood ratio is 354.46 (χ^2 7 = 36.12, p < 0.001). Thus, the null hypothesis is rejected and the restricted model is true. All the other restricted specifications are rejected, each with a p-value less than 0.001. The conclusion from these results is twofold. First, they suggest the inadequacy of the univariate Tobit specification for modelling tobacco-production behaviours, given the existence of separate participation and production decisions. Secondly, the results give further support to the generalised specification that accounts for non-normal error terms. Consequently, the model that best rationalises tobacco production data is the independent Box-Cox double hurdle model.

5.5.2 Maximum Likelihood (ML) Heteroscedastic Double Hurdle results

Maximum likelihood estimates of the models are presented in Table 5.4. The estimated parameters are reported for both the standard and Box-Cox double-hurdle models in order to account for their differences, although the discussion of results in subsequent sections focuses on the latter model. The covariance parameter is not statistically significant, confirming the result of the LR test that the independent Box-Cox double hurdle model is to be preferred to the dependent model. The likelihood ratio chi-square of 423 (*df*=14) in the standard model and 386 (*df*=14) in the Box-Cox model, both with a p-value of 0.000, tell us that the two models are statistically significant. That is, the models fit significantly better than a model with no predictors. The Pseudo R^2 is 63% for the Box-Cox model, indicating that the Box-Cox model explains the data better than the standard model (20%). The farmland variable has an effect on the conditional variance (σ_i) of the heteroscedastic equation, which confirms the earlier LR test for the presence of heteroscedasticity.

Before interpreting the results, it is important to highlight what they represent. The vector of coefficients reflects the participation and production decisions, as illustrated in equation 5.1. ML estimates in the double-hurdle model are not interpreted in the same manner as those from an OLS estimation because the double-hurdle estimates are based on the latent outcome variable (production output). However, the sign on the coefficients provides an intuitive interpretation of the factors determining tobacco production. The results are, however, better interpreted with the elasticity results presented in section 5.5.3.

Turning to the explanatory variables, not many household characteristics were significant in the tobacco farming participation equation. Economic factors were significant and had varying signs. The gender of the head of the household was significant in both models and had a negative sign with farming tobacco.

Table 5-4: ML estimation of the heteroscedastic double-hurdle models

Variables	Heteroscedastic Double-Hurdle Model			Box-Cox Heteroscedastic Double-Hurdle Model		
	Participation equation	Production equation	Het.	Participation equation	Production equation	Het.
Age of HH head	-0.179 (0.468)	0.196 (0.205)	-	-0.179 (0.468)	0.289 (0.299)	-
Gender (*male=1*) of HH head	-1.085** (0.630)	0.008 (0.172)	-	-1.085** (0.630)	0.005 (0.251)	-
Education of HH head						-
Secondary level	-0.270 (0.319)	-0.185* (0.114)	-	-0.270 (0.319)	-0.262* (0.167)	-
Tertiary level	-0.045 (0.323)	0.090 (0.164)	-	-0.045 (0.323)	-0.129 (0.240)	-
Farming experience of HH head	0.007 (0.024)	0.001 (0.008)	-	0.007 (0.024)	0.002 (0.012)	-
Extension services	0.203 (0.296)	0.023 (0.160)		0.203 (0.296)	0.036 (0.236)	-
Family size	0.747* (0.493)	0.092 (0.103)	-	0.747* (0.493)	-0.130 (0.149)	-
Fertiliser price	-	0.012* (0.007)	-	-	0.017* (0.010)	-
Farmland	0.076 (0.224)	0.031 (0.059)	-0.312* (0.215)	0.076 (0.224)	0.044 (0.086)	-0.312* (0.215)
Output ratio – coffee	2.083*** (0.672)	-1.633*** (0.181)	-	2.083*** (0.672)	-2.307*** (0.267)	-
Output ratio – cassava	-0.907** (0.390)	0.464*** (0.136)	-	-0.907** (0.390)	0.679*** (0.198)	-
Price ratio – coffee	-1.208** (0.612)	-0.339** (0.219)	-	-1.208** (0.612)	-0.495* (0.318)	
Price ratio – cassava	-	2.693*** (1.130)	-	-	3.939*** (1.647)	-
Tobacco production value	0.827*** (0.237)	-	-	0.827*** (0.237)	-	-
Number of observations	125			125		

Pseudo R^2	20%	63%
Wald χ^2 statistic	423 (df=14)***	386 (df=14)***
Log pseudolikelihood	-495.38	-73.14

Source: Field survey data, 2014. $^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$

There was a reduced probability that the household would produce tobacco if the head of the household were male than if the head were female. This result could imply that male heads of households were more concerned with off-farm activities, such as working as causal labourers or even as civil servants and were less engaged with farming priorities of the household. The result should not imply that male farmers were less interested in tobacco farming.

The results for the education variable imply that if the head of the household had a secondary or tertiary level of education, there was less probability of that household farming tobacco than if the farmer had only a primary level education. This could imply that farmers with higher education qualifications were employed mostly in off-farm activities and farming tobacco was perhaps their secondary and not primary source of income. The result should, however, not imply that persons with higher education qualifications are not interested in farming tobacco.

The output of alternative crops, relative to the output of tobacco, also had varying signs. The output of coffee relative to the output of tobacco had a significant and positive relationship with tobacco farming in the participation equation and a significant and negative relationship in the amount equation. The positive relationship in the first stage of the decision-making process could imply that households found the decision to farm both tobacco and coffee appealing and perhaps profitable. Because farm households are typically risk averse, they would decide to farm both crops in case of a bad harvest in one crop. But since both crops are cash crops and inputs, particularly for tobacco, are substantial, farmers ended up paying more attention to one crop, which affected production of the second cash crop, hence the negative relationship in the production equation. On the other hand, the output of cassava relative to the output of tobacco had a significant and negative relationship with farming tobacco in the participation models.

The prices of alternative crops relative to the price of tobacco had varying relationships with farming tobacco. The price of coffee relative to the price of tobacco had a significant negative relationship with farming tobacco in both models. The result implies that if the price of coffee relative to the price of tobacco increased, the probability of that household farming tobacco is reduced. While the elasticity is presented in section 5.5.3, the current result suggests that coffee and tobacco are competing crops or substitutes. This makes sense because both are export crops.

The price of cassava relative to the price of tobacco had a significant and positive relationship with farming tobacco in the second equation. This implies that if the price of cassava relative to the price of tobacco increases, the probability of farming tobacco increases. The explanation for this could be that, since cassava is a food crop, the cassava price was less relevant, compared to the tobacco price, which made it less likely to influence tobacco farmers, hence the probability of farming tobacco increased even if the cassava price increased. This might be a pure coincidence, rather than indicative of a structural reason. Also, the elasticity result could be different.

The input price (fertiliser price) had a significant and positive effect on tobacco farming, particularly in the second step of the decision-making process. In the first step, the effect remained positive but was not statistically significant (hence it was dropped), particularly in the Box-Cox model. The result shows that if there was an increase in the input price, this increased the probability of farming tobacco. In the present study, however, tobacco farmers do not experience a direct impact of any change in the fertiliser price because they do not purchase fertilisers directly from the market. Farmers receive their farm inputs from tobacco companies and only pay the cost at the end of the farming season. For this reason, changes in the price of fertiliser may not influence a farmer's decision greatly. They can in fact increase tobacco production even with increases in the fertiliser price.

This result is unexpected, because theoretically any increases in the input price negatively impacts on farmers' decisions to farm, especially to farm a crop that requires significant amounts of farm input. But conceptually, the effect of input prices on supply response is ambiguous. For instance, the effect of a reduction in fertiliser use as induced by an increase in fertiliser prices is likely to be negative for tobacco production. However, with an increase in fertiliser price, farmland with low productivity may be converted to other crops so that highly productive land is reserved for tobacco production, which may increase the average harvested output for tobacco. The effect of an increase in the fertiliser price on tobacco production could be negative if it leads tobacco farmers to switch to alternative crops that require less fertiliser in order to save on input costs.

Tobacco's production value had a significantly positive relationship with farming tobacco in the participation model. The result showed that if the tobacco value of production increased, the probability of farming tobacco increased.

5.5.3 Elasticities

As indicated, the magnitudes of the ML estimates in the double-hurdle model are not clearly interpretable, especially where parameters have opposite signs in the two hurdles. For this reason, the effects of explanatory variables are better explored by computing elasticities which explain the probability, conditional mean, and unconditional mean of production. For continuous variables, these are computed at the sample means of selected variables. The elasticity of the probability of having produced tobacco indicates how a variable affects the likelihood (probability) of producing tobacco leaf, while the elasticity of the conditional mean of tobacco measures how a variable affected the production output conditional on a farmer having participated in tobacco-leaf farming, that is to say, given that a decision was made to farm tobacco. The elasticity of the unconditional mean of tobacco thus indicates the overall responsiveness of a farm household's output to a change in the exogenous variable.

For statistical inference, the standard errors of all the elasticities were computed (Su & Yen, 1996; Spanos, 1999). Estimated elasticities and discrete effects for categorical variables are presented in Tables 5.5 and 5.6, respectively. Most elasticities were significant at the 10% level of significance or lower. Elasticities are computed from the Box-Cox double-hurdle model; standard errors are in brackets. Among the household characteristics, only the size of the family is statistically significant with tobacco output supply. The result shows that in West Nile, an increase in family size increases the likelihood of farming tobacco by at least 1.06%.

Analysing the effects of the physical output of alternative crops relative to the output of tobacco shows that the elasticities of coffee and cassava output relative to the output of tobacco are statistically significant with varying signs. The elasticity of coffee output relative to tobacco output suggests that households with a higher coffee output relative to tobacco output were more likely to farm tobacco. However, for tobacco-farming households, a higher coffee output relative to tobacco output means lower tobacco production, on average. The level of coffee output relative to tobacco output positively affects the unconditional mean of tobacco production, revealing that, for all households, higher coffee output relative to tobacco output means more tobacco produced. A possible explanation for this result could be that, since both crops are export crops, risk-averse farmers who specialise in both coffee and tobacco would produce both crops if coffee production increases.

Table 5-5: Elasticities with respect to continuous variables

Variables	Probability $P[y_i > 0 \mid x]$	Conditional level $E[y_i \mid x, y_i > 0]$	Unconditional level $E[y_i \mid x]$
Age	-0.441 (1.174)	0.124 (0.128)	-0.316 (1.159)
Farming experience	0.052 (0.158)	0.002 (0.014)	0.054 (0.155)
Family size	1.068** (0.581)	-0.032 (0.037)	1.035** (0.577)
Fertiliser price	–	0.081* (0.050)	0.081* (0.050)
Farmland	0.194 (0.218)	0.007 (0.013)	0.201 (0.218)
Output ratio – coffee	0.799*** (0.219)	-0.155*** (0.016)	0.644*** (0.218)
Output ratio – cassava	-0.437** (0.152)	0.057*** (0.016)	-0.380*** (0.152)
Price ratio – coffee	-1.413*** (0.511)	-0.101* (0.065)	-1.515*** (0.510)
Price ratio – cassava	–	0.166*** (0.069)	0.166** (0.069)
Production value – tobacco leaf	3.451*** (0.789)	–	3.451*** (0.789)

Source: Field survey data, 2014. *$p< 0.1$, **$p< 0.05$, ***$p< 0.01$

The effect of the cassava/tobacco output is negative on the probability of farming tobacco and the unconditional mean of tobacco production, and positive on the conditional mean of tobacco production. This result implies that households that produced more cassava output relative to tobacco output were less likely to farm tobacco. A possible explanation for this relationship is that, in West Nile, cassava is an important staple food. Even in the presence of food markets, rural tobacco farmers' food security is best assured by food self-sufficiency. As a result, even with better output for tobacco, farmers would rather prioritise producing food for their households than producing a cash crop.

The effect of prices of alternative crops relative to the price of tobacco was also hypothesised. The coffee price relative to the price of tobacco has a negative effect on the conditional mean of tobacco production, the probability and unconditional mean. A 10% increase in the price of coffee relative to the price of tobacco decreases the quantity of tobacco produced by 1%, conditional on tobacco production. In terms of the probability to farm tobacco, a 10% increase in the relative price of coffee to tobacco decreases the likelihood by 14%. The result on the unconditional mean indicates that a 10% increase in the coffee price relative to the tobacco price would reduce the quantity of tobacco produced by

15%. The result differs from those of Magrini et al. (2018), who report that cross-prices are less important in explaining the supply response. This result implies that if the price of coffee relative to the tobacco price goes up significantly at a time when other prices are constant, there might be a corresponding decrease in tobacco production. The result also reveals the existence of a significant substitution effect between coffee and tobacco.

This result is comparable to those reported in the literature. A previous study by Shahzad et al. (2018) on tobacco supply, based entirely on time-series data, indicates that a 10% increase in the price of a competing crop causes tobacco production to fall by 2.6% in the short run. However, the result is contradicted by results from Askari and Cummings (1977) and Leaver (2004), who report that tobacco farmers in Malawi and Zimbabwe respectively were relatively unresponsive to tobacco leaf prices which could also be the case with this sample. Since here, relative and not absolute prices are used.

The price of cassava relative to the price of tobacco has a positive effect on the conditional mean and the unconditional level of tobacco production. The result suggests that a 10% increase in the price of cassava relative to the tobacco price increased the quantity of tobacco produced by 1.6%. Both elasticities on the conditional and unconditional level of tobacco production further reveal the existence of significant characteristics of a joint product between cassava and tobacco, with tobacco production rising as cassava production increases. The result confirms that cassava is not a cash crop like coffee, and therefore does not compete with tobacco. It is therefore possible that majority of tobacco farmers in this sample also specialise in cassava production.

Even though the variable for 'value of production of tobacco' was excluded from the quantity equation, its elasticities for the probability of farming tobacco and the unconditional mean of tobacco production are calculated. The elasticity with respect to the production value has positive and significant effects for the two components. The results show that for households participating in tobacco production, a 10% increase in the production value of tobacco increased the likelihood tobacco production by 34% in both the unconditional and probability equations. The literature suggests that increases in gross income are associated with increases in the supply response (Rosegrant et al., 1998; Kanwar, 2006; Klasen, Priebe, & Rudolf, 2013).

The effects of discrete and categorical variables are presented in Table 5.6. The education variable has a statistically significant negative effect on the conditional mean of tobacco production.

Table 5-6: Effects of discrete and categorical variables

Variables	Probability $P[y_i > 0 \mid x]$	Conditional level $E[y_i \mid x, y_i > 0]$	Unconditional level $E[y_i \mid x]$
Education			
Secondary level	-0.187 (0.221)	-0.029 (0.019)*	-0.217 (0.216)
Tertiary level	-0.025 (0.188)	0.014 (0.027)	-0.040 (0.189)
Gender *(male=1)*	-0.700 (0.425)*	0.001 (0.028)	-0.669 (0.246)**
Extension services	-0.131 (0.177)	0.004 (0.026)	0.135 (0.175)

Source: Field survey data, 2014. $^{*}p< 0.1$, $^{**}p< 0.05$, $^{***}p< 0.01$

The result confirms its ML estimate and follows a similar explanation that if heads of households who participated in tobacco farming had a secondary level of education, they were less likely to farm tobacco than heads of households who had a primary level of education, *ceteris paribus*. This implies that more educated individuals are more aware of their off-farm social networks and perhaps do not spend all their hours of labour on tobacco farming. This may be because tobacco farming to these farmers is a secondary and not a primary source of income.

Analysing the effect of household head's gender, it can be seen that gender has a significant effect on the probability of farming tobacco and on the unconditional level of tobacco farming. The result suggests that if the head of the household is male, the probability of farming tobacco is reduced than if it was a female-headed household. The effect on the unconditional level of tobacco production suggests that, if all households had a male-headed household, this would reduce the quantity of tobacco produced compared to if they were all female-headed households. In other words, female heads of households are more likely to farm tobacco and to produce more tobacco than households headed by males. It does not necessarily imply that male heads of households do not enjoy farming tobacco, it could mean that male heads of households are engaged in other activities than female respondents.

5.6 Discussion of results

The results indicate that price and non-price elasticities of tobacco leaf supply are important determinants of crop production. Tobacco production responds significantly to all three domains of incentives, that is, some household characteristics, gross revenue, price and output incentives, and farm resources. The price of fertiliser is less important empirically. Even in the absence of other important variables such as biophysical factors, these factors have an impact.

On the basis of these results, there is good reason not to reject the hypothesis that expected gross revenue, prices of alternative crops relative to tobacco, the harvested output of alternative crops relative to tobacco output, and selected household characteristics have a significant effect on tobacco production. Although all factors are equally important, the discussion here focuses on the price elasticities of supply, elasticities of output, and revenue elasticity. This is because these are policy variables and thus have implications for policy decisions. It is difficult to formulate policy around household factors. Two main findings of this analysis are summarised in the sub-sections below.

5.6.1 Tobacco farmers are capable of responding to staple food and cash crop prices and output from alternative crops

The results of this analysis show that the structure of the decision-making process in farming tobacco is independent but, more importantly, farmers interpret market signals and respond to the prices of staple food and cash crops. The cross-price elasticities show that higher prices for alternative cash and subsistence crops discourage farmers from growing more tobacco. There are two possible reasons for this.

First, the fact that smallholder tobacco farmers are not subjected to supply control programs for any crop enables tobacco producers to respond swiftly to changes in the expected price of any competing alternative crop. If higher prices are offered in the coffee market, farmers will allocate more land to coffee. Coffee also provides an interesting analytic complement. Coffee is the major cash crop in Uganda, and there is a high coffee production component – perhaps as much as 75%. In addition, coffee is grown under more varied geographical conditions. If coffee prices are deliberately changed through, for example, a price policy or an export subsidy, households farming coffee would benefit, gradually decreasing the dependence on tobacco leaf. However, this could lead to overproduction of coffee, if not well managed.

Second, food security needs are an important consideration in rural farming production decisions. Any measure or effort to expand production must simultaneously address farmers' food requirements. This was evident in the negative output elasticity of cassava relative to tobacco but also the weak inelastic value on the cassava price. Because the two crops often are planted in the same farming periods, to protect against food insecurity, prices may be incidental to cropping patterns, and the acreages of these two crops may change in relation to total acres.

As mentioned earlier, cassava remains a staple in the study area, and thus a competitive relationship might not be expected between tobacco and cassava, because the former is often sold for cash. The harvested output of cassava relative to tobacco was negative and statistically significant, suggesting that if cassava output goes up (relative to tobacco output) this is associated with a decrease in tobacco output. This result could imply that tobacco farmers in West Nile are risk-averse, which relates to the fundamental issue of food self-sufficiency in rural farming communities.

5.6.2 The production value of tobacco and farm resources enable the supply of tobacco

The strong evidence of a positive association between the value of tobacco production (gross revenue) and tobacco production itself is consistent with findings in the literature. The positive association arises primarily from farmers earning better prices for tobacco than for subsistence crops. Even if the variable for farmland is not significantly associated with the tobacco output, revenue is related to tobacco. Intrinsically, having more land under tobacco production allows farmers to benefit from higher outputs which lead to higher revenue. Because having more farmland is correlated to tobacco production, it captures the change in revenue associated with tobacco prices, which translates into better revenue, thus the positive association of tobacco and revenue.

The point here is much as the variable, farmland, is not statistically significant, land is crucial in tobacco production and should not be considered lightly. But at the same time, if other competing crops are in place, dependence on tobacco could be diminished by crops that can generate better farm revenue. This fact is reflected in the negative elasticity of the coffee price relative to the price of tobacco. The important question is, can tobacco acreage change with changing output prices? In different studies, literature shows that better crop prices are associated with acreage stability. This implies that if tobacco farmers continue receiving better crop prices, they will maintain stable tobacco acreage. In addition, this suggests that the decision to farm a cash crop is of paramount importance to tobacco-farming households.

It has been shown that the practice of farming tobacco is rational and justified on economic grounds as long as crop prices are in line with the incentives facing the farmer. If the price of a competing crop increases, it is likely that tobacco production will fall. But the implications of these results should not be overstated; for example, a price policy for alternative crops aimed at aiding farmers to transition to alternative crops could be disruptive and inefficient in the short run. Instead, support for the transition to other crops could be extended to a wider base spectrum of cash crops, such as cotton and tea, so that tobacco farmers can increasingly move to a farming system that does not depend entirely on tobacco farming.

It would appear that, in view of the effect of alternative crop prices on tobacco farming, policies of land use or even land reform that support alternative crops would be ideal. However, this could force the fragmentation of farms. As Hayami (2010) points out, coercive reforms aimed at the breaking down of farms are likely to be inefficient. Land reform cannot help farmers to switch from tobacco to alternative crops, because tobacco farmers earning higher crop prices will earn higher returns on their land and farm capital. In fact, the constraint on acreage under tobacco does not hold. The income gain from land is determined by how one additional dollar in revenue from a higher crop price translates into farm income.

Thus, policy should support an enabling environment for the expansion of an alternative cash-crop system. This would involve two key elements. The first element is developing a widespread and reliable cash-crop base, or export crops, that will ease farmer dependence on tobacco leaf and improve returns for farmers. This can be achieved with strong service delivery in government extension service programs. Secondly, since the results show that tobacco farmers are responsive to a cash-crop price, a policy support structure for all cash crops is necessary. This can be in the form of an export subsidy. More importantly, this should be applied to cash crops that can thrive in a tobacco-farming agro-ecological zone such as West Nile.

5.7 Concluding remarks

'Zero' data is common in survey data and the use of limited dependent variable models is often called for. However, misspecification in parameterisation and distributional assumptions can lead to inconsistent estimates. The chapter develops a model that allows flexible parameterisation and distributional assumptions. The Box-Cox heteroscedastic double-hurdle model nests the standard double-hurdle model with the generalised Tobit model. To facilitate estimation of the Box-Cox model, the analysis presents the relevant score functions. The Box-Cox specification is shown to outperform all the nested models that have been extensively used in the empirical literature.

The chapter finds that the structure of the decision-making process in tobacco farm households may be independent. The selected demographic or household-specific factors play important roles in determining household tobacco production. Emphasis is put on the economic incentives of tobacco supply. Policy measures should be taken to support more cash crops since an increase in the output price of a cash crop leads to a decrease in tobacco output.

At the same time, policy should not neglect other incentive elements such as improving the outputs of alternative crops. Indeed, in West Nile in particular, non-price factors are equally if not more important than the output price. One such factor is the production value of tobacco. This analysis is useful both for the supply-side policies related to tobacco control and for agricultural policy on rural development. The results can be used as a first step for the definition of recommendations to identify effective incentives to assist tobacco-farm households.

In addition, the methodology gives insight into the different modelling pathways and the critical factors that influence the decision-making processes that farmers use when deciding to farm tobacco. The model considers tobacco production but is equally applicable to other microeconometric analyses, such as the supply of other crops in which the dependent variable is censored.

Chapter 6
Efficiency analysis of tobacco and alternative farming

6.1 Introduction

The performance of tobacco-leaf production, whether viewed in terms of factor productivity, technological progress, or simply the ability of tobacco farmers to utilise farm resources adequately, can be viewed as the Achilles' heel of tobacco control research, particularly for Article 17. Some studies have indicated the poor performance of tobacco farming and attributed it to the high cost of production and a polarised value chain that is obstructed with monopsony behaviours from the private sector (National Institute for Tobacco-Free Kids, 2001; Makoka et al., 2017). These studies have mostly advocated a transition from tobacco to alternative crops. And yet, tobacco farming remains resilient because the crop pays well, is drought resistant and storable, and the industry is willing to extend production credit (Natarajan, 2017). Under these circumstances it is unlikely that current tobacco producers will change crops willingly.

Whether conventional studies by the National Institute for Tobacco Free Kids and Makoka et al. (2017) or Natarajan's more revisionist view are correct is of considerable practical importance. Equally important is the unanswered question of *is tobacco farming efficient when compared to alternative crops?* The chapter ultimately examines why or if these farms differ in their relative efficiency, because this aspect remains crucial to several debates concerning the potential structural changes and supply response of tobacco leaf, and the competitiveness of feasible alternatives. The results are important for policy aligned to Article 17, and to the farmer, the tobacco control expert, and the policy maker.

The objective of this chapter is to investigate farm economic efficiencies for tobacco and other crop types, with the aim of building a conceptual picture of farm efficiencies in rural tobacco-farming communities. This chapter examines the following research questions: Are tobacco-farming households efficient users of resources? Is there a systematic difference in efficiency between tobacco growers and others? Could farmers that grow other crops become as efficient as those growing tobacco? And, are there factors that deter tobacco growing households from farming alternative crops.

The debate on the appropriateness of agricultural support is tested by dummies that represent extension services and training received with efficiency. This tests whether agricultural support benefits efficiency. Other factors that could influence farm efficiency are also investigated, such as farming system practices, land tenure, and household characteristics. The hypothesis for his chapter is that tobacco leaf farmers/farms are more efficient in using farm resources than alternative farming for comparable scales of farm operation, all other things kept equal. This hypothesis is supported by the fact that tobacco farmers derive efficiency gains from farm input support; hence their efficiency advantage is fully established before they start farming.

6.2 Literature review on efficiency, measurement and application

The literature review section presents an overview of the concept of efficiency, the different approaches used to measure efficiency, and empirical studies on efficiency. The review is intended to provide an understanding of efficiency analysis and to clarify the framework for the analysis.

6.2.1 The concept of efficiency and frontier models

The concept of efficiency is explained using a production function, which is defined as the maximum output that can be produced from a specified set of inputs available to firms (Battese, 1992). The benchmark is set by firms that produce the highest output for a given bundle of inputs or do so at the lowest cost, which is why Coelli (1995) describes frontier models as bounding functions. In the economic literature, the work by Debreu (1951) and Koopmans (1951) informed the initial discussions on productivity measurement.

This was extended by Farrell (1957) who proposed a way to measure productivity and efficiency. Figure 6.1 illustrates concepts of efficiency and productivity. If a farm uses two inputs, defined by point C in Figure 6.1, to produce a unit output of y, the ratio OQ/OC measures technical efficiency and defines the ability of a farm to maximise output from a given set of inputs, which implies that the farm is technically efficient. Technical efficiency takes on values between zero and one and therefore provides an indication of technical inefficiency. The technical inefficiency of the farm is represented by $1 - OQ/OC$, which also measures the proportion by which quantities of inputs can be reduced without reducing the output y.

A farm that is fully technically efficient would lie on the efficient isoquant, that is, point Q and would take on a value of 1.

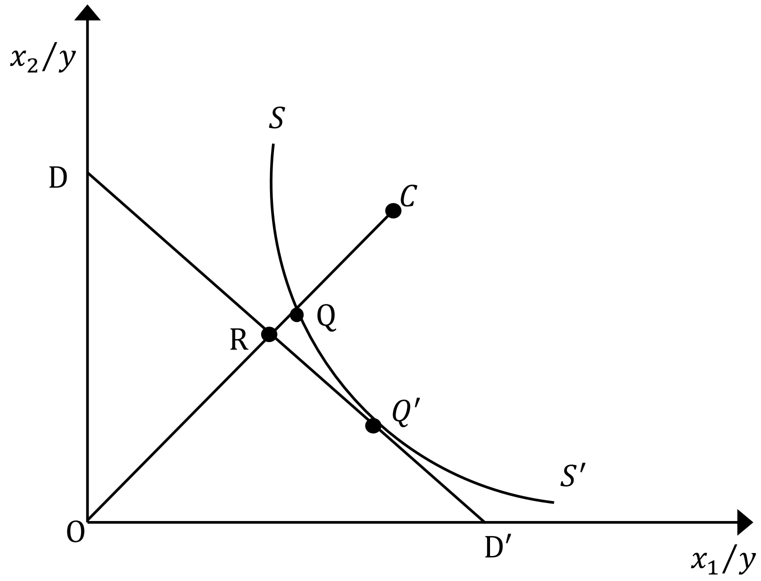

Figure 6-1: Technical, allocative and economic efficiencies according to Farrell's framework

Farrell (1957) argued that the unit isoquant can provide a set of standards for measuring allocative efficiency, which is also defined as price efficiency. If the input price ratio, which is represented by DD' is known, the allocative efficiency of the farm can be calculated. Farrell defined allocative efficiency (AE) as the ratio OR/OQ. The allocative efficiency of this farm is its ability to use inputs in optimal proportions, given their respective prices at point C. Thus, allocative inefficiency would be calculated as one minus the ratio OR/OQ. The distance RQ represents a reduction in a farm's production costs that can be attained if production is achieved at point Q'. The point Q' is reached if a farm is technically and allocatively efficient, other than at point Q which is when a farm is technically efficient but allocatively inefficient. Lastly, the cost efficiency of the farm is defined as the ratio of input costs with associated input and thus the ratio OR/OC measures cost efficiency, which Farrell also refers to as overall or economic efficiency.

Prior to the work of Farrell (1957), efficiency was measured by interpreting the average productivity of inputs and then constructing efficiency indices. The approach suffered from several shortcomings. The use of the least squares method to estimate the production function was criticised as inconsistent with the definition of the production function. This was because the estimated functions captured the mean response rather than the maximum output for the quantities of inputs used (Schmidt, 1985). This criticism led to the development of theoretically-founded frontier methods.

Frontier models improve on mean response functions in several ways. First, the results from a frontier model are strongly influenced by the best-performing firm and therefore the frontier reflects the technology set that the most efficient firm uses. Average functions only reflect the technology set used by an average firm. Secondly, frontier functions provide a useful performance benchmark against which the efficiency of other firms within the industry can be measured (Lau & Yotopoulos, 1971). These advantages have led to a wide application of the frontier approach in applied economic research (Piesse, Von Bach, Thirtle, & Van Zyl, 1996; Alene, 2003; Conradie & Piesse, 2015).

6.2.2 Approaches to the measurement of efficiency

The next choice is between parametric and non-parametric methods and here there are two considerations, which are related. If outliers are likely to cause problems, it is safer to opt for stochastic frontier methods which generate statistical significance levels on the coefficients of the production function. Stochastic frontier models come in many varieties, some of which allow for productivity estimates to be time variant while others can explain the efficiency residual with firm and environmental characteristics (see Coelli and Battese (1996); Coelli (1995)). All of them require a specific functional form which must be the same for all firms in the sample. This is the second potential problem.

If a sample includes firms that follow radically different production methods from each other, the result will be lack of significance on the coefficients of the production frontier (Van Biesebroeck, 2007, 2008). If there is reason to believe that firms employ different technology sets, for example tobacco growers and non-tobacco growers, it will be better to opt for a non-parametric method which defines productivity as the ratio of a linear combination of outputs over a linear combination of inputs. The standard approach is Data Envelopment Analysis (DEA), a linear programming routine that fits a convex hull around fully-efficient firms (Charnes, Cooper, & Rhodes, 1978). Farms that are not dominated are labelled 100% efficient. Domination occurs when another farm, or a linear combination of farms, produces more of all the outputs using the same input bundle, where inputs are aggregated using the same weights (Van Biesebroeck, 2008).

6.2.3 Empirical studies on efficiency measurement

Ever since the pioneering work of Farrell (1957), which showed how productive efficiency can be measured, researchers have searched for factors that influence farm performance. Identifying an appropriate methodology for measuring farm efficiency and policy factors that affect farm efficiency has been a great challenge. In agricultural economics, the DEA approach has found favour although stochastic frontier methods have been rising in popularity. This section reviews a selection of DEA studies, and the next section includes all productivity studies on Ugandan agriculture.

6.2.3.1 Empirical studies in agriculture

A summary of the DEA studies that are reviewed here is presented in Table 6.1. These include Piesse et al. (1996); Townsend, Kirsten, and Vink (1998); Chavas, Petrie, and Roth (2005); Alene, Manyong, and Gockowski (2006) and Conradie and Piesse (2015). Studies from Europe and the United States are also included. Piesse et al. (1996) used the DEA methodology, together with a regression analysis, to measure technical efficiency. Their work applied variables such as farm output, labour, land, seed, and fertiliser to smallholder maize farms from the former Northern Transvaal homelands. Their results showed that the DEA technique yielded large differences in efficiency across the selected study regions. Farm size and technical efficiency explained almost half of the differences in efficiency. Land constraints were the primary source of farm inefficiency.

Using DEA, Townsend et al. (1998) studied the relationship between productivity, returns to scale and farm size in the wine industry. Their frontier included a single output and seven input variables and reported that 50% of wine grape producers experienced constant returns to scale, approximately 10% had increasing returns to scale, and 40% had decreasing returns to scale. Increasing returns to scale were caused by the limited scale economies in processing and marketing. One important finding was how misleading it was to generalize the presence of an inverse relationship between farm size and productivity.

Chavas et al. (2005) applied the DEA approach in The Gambia and determined the farm household efficiency of 120 households. Their results showed that the mean technical efficiency ranged from 0.895 to 0.995. Farm households were less allocatively efficient, with a mean of 0.512 in Sanyang, 0.551 in Sinchu, and 0.639 in Pirang.

Table 6-1: Summary of studies applying Data Envelopment Analysis and parametric methods

Authors	Modelling	Empirical application and country of the study	Main results
Chavas and Aliber (1993)	Output, family labour, hired labour, animal expenditure, crop expenditure, and other miscellaneous inputs	Crop and livestock/efficiency/ United States	Economic losses are often generated by allocative inefficiencies and scale inefficiencies. The majority of farms exhibit at least one form of inefficiency.
Piesse et al. (1996)	Land, yield, labour, seed, and Fertilisers	Crop/productivity and efficiency/ South Africa	Technical inefficiency exists across selected regions, and the sources of inefficiencies include inadequate farm sizes.
Townsend et al. (1998)	Output, fertiliser, herbicides, pesticides, labour, machinery, vineyard improvements, and land	Crop/scale efficiency (returns to scale)/South Africa	Productivity does not have an inverse relationship with farm size; for example, it appears to be feasible to farm wine even on 7ha.
Thiele and Brodersen (1999)	Labour, land, capital, and other inputs	Crop and livestock/Efficiency/ Germany	Farms in East Germany are reported to have lower overall efficiencies than West German farms. Inefficiencies in East German farms are due to sub-optimal input allocation.
Lansink, Pietola and Bäckman (2002)	Output, capital, land, labour, with a sample size of 4027	Crop and livestock/efficiency/ Finland	The authors report that organic farms are more efficient than conventional farms. This is because organic farms use fewer productive technologies than conventional farms.
Dhungana, Nuthall, and Nartea (2004)	Labour, output, land, seed price, mechanical labour, fertiliser and other inputs	Crop/efficiency/Nepal	Technical inefficiencies are reported in the study and these are due to the improper allocation of resources, such as fertilisers.
Chavas et al. (2005)	Land, labour and capital	Crop/technical efficiency/The Gambia	Technical inefficiency as well as scale inefficiency exists. Sources of inefficiency are labour market imperfections.
Atici and Podinovski (2015)	Land, labour cost, costs of production, capital expenditure	Crop/efficiency and trade-offs/Turkey	They report that the use of VRS and CRS models may lead to a poor efficiency frontier. However, production trade-offs improve their

			results dramatically.
Conradie and Piesse (2015)	Output, grazing land, labour and purchased inputs	Livestock/productivity and scale efficiency/South Africa	Farm overall efficiency varies substantially across farms, which shows that farms can improve. Almost half the farms were technically efficient, implying that different farms had different coping mechanisms under financial pressure.
Guesmi and Serra (2015)	Land, labour, fertilisers, pesticides, seeds and capital	Crop and environmental /efficiency/Spain	Their findings suggest that average technical efficiency for sampled farms was 93%. Farms can reduce their input use by 7% without affecting their output levels.
Studies from Uganda			
Obwona (2006)	Value of tobacco, labour, fertiliser, land	Crop/efficiency	There was potential in improving efficiency for tobacco farmers because some farmers operated at 45% level of efficiency
Bagamba, Ruben, and Rufino (2007)	Output, labour, cultivated area, organic manure	Crop/efficiency	Substantial inefficiencies in cooking bananas at a lower elevation
Hyuha, Bashaasha, Nkonya, and Kraybill (2007)	Cultivated land, labour, capital	Crop/technical efficiency/allocative efficiency	Rice farmer in the eastern and northern regions of Uganda did not operate on the profit frontier due to low levels of education, limited access to extension education and services.
Bukenya, Hyuha, Molnar, and Twinamasiko (2013)	Output, pond size, feed, labour	Aquaculture/efficiency	Presence of inefficiency was noted in pond fish production, particularly for small-scale farmers that operated below the frontier. efficiency was associated with access to extension services, credit and keeping records
Abass et al. (2017)	Farm size, cassava cuttings, fertiliser, labour, tractor services	Crop/efficiency	Mechanised cassava processing improved production efficiency among farmers through better access to markets and cassava sales.
Kansiime et al. (2018)	Value of production, cultivated land, input costs of fertiliser, seeds	Crop/ efficiency	Use of seed, labour, fertiliser and cultivated land showed positive effect on output

Alene et al. (2006) measured the efficiency of intercropping systems of annual and perennial crops in southern Ethiopia. Alene et al. (2006) reported that the average technical efficiency of farms was 0.91 and this was the result of farmers' efficient use of land and other resources through innovative cropping systems. In South Africa, Conradie and Piesse (2015) applied the DEA approach to a livestock setting, and undertook the productivity benchmarking of free range sheep farms in the central Karoo. Their frontier results identified twelve efficient farms. The authors reported a correlation of total productivity with production costs, net farm income, and family history. More importantly, pure technical and scale efficiencies were highly correlated with overall technical efficiency.

Of studies outside Africa, Chavas and Aliber (1993) constructed a non-parametric frontier and examined technical, allocative and scale efficiency in the United States. The frontier in Chavas's analysis included 545 farms with cropping systems that included crops and livestock. Crop inputs included hired labour, family labour, repairs, seeds, fertilisers, and pesticides. Results from the study showed that the majority of farms had at least one form of inefficiency. Farms experienced economic losses due to scale inefficiencies. However, the study found that technical inefficiencies were minor. Surprisingly, small-scale farmers experienced more economies of scale than large-scale farm operations.

In Germany, Thiele and Brodersen (1999) used a DEA approach and determined differences in farm efficiency in market-transitioning economies. Their results identified farm differentials between two regions in terms of scale and technical efficiencies. Atici and Podinovski (2015) used a dataset with 374 respondents from the Turkish ministry of agriculture, and identified production trade-offs between different crops. Guesmi and Serra (2015) evaluated the economic and environmental performance of farms in Spain. Their study measured the performance of Catalan arable crop farms and used DEA, but slightly extended the approach to include stochastic conditions.

6.2.3.2 Recent empirical studies of farm efficiency in Ugandan agriculture

Table 6.1 shows a summary of recent studies undertaken in Uganda using mostly parametric methods to estimate efficiency.

Obwona (2006) analysed the determinants of the technical efficiency of small- and medium-scale tobacco farmers and the effect of demographic, socio-economic, and institutional characteristics on technical efficiency. Obwona's study used a stochastic production frontier approach. The results showed that tobacco farms operated at a 45% level of efficiency, which indicated that tobacco farms had room to improve their performance. The results on socio-economic and institutional variables showed that technical efficiency improved with access to credit, extension services and the education of the head of the household. The provision of farm inputs by tobacco companies also improves efficiency. It would be interesting to compare Obwona's results and this study, to see the effects of parametric versus non-parametric modelling.

Bagamba et al. (2007) analysed technical efficiency in a banana production system with the aim of assessing the effect of improved banana cultivars, and estimated technical efficiency using a stochastic production frontier. This study accounted for the effects of soil nutrient and farm practices, such as the application of animal manure, on farm efficiency. The study also incorporated the effects of farm size, education, household size, and market access. Their findings showed that there were substantial inefficiencies in the production of bananas, but suggested that education of the household head improved technical efficiency, particularly in highland areas. Market access was reported to reduce efficiency, but access to credit and household size were found to be positively associated with efficiency.

A study by Hyuha et al. (2007) incorporated the aspect of allocative efficiency and estimated profit losses from a rice production system. They used a stochastic profit function to estimate efficiency and their results showed that rice farmers did not operate on the profit frontier. The study reported that inefficiency was due to the low educational level of farmers and limited extension services to them. This study showed that extension services are a significant factor in efficient producer behaviour. Off-farm employment, however, had a positive association with farm efficiency. Farmers who had links to non-farm activities were more likely to be efficient with their resources. But the study concluded that a sound education and the provision of an extension system were key factors to be considered when forming policy.

Bukenya et al. (2013) studied the efficiency of resource use among fish farmers and applied a stochastic production frontier approach. The estimated index of resource-use efficiency showed that fish farmers were inefficient in resource allocation. Their results further suggested that policy-targeting variables, such as access to extension services and credit, were associated with technical efficiency. Sibiko, Ayuya, Gido, Mwangi, and Egerton (2013) measured economic efficiency in the production of beans in the eastern region of Uganda. They applied a stochastic frontier cost function to a sample of 580 farm households. Their findings were similar to those of earlier studies and showed that economic efficiency in bean production was at 60%, and was positively associated with the value of assets, off-farm income, and credit, but negatively associated with a farmer having only primary education.

Abass et al. (2017) undertook a comparative study between farmers who had adopted a mechanised farm practice in cassava processing and those who did not use it. They specified a translog production function and reported a mean technical efficiency of 0.69 and 0.52 for mechanised and non-mechanised farms respectively. Socio-economic factors in this study were also important in determining efficiency. The results showed that level of education, membership in farmers' associations, and access to markets were negatively associated with technical inefficiency, which confirmed their *a priori* expectation. The explanation given for this was that any increases in the selected factors would lead to a decline in the level of technical inefficiency, and thus the variables had a positive association with technical efficiency in cassava production.

Finally, the study by Kansiime et al. (2018) applied a stochastic production frontier to a group of farm types and assessed their farm resource use efficiency. Their results showed that farm-specialised farms exhibited farm inefficiencies, particularly in labour and fertiliser, compared to diversified and off-farm specialised farms. Technical efficiency was also positively associated with extension services and market access. The study therefore recommended that interventions should focus on extension services and market access to improve farm efficiency.

Based on the above studies in the Ugandan context, two points are noted. First, all parts of Ugandan agriculture experience a degree of inefficiency, explained to a large degree by market access and extension support. The extension services factor will be examined in detail in the analysis that follows. Secondly, almost all efficient estimates for Ugandan agriculture have been generated with stochastic frontier models which treat all variation as measurement error. It is known that, in agriculture, climate variation can save or destroy a crop, and so to ascribe all variation to measurement error misses a potentially important part of what explains the variation in observed farm efficiency. Therefore, the analysis that follows employs DEA, which ignores measurement error, in order to allow the full effect of environmental variation to surface.

6.2.4 Literature on the determinants of (in) efficiency

The purpose of the efficiency analysis is, in most cases, not only the computation of scores of farm performance, but also the characterisation and analysis of the causes of the observed farm performance. This should have a theoretical foundation. The two competing hypotheses are that farm performance is determined mainly by agency and structural factors (Mathijs & Swinnen, 2000) or that human behaviour, and hence performance, is shaped by institutions, such as the law or informal and formal rules and regulations (Williamson, 1988).

Agency factors include characteristics of the farm household, such as the age of the farmer, farming experience, schooling, and family size. The most common agency factor investigated has been human capital. Martin and Alejandro (2016) tested for the effects of education and the experience of microenterprise entrepreneurs on efficiency. They found that both education and experience have a significant positive effect on the level of efficiency. Stefanou and Saxena (1988) concur. Their results showed that both education and experience were significant factors and that they were substitutes for each other.

Earlier studies by Welch (1970) and Huffman (1977) treated human capital as a factor of production and attributed the productive value of education to two different phenomena. The first is the allocative effect that enhances a farmer's ability to acquire and decode information about farm inputs. Huffman (1977) emphasised the improved ability to search for information and optimally allocate resources that comes from experience. This is the second effect. Together they are capitals in the sense that they are costly to acquire and yield a valuable stream of services over a period of time.

Structural factors are often divided into on-farm and off-farm structures. The most prominent on-farm structures examined include agri-environmental conditions such as climate, rainfall, soil quality and access to water. One can even include access to markets and transport networks in this list, although some would classify these to be off-farm structural factors. Several authors have reported that certain regions or land forms confer an advantage. Davidova et al. (2002) found a benefit associated with being located in the Navarra region while Hadley (2006) and Iraizoz, Bardaji, and Rapun (2005) reported that the mountainous areas of the United Kingdom and Spain are less productive than flat lands.

Other off-farm structural factors include land tenure rights, the policy environment, institutional factors and farmers' social capital. Security of land tenure leads to better long-term investment choices. Performance gains from better terms of trade can lower average costs of production (Gorton & Davidova, 2004) and farms can benefit from a backward transmission of scale economies from the downstream sector via improved contractual arrangements with agents. By altering incentives, farm input subsides could affect farm decisions and future market structures. Hughes (2000), for example, argues that smallholder farm operators benefit from favourable institutional environments with supply and marketing opportunities which reduce transaction costs. This is the case in the tobacco industry where large firms reach out to smallholders with production credit and market contracts. Hughes (2000)'s study tested the effect of farm support on efficiency, while also controlling for age, education, farming experience, the land tenure system and farming practices.

6.3 Analytical framework

The approach here is semi-parametric. In stage 1, a non-parametric DEA model generates efficiency scores which are used to run a second stage parametric model. Tobit is needed in stage two to deal with the non-normal distribution of efficiency scores.

6.3.1 Input-oriented DEA models

The input-oriented DEA models use linear programming to construct a non-parametric frontier over the data, and efficiency measures (technical, allocative, and cost efficiency) are then calculated relative to the surface. In this analysis, the input-oriented DEA frontier was computed following two models, which included the constant returns to scale frontier and variable returns to scale, as proposed by Charnes et al. (1978) and Banker, Charnes, and Cooper (1984), respectively. The purpose of the input-oriented DEA frontier is to construct a non-parametric envelopment frontier over the data points, such that all the observed points lie below or on the production frontier.

A discussion of the DEA framework starts with the input-oriented constant returns to scale model. The analysis assumes a set of observations of farms in a sample that uses K inputs and M outputs from N farms. For a given farm, these are represented by the vectors x_i and y_i respectively. The K x N input matrix, X, and the M x N output matrix, Y, represent the data of all N farms. With the assumption of constant returns to scale (CRS), the input-oriented DEA frontier was defined by the solution to N linear programs which is written in the form:

$$\begin{aligned} &\min_{\theta,\lambda} \theta, \\ &\text{subject to } -y_i + Y\lambda \geq 0, \\ &\theta x_i - X\lambda \geq 0, \\ &\lambda \geq 0 \end{aligned} \tag{6.1}$$

where θ is a scalar and λ is an Nx1 vector of constants. The value of θ is an index of technical efficiency for the given farm and does satisfy the condition $0 \leq \theta \leq 1$, with the value of 1 indicating a point on the frontier. Based on Farrell's definition, this implies that the particular farm is technically efficient. Hence, $1 - \theta$ computes how much the farm's inputs can be proportionally reduced without any loss in farm output.

The constant returns to scale assumption is only appropriate when all farms operate at optimal scales (Coelli, Rahman, & Thirtle, 2002). Farm constraints, such as imperfect competition and access to credit, could cause a farm not to operate at an optimal scale. If the CRS assumption is followed when farms are not operating at their optimal scale, the technical efficiency measure is confounded by scale efficiencies and the measure of technical efficiency would be incorrect. The use of a VRS frontier permits a calculation of technical efficiency without the scale efficiencies. With the variable returns to scale (VRS) assumption, the CRS linear programming problem can be modified by adding the convexity constraint: $N1'\lambda = 1$ to equation 6.1, which produces an input-oriented VRS model written in the following form:

$$\min_{\theta,\lambda} \theta$$

$$\text{subject to } -y_i + Y\lambda \geq 0,$$

$$\theta x_i - X\lambda \geq 0, \qquad (6.2)$$

$$N1'\lambda = 1$$

$$\lambda \geq 0$$

where N1 is an Nx1 vector of ones. This method forms a convex hull of intersecting planes which envelops the data points more tightly than the CRS conical hull does, and thus provides technical efficiency scores which are greater than or equal to those obtained with the CRS model (Coelli, 1996; Coelli, Rao, O'Donnell, & Battese, 2005). Scale efficiencies were also calculated from the VRS DEA models by decomposing technical efficiency scores from VRS DEA into scale efficiency and pure technical inefficiency. Scale inefficiency of farms is identified if there are differences between the CRS and VRS technical efficiency scores for a given farm (Coelli et al., 2005).

Because the study's survey dataset has input price data, it was possible to compute a behavioural objective which was based on cost minimisation, because the analysis followed an input-oriented approach. If the output-oriented approach was used, it would have been appropriate to compute a revenue maximisation objective. Using cost minimisation, both technical and allocative efficiency measures were decomposed. Considering a VRS cost-minimisation problem, the input-oriented DEA model presented as equation 6.2 is computed to obtain technical efficiency. The cost-minimisation DEA problem is written as follows:

$$\begin{aligned} &\min_{\lambda x_i^*} w_i\, x_i^*, \\ &\text{subject} -y_i + Y\lambda \geq 0 \\ &\qquad x_i^* - X\lambda \geq 0 \\ &\qquad N1'\lambda = 1 \\ &\qquad \lambda \geq 0 \end{aligned} \tag{6.3}$$

where w_i is a vector of input prices for a given i^{th} farm and x_i^* is the cost minimising vector of input quantities for the i^{th} farm given the input prices w_i and the farm output levels of y_i. This is computed through linear programming and the total cost efficiency (CE), also referred to as economic efficiency, of the i^{th} farm would be calculated as follows:

$$CE = \frac{w_i' x_i^*}{w_i' x_i} \tag{6.4}$$

The measurement of cost efficiency, as represented by equation 6.4, was computed by dividing the minimum cost by the observed cost and was further used to calculate allocative efficiency by dividing cost efficiency by technical efficiency:

$$AE = \frac{CE}{TE} \tag{6.5}$$

TE is the θ obtained from equation 6.2. This approach includes slacks into the allocative efficiency measure but it is justified on the basis that slacks reflect an inappropriate input mix (Ferrier & Lovell, 1990). The analysis was implemented using Data Envelopment Analysis Program version 2.1 by (Coelli, 1996).

6.3.2 Tobit regression model for determining farm inefficiency

In stage two the variation in efficiency scores is explained with a Tobit model populated with selected structural, institutional and agency variables. A Tobit model is needed because efficiency scores are bounded between 0 and 1, which implies that the distribution of the efficiency scores is censored above from unity (Greene, 2018). Estimation with an ordinary least squares (OLS) regression would lead to biased estimates, since OLS regressions assume a normal distribution and homoscedastic distribution of the disturbance and the dependent variable (Greene 2018, p.768). The model (Tobin, 1958)[6] is specified as:

$$E_I^* - \sum_J \beta_i x_i + v \qquad (6.6)$$
$$E_I - 1 \quad \text{if } E_i^* \geq 1$$
$$E_i - E_i^* \quad \text{if } E_i^* < 1$$

where E_I is an efficiency score, and $v \sim N(0, \sigma^2)$ and β_i are parameters which are of interest to the study (Amemiya, 1984). Marginal effects are derived from the Tobit regression coefficients.

6.4 Data and construction of variables

6.4.1 Data used in Frontier and Tobit analysis

This section provides a description of all variables used for the analysis. The output variables were the quantities of all crops produced per household and were measured in kilograms. Inputs included area harvested (in acres), labour, representing total man-days worked (hired and family labour), and purchased inputs such as fertiliser and seeds, seedlings, and planting stock. Tobacco-producing households have additional inputs, such as jute twine, fuelwood, and fuel pipes.

The subset of production variables used in the frontier analysis is summarised in Table 6.2. The analysis computed separate farm efficiency measures for each type of crop farm and later included an analysis at the household level. The decision to include the unit of analysis at a farm plot level was motivated by the existence of important differences in farm input usage across the different types of crops. The results of the frontier analysis are reported as mean percentages, the coefficient of variation, and the number of efficient farms and households. The coefficient of variation adjusts the standard deviation by dividing by the average, which gives a measure of relative rather than absolute dispersion.

Thirteen variables were considered for the second stage procedure (Tobit models) together with the single variance of analysis tests. This is in Table 6.3. The three Tobit models explain efficiency scores, with farm and farmer characteristics. Farmer characteristics include experience and educational level. Age is in years for the head of household, who is assumed to be the farm decision maker. The expected sign on age is not predetermined; older farmers are more

[6] Amemiya, T. (1984) surveys the applications of the Tobit model and provides the origins of the model.

experienced, which could benefit productivity, but they also tend to be more poorly educated and set in their ways than younger farmers, which will be detrimental to productivity. Given that there is data on experience and education, the most likely outcome is that the coefficient on age will be insignificant.

Table 6-2: Description of variables in the Frontier analysis

Variables	Description and units of measurement
Quantities	
Production output	The production output used in the analysis was based on the number of outputs that a household reported to have produced. From one to three outputs were used for each household. These outputs were measured in kilograms.
Area harvested	This was area harvested for the reported outputs and was measured in acres.
Labour	Labour was measured in man-days and captured total labour for all farm operations.
Planting material	Planting material varied with different crops. Seeds, seedlings and planting stock were used.
Fertiliser (Inorganic/Organic)	Fertiliser was used in the forms of chemical fertiliser and organic or animal/plant manure. Chemical fertilisers were measured in 20kg bags and organic fertilisers in kilograms.
Jute twine	Jute twine was measured in rolls; it is used for tying and hanging tobacco leaves.
Fuelwood	Fuelwood was measured in cubic metres and is used for curing tobacco leaves.
Fuel pipes	Purchased for the curing process and is measured per piece.
Prices	
Rented land	Included extra land rented for the farming season. Prices were measured per season.
Wages	Per day/UGX
Planting material	Per kg of seed or seedling/UGX
Inorganic fertiliser price	Per 20kg bag/UGX
Jute twine	Per roll/UGX
Fuelwood	Per cubic metre/UGX
Fuel pipes	Per piece/UGX

The farming experience variable was pre-coded as two-year and four-year intervals, and so could function like a continuous variable. The expected sign is positive, with greater experience delivering higher farm productivity. The education variable is categorical, with 1 = primary education, 2 = secondary education and 3 = tertiary education. The latter is rare in the sample, and therefore a secondary and tertiary dummy variable (D sec/tert) was constructed to take a value of zero if the respondent has primary education only and one if he has more. The expected sign is positive, with higher levels of education expected to deliver higher levels of productivity.

Table 6-3: Description of variables that determine efficiency

Variable name	Description
Farming experience	Number of years the household head has been farming
Education	1=primary level; 2=secondary level; 3=tertiary level
Dsec/tert	= 0 if primary education, =1 if secondary or tertiary education
Sources of training	0=no training, 1=private sector, 2=public sector, 3=both private and public
D training_public	= 0 if the respondent underwent no formal agricultural training or received training from the private sector and = 1 if (s)he received training from a public service provider
Extension services provider	0=none, 1=one source, 2=two sources, 3=more than two sources
D public extension	1 if yes, 0=otherwise,
Finance type	0=none, 1=own finances, 2=banks/money lenders, 3=tobacco companies
D no loan	1 if yes, 0= otherwise
Land tenure system	1=leasehold; 2=freehold; 3=mailo; 4=customary
D communal tenure	1=communal, 0=otherwise
Farming system practices	1= intercropping; 2= mono-cropping; 3=mixed cropping
D mono cropping	= 1 if yes, = 0 otherwise

There are two training variables. The first is a categorical variable (Sources of training) which shows the sources of training. This is captured as four categories by the variable training categories that can be used in an analysis of variable model (ANOVA) to check for systematic training effects. The second is a simple dummy variable (D training_public) which indicates if a farmer was trained by a public sector official or not. Depending on those results, further training dummy variables might need to be formulated. The expectation was that public training would be more effective than private training, although Dinar, Karagiannis, and Tzouvelekas (2007) claimed that both have a role to play.

The treatment of extension services followed a similar pattern. There were four possible sources of extension: cooperatives, farmers' groups, public, and private, the last provided by tobacco leaf companies. This categorical variable is used to run an ANOVA. A dummy extension variable that represents extension services from the public sector (D public extension) is created. It is expected that extension from the public sector would result in higher productivity.

The survey provided for four possibilities for loan financing of production inputs: no loans when the farmer either does not buy inputs or is able to put up the capital himself, banks, money lenders, and loans extended by tobacco leaf companies. This categorical variable was used to run an ANOVA and there was no *a priori* expectation about how efficiency would be impacted by loan finance. Hadley (2006) found that UK firms with higher debt ratios are more efficient, although here only the source and not the size of the debt was available. The best way to get at the size of a farmer's debt was to construct a dummy variable (D no loan) to take a value of one if a farmer is free of production debt and zero otherwise.

The survey uncovered four land tenure systems: communal land, private, freehold, and the customary system called *mailo*. From the categorical variable a dummy variable for communal land tenure was constructed which took a value of one if yes and otherwise zero. It is expected that because of the inherent uncertainties about accessing communal land on an on-going basis, farmers in this tenure system would be less efficient than farmers that hold land in any of the other farming systems.

Finally, there was also a categorical variable for farming practices. The most traditional system of crop production involves an informal mixture of crops in one field, here labelled mixed cropping. Formalised crop production either involves the production of a mixture of crops in alternative rows (labelled intercropping) or mono-cropping. Tobacco is grown as a monocrop while cassava and maize are often grown as alternate rows. The agro-ecology literature suggests that mono-cropping, especially mono-cropping that continues on the same plot of land year after year will be less efficient than mixed or rotational systems. This categorical variable was used to run an ANOVA and there was no *a priori* expectation about how efficiency would be impacted by farming practices

6.5 Interpreting results

The efficiency of each farm type in the sample was investigated using the different optimal objective functions listed as equations 6.1 and 6.3. The analysis uses both constant (CRS) and variable returns to scale (VRS) frontiers to compute the efficiency measures in order to check the consistency of results between the two approaches. When calculating cost efficiency one often finds that the smallest, least efficient, firms show up as fully efficient because they lie so far out in the tail of the isoquant that they do not have more efficient larger-scaled peers (Estache, Rossi, & Ruzzier, 2004). Cost efficiency was computed from input-oriented VRS and CRS models.

Efficiency analysis was applied to individual crop types first, and then to the pooled dataset for all the nine crops together, to allow comparisons between the crop and farm types. Table 6.4 summarises the findings of the relative efficiency measures, beginning with 73 tobacco farms. Similar results appear in Table 6.6 for the cassava, coffee, maize etc. subsets of the data. The smaller the sub-sample, the higher efficiencies tend to be and therefore the comparisons focus on cassava and coffee, which have reasonable sample sizes. Table 6.7 contains the comparison of from the global frontier (tobacco only, mixed, and no tobacco at all).

All TE, AE and EE measures are the CCR DEA solutions, whereas the PTE measure is the BCC DEA solution. The former model characterises the constant returns to scale, whereas the latter assumes variable returns to scale. Efficiency measures of cost, allocative, total technical, pure technical, and scale efficiency are presented. For each of the measures, the maximum score found was unity, therefore only averages are reported here. The percentage of efficient farm households represents the share of farms with an efficiency score of unity.

6.5.1 Efficiency analysis results

The efficiency indices are multiplicative. Pure technical (PTE) multiplied by scale (scale) efficiency gives technical efficiency (TE). Technical efficiency multiplied by allocative efficiency (AE) gives economic efficiency (EE). In each sub-index there is a maximum score of unity. Table 6.4 reports mean and minimum scores as well as the number and percentage of observations that lie on the frontier in tobacco farming. The final measure of dispersal is the coefficient of variation (CV), which divides the standard deviation by the mean. Figure 6.2 shows how the components stack up.

The typical tobacco farm was more than 80% efficient with respect to the way in which it converts inputs into outputs (PTE). Some were the right size and others too large or too small, with a scale efficiency of 68%, and when combined into overall technical efficiency (TE), scores fall to just over 50%. This means that there are considerable potential gains from refining production methods and getting farms to the right size (larger). If one looks at the minimum scores and the coefficient of variation it is evident that there are more gains to be made on the scale than on the purely technical side of production.

While there were 30 farms that were perfect technically, only fifteen were the right size and only eleven were both technically perfect and the right size. The mean allocative efficiency score is 50%, which is similar to technical efficiency, but the number of farms that got this right (just one) reveals that it is the most difficult part of tobacco farming. Tobacco farms are either overcapitalised in the sense that they over-purchase farm inputs without consideration of farm size and input prices, or that they lack information on the costing of farm inputs. Putting the two together, tobacco growers should be able on average to achieve four times more with the current inputs than they in fact do.

Table 6-4: Descriptive statistics of efficiency indices for tobacco farms

Efficiency	EE	AE	TE	PTE	Scale
Mean scores	23	50	52	83	68
Coefficient of variation	64	37	60	22	45
Minimum	2	20	4	44	5
Maximum	100	100	100	100	100
Number efficient	1	1	11	30	15
% efficient	1	1	15	41	21

Source: Field survey data, 2014

If a tobacco company is looking for supplier loyalty, the best strategy is to broadcast relative prices, and for the tobacco control lobby, this is a good way to lure tobacco farmers to other crops. The steepness of the various cumulative distribution functions in Figure 6.2 reveals who should be targeted with what kind of help. The allocative efficiency (or price response) line is much flatter than the technical efficiency line. Support organisations should focus on what is lacking. The top 25% of tobacco growers are already technically very proficient and the right size, but they need to get better at responding to the price environment. The average ones are technically reasonably good and more or less the right size too but could be better at responding to relative prices. Even the bottom 25% of producers know how to grow tobacco well, but they are the wrong size and they buy inputs and sell output at the wrong price.

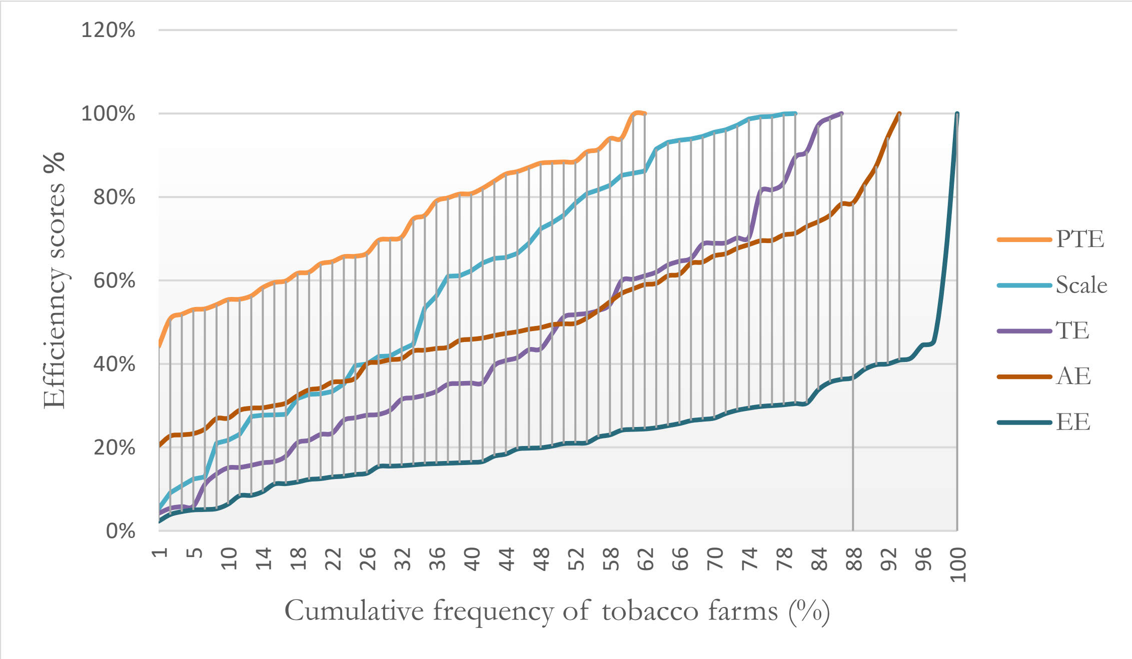

Figure 6-2: Distribution of various measures of efficiency for tobacco farms

A different way to present the same data is to consider correlation coefficients (Table 6.5). Economic efficiency is only weakly and inversely correlated with allocative efficiency. Technical efficiency, particularly its scale efficiency component, is much more strongly correlated with overall economic efficiency. Technical efficiency is strongly negatively correlated with allocative efficiency and within the technical efficiency sub-index, scale and pure technical efficiency are only weakly positively correlated.

Table 6-5: Spearman's rank correlation

Efficiency measures	EE	AE	TE	PTE	SE
Economic (EE)	1.00				
Allocative (AE)	-0.11	1.00			
Technical (TE)	0.84	-0.56	1.00		
Pure technical (PTE)	0.28	-0.42	0.49	1.00	
Scale (SE)	0.80	-0.49	0.90	0.35	1.00

Table 6.6 shows the summary of efficiency results for alternative crops. The average overall Farrell's economic efficiencies in alternative crops are 9%, 27%, 23%, 26%, 38%, 35%, 22% and 35% for cassava, coffee, maize, beans, sweet potatoes, sorghum, rice and sunflowers respectively.

Table 6-6: Efficiency results at the farm plot level - alternative farms

Farms	EE	AE	TE	PTE	Scale
Cassava farms, n=66					
Mean score	9	58	13	61	28
Coefficient of variation	1.63	0.53	1.16	0.31	0.78
Number efficient	1	2	1	7	2
% efficient	1	3	1	11	3
Coffee farms, n=38					
Mean score	27	65	42	79	77
Coefficient of variation	0.80	0.26	0.73	0.24	0.26
Number efficient	0	5	5	13	7
% efficient	0	13	13	34	18
Maize farms, n=11					
Mean score	23	49	41	95	59
Coefficient of variation	1.30	0.77	0.88	0.15	0.42
Number efficient	1	1	2	9	2
% efficient	9	9	18	81	18
Beans farms, n=21					
Mean score	26	61	39	80	65
Coefficient of variation	1.08	0.49	0.87	0.30	0.54
Number efficient	0	0	4	9	4
% efficient	0	0	19	43	19
Sweet potato farms, n=17					
Mean score	38	52	75	99	88
Coefficient of variation	0.58	0.40	0.29	0.05	0.20
Number efficient	1	1	5	16	8
% efficient	6	6	29	94	47
Sorghum farms, n=7					
Mean score	35	56	58	99	62
Coefficient of variation	1.26	0.91	0.64	0.04	0.55
Number efficient	1	1	2	6	2
% efficient	14	14	29	88	29
Rice farms, n=12					
Mean score	22	25	68	97	77
Coefficient of variation	1.41	1.20	0.44	0.10	0.35
Number efficient	1	1	4	11	5
% efficient	8	8	33	0.92	42
Sunflower farms, n=10					
Mean score	35	66	56	86	75
Coefficient of variation	0.71	0.36	0.55	0.21	0.26
Number efficient	1	1	2	4	3
% efficient	10	10	20	40	30

As mentioned before, mean efficiencies are influenced by sample size. Since sample size is smaller for the alternative crops than for tobacco, similar actual efficiencies should produce higher efficiency scores in smaller samples. In the extreme case with very few observations, almost every firm in the group becomes its own peer or benchmark. While all the crops are included for completeness, only the cassava subsample has a sufficient sample size to be comparable to the tobacco result. Cassava is a food crop that is generally not traded between households in West Nile.

Cassava production's pure technical efficiency is 61%, a quarter lower than tobacco's, and its scale efficiency is 28%, less than half of that of tobacco. As in the case of tobacco, most cassava plots are too small. For cassava, 53 plots are too small and only one too large. When these two factors are combined at the plot level, the mean technical efficiency score falls by three-quarters, from 52% for tobacco to 13% for cassava. Seven farmers in the sample know how to grow cassava properly; three do so at the right scale and only one person grows cassava correctly at the right scale. Since cassava is not sold, the crop's allocative efficiency is higher than tobacco's, but this is not enough to make up for the deficiencies in pure production knowledge and scale efficiency. Low efficiency in this crop might be evidence of satisficing behaviour at the household level; the objective with cassava growing is to provide for lean times, not to grow the maximum amount of cassava possible with the resources at hand.

At approximately half the sample size of cassava and tobacco, coffee is the only alternative cash crop on which a reasonable amount of data is available. Its mean pure technical efficiency is 79%, its scale efficiency 77%, and its overall technical efficiency 42%. This means that the typical coffee grower should be able to achieve about 60% more physical output with current inputs scaled to the optimal plot size. Technical efficiency is almost as high for coffee as for tobacco and four times higher than for cassava. In this case, right-sizing would involve increasing the scale of operations of 28 farms and decreasing the scale of operations of just three coffee producers.

Coffee farmers are even better at responding to relative prices than tobacco growers and thus have a higher overall Farrell efficiency than the tobacco growers in the sample. It is an intriguing possibility that this higher allocative efficiency arises from the different power dynamic that operates in the coffee value chain. While tobacco farmers sign up with tobacco companies for loans, inputs and advice, and are then restricted to selling to a specific firm at a fixed price by the loan the firm extended to them, coffee farmers retain a decree of independence through their membership of local producer cooperatives. These cooperatives seem to be no worse at extending technical advice than the big tobacco companies, which is a surprise. The role of institutional arrangements at the grassroots level deserves further work.

These results unfortunately come with a warning, which must be restated here – DEA efficiency is a function of sample size and while the two sub-groups are of a similar size, the one is 50% smaller than the other. Subsequent studies will have to achieve perfectly equal strata in order to evaluate efficiency differences between crops.

The six remaining crops have similar sample sizes to each other and they rank in the following order in terms of pure technical efficiency: sweet potatoes, sorghum, rice, maize, sunflowers and beans. The overall Farrell efficiency ranking is different: sweet potatoes, sunflowers, sorghum, beans, maize and rice. The small amount of data on each crop means that these rankings are of no more practical use than to give a preliminary indication of which crops should be included in further field trials by programmes that aim to develop alternatives to tobacco growing. Due to the difference in sample size, it can be concluded that tobacco and coffee production completely dominate maize, beans and rice which are then not viable switches. Even for the alternative crops with the best potential – sweet potatoes and sunflowers – a size-adjusted sample is unlikely to yield a mean productivity score that is comparable to tobacco or coffee.

The analysis up to this point was at the plot level. The data in Table 6.7 refers to the household level. Three similarly-sized sub-samples of farms were created: purely tobacco farm households (n = 30), farm households that grow no tobacco at all (n = 53) and farm households that combine tobacco with alternative crops (n = 43).

The surprise in Table 6.7 is that farmers specialising in tobacco are not the most efficient tobacco growers in the region. Specialised tobacco growers' scale efficiency is comparable to that of the bigger tobacco group, but their pure technical efficiency is 40% worse, which translates into a 40% worse technical efficiency (see Table 6.4). There are 60% that are too large than those that are too small. Specialised tobacco growers are particularly weak on allocative efficiency, as they perform 80% less efficiently than the larger tobacco group. Since these comparisons are not sample-size adjusted they understate the problem. Combined with technical performance, the allocative efficiency performance yields an overall Farrell efficiency of 6% for tobacco specialists. The bottom panel in Table 6.7, which refers to the non-specialist tobacco growers, shows that non-specialists are at precisely the same level of technical knowledge as specialists, but closer to the right size of farm, and slightly better at adjusting to relative prices, despite the more complicated system that they manage.

Table 6-7: Efficiency results at the household level all crops

Farm households specialisation, ***n=126***	EE	AE	TE	PTE	Scale
Households farming only tobacco, n=30					
Mean score	6	11	33	51	67
Coefficient of variation	2.92	1.88	0.55	0.49	0.38
Number efficient	1	1	1	5	1
% efficient	0.79	0.79	0.79	4	0.79
Households farming only alternative crops, n=53					
Mean score	46	51	69	85	79
Coefficient of variation	0.73	0.67	0.43	0.22	0.31
Number efficient	9	9	19	26	19
% efficient	7	7	15	21	15
Households farming tobacco and alternative crops n=43					
Mean score	9	16	44	51	84
Coefficient of variation	2.19	1.46	0.63	0.52	0.19
Number efficient	2	2	6	6	6
% efficient	1.6	1.6	5	5	5

Turning to farmers who have never or do not currently grow tobacco, the middle panel of Table 6.7, it is revealed that this group is technically the most accomplished and on average maintains a good level of scale efficiency, which makes them twice as technically efficient as the two tobacco sub-groups. Non-tobacco growers are also much better at responding to relative input prices and consequently have a mean overall Farrell economic efficiency that is five times that of tobacco growers. Since all three groups are comparable sizes, there are grounds for recommending a mixed farming system as an alternative to specialised or diversified tobacco farms.

So far, this analysis has produced a few interesting conclusions, several of which have been recommended before:

- Subsistence food crops do not offer a viable alternative to tobacco in West Nile, Uganda. It is worth looking into whether this recommendation also applies in other settings.

- Coffee might have some potential as a specialised cash crop in West Nile, but none of the grains or pulses do as mono-crops.
- A balanced mixed of grains and pulses that includes some coffee can certainly compete with tobacco in West Nile.

Vertically integrated farmers are at the mercy of powerful buyers/processors who are generally very prescriptive about quantities while at the same time controlling prices, so that farmers have very little room to manoeuvre. Only the good ones escape.

6.5.2 Characteristics of efficient farms – benchmarking for tobacco farm households

One way for individual producers to improve their performance is to turn to their peers for help. Peers are efficient reference farms that share the same factor ratios with the farm under consideration (Plà-Aragonés (2015). Conradie and Piesse (2015) use a simple peer count to identify the most representative production systems amongst farms, and the same is used here. Since the aim is to find feasible alternatives to efficient production technologies which can be identified for tobacco growers. Coincidentally, only farm households that specialised in alternative crops were peers to other households. None of the households that specialised in tobacco only or even in both tobacco and other crops appeared among the most referenced peers.

Ten farm households, which included farm household numbers 5, 6, 11, 15, 50, 83, 92, 101 and 102, had higher reference counts. Among these farm households, household number 92 had the highest reference count of 71, followed by household numbers 5 (50 counts), 83 (35 counts) and 101 (24 counts). The lowest count was for household number 102, with 11 counts. The characterisation that follows focuses on the first four farm households with higher counts. Farm household 92 was a specialised farm, by West Nile rural farming standards. This farmer cultivates only cassava and only has two years of farming experience.

This was a younger farmer (32 years old), educated, who did not apply fertiliser and pesticides in order to minimise the cost of inorganic fertiliser. Family labour was not supplemented by hired labour. The farmer was scale efficient (1.00) in spite of the limited farm size (0.5 acres) and the lack of expenditure on renting extra farmland. Half an acre of farmland produced 900 kilograms of cassava in 2014. Membership of farm organisations made this farmer a good example of how farmers should supplement their farm skills and resources with new farm information from external peers. The farm is a good reference for other farmers, in that it shows that farmers do not have to apply excessive chemical inputs to become efficient. Farmer 92 is an example of the power of education to transform traditional production systems into more modern enterprises that can ensure food security for all.

Farm household 5 was a specialised and intensive modern farm, producing cassava and sunflower on 2.5 acres of family-owned land. This is consistent with the farm's scale efficiency of 1.00 with constant returns to scale. This farm's total harvested output for 2014 was 2 250 kilograms of cassava and 900 kilograms of sunflower. The head of this household had five years' farming experience, never used chemical fertiliser or pesticides on the farm plots, used family labour, and used improved planting stock.

This household rented extra land to accommodate their farming ambitions. Extension and credit services are part of this farm's production strategy. The agricultural training received enabled the farmer to adopt modern farming practices. The efficient use of this farm's resources confirmed that Farm 5 was technically efficient (1.00). Farm household number 83 (which was a peer to 35 inefficient farms) had a specialised production system, producing cassava on a 2-acre farm plot. This farm household had no rented extra farmland but managed to produce an output of 6 380 kilograms of cassava. This farmer seemed conservative, but improved the farm's soil quality by applying farm manure and making proper use of family labour. This significantly improved the farm's cost and allocative efficiency when compared to other farm households. Technically, Farm 83 was efficient, with overall and pure efficiencies of 1.00.

These three examples demonstrate the multiple ways in which farmers who currently produce tobacco can be successful in a post-tobacco world, especially one that takes the reduced use of chemical fertilisers seriously. Tobacco growers can relate to such farms since it is evident that there are non-tobacco production systems in West Nile that are more productively efficient than tobacco. Specialised production systems based on cassava, coffee, and maize make suitable alternatives for tobacco growers. This is especially true for cassava and/or coffee peer farms that are efficient in all efficiency measures. West Nile, being a rural setting with limited services, may require government interventions that target modern farming methods in order to improve the efficiency of most of these farms.

6.5.3 The determinants of farm efficiency – preliminary analysis

In this section the analysis turns to potential policy interventions to improve farm productivity, particularly training and extension, but also investigates the role of land tenure, production system, farming experience, and education on efficiency. A series of single variable Analysis of Variance (ANOVA) tests investigates how mean technical, allocative and economic efficiency varies by each variable category. The ANOVA output is presented in Appendix F, indicating whether there is a statistically significant difference between the mean of the three efficiency measures and the selected variables. But since the ANOVA output does not show which of the specific groups differed, the pairwise comparisons of means with equal variances that contain the results of the *post hoc* tests are reported in Table 6.8. Results are presented as mean ± standard error. Where the distributional assumption of the ANOVA is not met (as diagnosed by Bartlett's test of equal variances in Stata), the Kruskal-Wallis test constitutes a non-parametric alternative.

Education matters for technical and allocative efficiency and for overall efficiency. Since there were very few observations of farmers with a tertiary education, the main difference is between persons with primary education only and people who went on to secondary education. Here the results were unambiguous; more education delivers higher levels of productivity.

Experience, defined as two- and four-year intervals up to ten years, shows that technical efficiency is statistically significantly lower in the group of persons with more than ten years of farming experience than in the group of people with between four and eight years of farming experience. However, there were no statistically significant differences between the 'two to four years' and 'four to eight years' categories, or 'four to eight years' and 'eight to ten years' for allocative and economic efficiency. Since most observations fall into the 'four to eight years' category, it is possible that experience of up to eight years makes a difference while experience of from eight to twenty-seven years could be associated with lower productivity as farmers tend to repeat their farm management practices other than learning or adopting new practices.

Efficiency varied significantly by training categories, although in unexpected ways. The survey produced the obscure result that the three farmers who claimed not to have had any training, were the most efficient in each dimension, while persons that attended both private and public sector training courses were less productive than farmers who only attended public sector offerings. The only way to explain this uncharacteristic result is that courses may differ in quality

Table 6-8: Post hoc tests on efficiency by farm and farmer characteristics

Theme	Categories	TE	AE	EE
Education	Secondary vs primary	0.170 (0.052)***	0.135 (0.062)*	0.168 (0.059) ***
	Tertiary vs primary	0.061 (0.110)	0.081 (0.129)	0.049 (0.125)
	Tertiary vs secondary	-0.108 (0.113)	-0.055 (0.133)	-0.119 (0.128)
Experience	4-8 years vs 2-4 years	-0.287 (0.284)	0.235 (0.336)	0.194 (0.329)
	8-10 years vs 2-4 years	-0.380 (0.290)	0.228 (0.343)	0.168 (0.336)
	>10 years vs 2-4 years	-0.423 (0.285)	0.209 (0.338)	0.143 (0.330)
	8-10 years vs 4-8 years	-0.092 (0.077)	-0.006 (0.091)	-0.026 (0.089)
	>10 years vs 4-8 years	-0.136 (0.055)*	-0.025 (0.065)	-0.050 (0.064)
	>10 years vs 8-10 years	-0.043 (0.080)	-0.019 (0.095)	-0.024 (0.093)
Kruskal – Wallis		7.164*	0.230	0.183
Training	Private vs no training	-0.295 (0.138)†	-0.382 (0.171)†	-0.410 (0.164)*
	Public vs no training	0.010 (0.138)	-0.058 (0.172)	-0.082 (0.164)
	Both vs no training	-0.460 (0.152)***	-0.398 (0.189)†	-0.465 (0.180) **
	Public vs Private	0.306 (0.044)***	0.324 (0.055)***	0.328 (0.052)***
	Both vs Private	-0.165 (0.076)†	-0.015 (0.095)	-0.054 (0.091)
	Both vs Public	-0.471 (0.077)***	-0.340 (0.096)***	-0.383 (0.092)***
Kruskal – Wallis		41.676***	28.439***	36.957***
Farm extension services – sources	One source vs no extension	-0.017 (0.171)	0.058 (0.194)	0.105 (0.189)
	Two sources vs no extension	-0.063 (0.169)	-0.098 (0.193)	-0.061 (0.188)
	Three sources vs no extension	-0.0163 (0.178)	0.034 (0.203)	0.007 (0.198)
	Two sources vs one source	-0.046 (0.056)	-0.156 (0.064)*	-0.167 (0.062)**
	Three sources vs one source	-0.146 (0.079)	-0.024 (0.091)	-0.098 (0.088)
	Three sources vs two sources	-0.099 (0.077)	0.132 (0.088)	0.069 (0.086)
Kruskal – Wallis		3.046	5.606*	4.307
Sources of farm	Own finances vs no finances	0.124 (0.098)	0.236 (0.122)	0.245 (0.116) †

Theme	Categories	TE	AE	EE
input financing	Banks/money lenders vs no finances	0.088 (0.105)	0.097 (0.130)	0.100 (0.124)
	Tobacco company vs no finances	-0.215 (0.096)*	-0.106 (0.119)	-0.122 (0.113)
	Banks/money lenders vs own finances	-0.035 (0.066)	-0.139 (0.081)	-0.145 (0.077)
	Tobacco company vs own finances	-0.339 (0.049)***	-0.342 (0.060)***	-0.367 (0.058)***
	Tobacco company vs banks/money lenders	-0.304 (0.062)***	-0.203 (0.077)**	-0.222 (0.073)***
Tenure system	Leasehold vs mailo	-0.225 (0.133)	-0.291 (0.154)	-0.313 (0.150)
	Freehold vs mailo	-0.173 (0.125)	-0.129 (0.145)	-0.156 (0.141)
	Customary vs mailo	-0.076 (0.112)	-0.169 (0.129)	-0.180 (0.126)
	Freehold vs leasehold	0.052 (0.101)	0.162 (0.117)	0.156 (0.114)
	Customary vs leasehold	0.148 (0.085)	0.121 (0.098)	0.132 (0.095)
	Customary vs freehold	0.096 (0.071)	-0.041 (0.082)	-0.024 (0.079)
Production system	Monocrop vs alternate rows	-0.119 (0.054)*	-0.132 (0.058)**	-0.124 (0.057)*
	Traditional vs alternate rows	-0.047 (0.078)	0.289 (0.084)***	0.253 (0.084)***
	Traditional vs monocrop	0.071 (0.079)	0.422 (0.084)***	0.377 (0.083)***

Source: Field survey data, 2014, *** $p< 0.01$, ** $p< 0.05$, * $p< 0.1$, † $p< 0.15$

and targeting. For example, the private sector could be seeking out the worst performers to ensure that these individuals also meet the minimum quality standards. Such courses will only emphasise technical aspects of production and not the marketing aspects to the same extent. The results show that efficiency was higher for persons who received training from the public sector than from the private sector. Training from the public sector is included in the Tobit model as a dummy variable, indicating whether a farmer received public training, that measures the marginal benefit of public sector training over any other sector courses. The anticipated sign is positive.

Extension services are provided by the government, tobacco leaf companies, informal farmers' groups, and the cooperatives to which they belong. As mentioned, cooperatives are important in the coffee value chain, while tobacco companies obviously limit their advisory services to tobacco. As with training, most farmers access advisory services, and most of them access more than one source of advice because, from their perspective, the various services are not mutually exclusive. Specialisation could also play a role. For example, Conradie (2016) found that South African sheep farmers prefer a different service for rangeland management, livestock matters and predator control. Here the quantity and quality of the extension contact is not known but it can be classified as public or private, as Dinar et al. (2007) do, who include farmers' groups, cooperative services and services provided by tobacco leaf companies.

In Table 6.8 above, a classification based on the number of sources indicates the unusual result that farmers who consult the highest number of different sources of advice have lower allocative and cost efficiencies. The technical efficiency result follows the same pattern but is not statistically significant, which suggests that extension is unlikely to work well in a Tobit model, unless dummies for sources of extension are used.

All three types of efficiency varied significantly by the source of funding for farm inputs, with formal banks and/or money lenders setting the highest standards followed by farmers who remain debt free and with tobacco leaf companies bringing up the rear. This result does not mean that increasing the number of farmers that have access to formal financial institutions (for example by forcing banks to take them on) or informal financial institutions will increase the sector's productivity.

The result merely means that those farmers whose financial and technical management skills are already of an acceptable standard are able to access formal financial services that might not be available to individuals with fewer management skills. There is a need for regulation of the conditions under which tobacco firms formulate their loans to farmers. The result shows that efficiency is lowest for those who were financed by tobacco companies compared to those who had their own finances and/or those who used formal and informal financial institutions.

The tenure system in Uganda is defined as leasehold, *mailo*, freehold and communal; and there is no statistical relationship between type of tenure and technical, allocative and economic efficiency. In contrast, the production system in operation affects all three types of efficiency. The traditional production system, in the literature known as mixed cropping, in which different crop types are combined in a haphazard way in a single field, delivers intermediate technical and superior allocative efficiency, particularly compared to mono-cropping.

On the other hand, the mono-cropping system often practiced on tobacco farms, does the worst technically because it relies on large quantities of artificial fertiliser and pesticides and is the worst from an allocative efficiency point of view. It seems that in West Nile, farmers who combine the traditional principles of building soil nutrition through crop rotation but do so using modern varieties and row cropping methods achieve the best technical efficiency results. The policy result here is that advisory services should respect and build on traditional knowledge when introducing technical innovations to rural communities. Farmers should be allowed to deviate from strict technical recipes in order to find their own optimal allocative efficiency that takes into account local price environments.

6.5.4 Tobit regression results – determinants of farm inefficiency

The results of three Tobit models are presented to explain technical, allocative and economic efficiency (see Table 6.9). The table presents marginal effects, their standard errors (in brackets), and all the customary goodness of fit tests on the underlying Tobit model. These tests include the log-likelihood ratio test, its significance, the pseudo R-squared value and the predicted and observed efficiency levels. Many specifications were tried. Only the most preferred model is given in each case. Age and experience did not have any explanatory power. Household size was consistently insignificant and the type of production (D mono) tended to overwhelm the explanatory power of more interesting variables.

There were 126 observations in each case. All three specifications pass the likelihood ratio tests with a probability of less than or equal to 0.000, the highest level of significance, and the pseudo R-squared values were low but reasonable for the limited sample size. Sample size also negatively affected the significance of individual coefficients, which reported all the way down to p ≤ 0.15. All three models predicted well.

Table 6-9: Marginal effects of factors explaining efficiency

Explanatory variables	EE	AE	TE
D Sec/tert education	0.065 (0.049)†	0.043 (0.053)	0.132 (0.062)**
D Communal tenure	0.005 (0.052)	-0.001 (0.056)	0.093 (0.065)†
D Training _public sector	0.088 (0.061)*	0.108 (0.066)*	0.095 (0.077)
D Extension _public	0.085 (0.058)*	0.084 (0.063)	0.151 (0.074)**
D No loan	0.121 (0.062)**	0.106 (0.068)*	0.144 (0.079)**
LR chi^2 (.)	26.92 (5)	22.22 (5)	34.77 (5)
Prob > chi^2	0.000	0.000	0.000
Pseudo R^2	0.17	0.14	0.22
Predicted efficiency	22%	28%	71%
Actual mean efficiency	24%	29%	65%
observations	126	126	126

Source: Field survey data, 2014, *** $p< 0.01$, ** $p< 0.05$, * $p< 0.1$, † $p< 0.15$

The determinants of technical efficiency are education, type of training, type of extension service provider, source of farm input finance and land tenure. Some variables were not significant, but were kept because they contribute to the explanation and/or explanatory power. The factors that significantly improve economic efficiency were secondary (and tertiary) education, which increases cost efficiency by 0.06 points over that of a farmer who only has primary education. People that had a secondary/tertiary level of education had an increase in productivity of 0.132 points compared to those with only a primary level of education. This result is in line with previous studies that show higher efficiency for farmers with more education (Obwona, 2006; Bagamba et al., 2007).

Obwona (2006) clarifies this finding, suggesting that it is not higher education that matters as such, but vocational and adult education that are really relevant to farm efficiency. Bagamba et al. (2007) further reports that the education of the head of the household increases a farmer's management capabilities and his/her ability to utilise technologies. Similar results are reported in Ali and Flinn (1989), Parikh, Ali, and Shah (1995) and Battese, Malik, and Gill (1996). Their results suggested that educated household heads understood agricultural instructions more easily and had a higher uptake of improved production technologies because they could access information more easily and apply technical skills more appropriately than less-educated farmers. This result should not imply that less educated persons cannot be as productive.

Farming on communal land is beneficial for productivity, as persons that used a communal land tenure system were 0.093 points higher in productivity than farmers that were on other forms of land tenure. Communal land posts lower allocative efficiency relative to other tenure systems, but this result was not statistically significant. People that attended public sector training, which is associated with 0.088 efficiency points in cost efficiency and 0.108 points in allocative efficiency, had a better outcome than those that attended any other source of training. Extension services provided by the public sector showed efficiency-enhancing effects for cost and allocative efficiency, but the effect is much higher for productivity.

Persons that had a government extension agent visit their farms were 0.151 points better in productivity than those that were visited by extension agents from the private sector. The predicted value of cost efficiency was 0.085 points higher for households that had extension visits from the public sector than for those that did not receive any extension services or that received extension services from the private sector. The gearing variable, whose coefficient indicates that debt free farmers are 14% more technically efficient than farmers who take loans, was statistically significant. It further indicates that persons who did not take up any form of debt were more cost efficient by 12%.

Most of these results were expected. Education is often beneficial for farm productivity. Being debt free is good because it gives the farmer more options and communal land tenure has a good reputation. The extension result was not a particular surprise either, as the survey merely counted access and not the amount of extension given or the quality thereof, although it is interesting to note how public extension services have an impact on farm performance. The real surprise in the table above was that training from public sector sources is more beneficial for productivity than training from other sources such as the private sector. This needs further work, although the comparison with training results for the other two models shows that it is a robust result in this dataset. The next section discusses further the major results on tobacco and alternative farming.

6.6 Discussion of results

Three key findings emerge in this chapter. First, both tobacco-leaf and alternative farms were too small and tobacco farms were over-capitalised. Secondly, the results highlight the importance of agricultural support, particularly for training and extension services. This warrants a closer look at agricultural support as it could potentially amplify the effects of efficiency, not only for tobacco but for alternative crops too. Thirdly, as inefficient management practices were particularly noticeable in tobacco farms, it is impossible for households that specialise in alternative crops to follow tobacco farming practices as a benchmark, but tobacco farmers can benefit from diversifying their farmland

6.6.1 Tobacco leaf and alternative farms are too small and tobacco-specialised farms are over-capitalised

The first important result is that, in 2014, 35% of farm households that farmed tobacco leaf and 24% of households that farmed alternatives were operating under increasing returns to scale. Thus, substantial efficiency gains could only have been realised if farmers increased their farm sizes, perhaps through farm consolidation or land rentals. The issue of land markets has not been addressed, yet are important to any agricultural development initiatives. Equally, if the international community is interested in a progressive development of alternative crops in rural areas such as the West Nile, the issue of improving land markets is crucial. Several barriers to farm consolidation, such as imperfect land markets, exist in Uganda, owing to the presence of different tenure systems.

Theoretically, proper land rights or markets can enhance allocative efficiency and productivity by equalising the marginal product of land among farm households with different land – labour endowments and by facilitating transfers of land from poorly productive households to more productive ones (Deininger, 2003; Deininger & Jin, 2005; Jin & Deininger, 2009). Land legislation in West Nile is still not favourable to tenants and does not stimulate the lease market. A communal land tenure system, which is the main tenure system in the West Nile sub-region, would be practical to some extent, but does not take into account farmers operating under freehold or *mailo* tenure systems. Land rights have important implications for agricultural production in these systems.

In fact, the present analysis confirms that farm households that are under the communal tenure system are technically efficient compared to households that are in other forms of tenure arrangements. This may be because there is more investment on communal land because of secure tenure rights and people invest more farm inputs on such farm plots and tend to maximise long-term farm efficiency and thereby increase household profits. Well-established land markets could improve efficiency gains for these farms but it is not clear that they would improve efficiency for farms that specialise in tobacco leaf. A number of farms with a current specialisation in tobacco leaf experienced decreasing returns to scale, implying that their farm size was too large and they needed to downscale their production in order to stay on the frontier.

Tobacco farms were over-capitalised, which seems counterintuitive. This finding strongly suggests two possible scenarios. First, there could be a weakness in farm management decisions, for example the decision to purchase excessive inorganic fertiliser, irrespective of farm size, or the potential efficiency with which it could be used. Secondly, the private sector's involvement in tobacco-leaf farming has some positive effects, but tobacco farmers, particularly specialised tobacco farmers, seem at the mercy of tobacco leaf buyers/processors who perhaps control prices, so that farmers have very little room to manoeuvre. Similarly, farmers that received training from the private sector, mostly from tobacco companies, achieved low efficiency compared to other farmers. At the same time farmers that accessed finance through tobacco companies achieved lower efficiency.

6.6.2 Reliance on agricultural support is beneficial to efficiency

The measurement of agricultural support was tested for a farmer's access to agricultural training and extension services from different service providers. The findings from the ANOVA and the Tobit regressions show varying effects for agricultural support on farm efficiency. The public extension service offered by government contributes more significantly to efficiency than private extension services. The difference between government extension support and private support is that farmers do not pay for government services, but they do for privately-offered extension services. Thus the result for public extension services shows it to be beneficial for farm efficiency in the sense that farmers who received extension services from government officials were less likely to be inefficient in using their farm resources. Kansiime et al. (2018) found that access to extension services allowed farmers easier access to market information and the best farm management practices from which to make informed choices regarding markets and the adoption of efficiency-enhancing technologies. Binam, Tonyè, wandji, Nyambi, and Akoa (2004) found that extension services improved efficiency and suggested a combination of extension services and training to strengthen extension services.

However, even if the public extension services variable works well with efficiency in the current context, effective extension services in Uganda as a whole are still lacking. Agricultural extension is a key policy instrument for the agricultural sector in Uganda and, in the past fifteen years, the government embarked on a radical reform of the National Agricultural Advisory Services (NAADS) that was meant to shift from traditional top-down government-led extension to a demand-led one where farmers define their own requirements for advice.

The reforms as conceived were ambitious, and NAADS has been suspended twice and drastically re-moulded and re-emerged as a government extension (Kjær & Joughin, 2012). Observers have documented that, in general, extension services in Uganda are characterised by informal educational systems caused by bureaucratic inefficiency, poor information delivery systems, and deficient program designs. The other major deficiency in agricultural extension support in Uganda is the tendency towards a top-down approach, both for public and private extension services providers. Information is often disseminated as a technological package, which is frequently perceived as irrelevant by the local farmer.

The development of alternative farming will require investments in agricultural extension support but also changes in the roles of farmers, not to be spectators but participants in the extension service delivery. This should be combined with training support since public training had positive influences on overall economic and allocative efficiency. This result implies that agricultural support should involve extensive training support, perhaps using participatory approaches to help farmers develop their analytical skills, critical skills, and creativity so as to make better farm decisions.

6.6.3 There are inefficient management practices on tobacco farms

The efficiency results showed that technical inefficiency appeared to be mostly due to pure technical inefficiency rather than scale inefficiency in tobacco-farm households. This implies that inefficient management practices had a stronger influence than farm size. The fact that inefficiencies in tobacco farms were mainly due to management practices is a substantive aspect that undermines the competitiveness of tobacco with alternative farms. There were several reasons for such inefficiencies.

First, as tobacco-leaf farming has traditionally been a crop supported by the private sector, agricultural reforms such as the Plan for Modernisation of Agriculture have not been directly applied to the tobacco industry, but provided a buffer for many other crops that seemed to alleviate poverty. Knowledge of-and information on- proper farm management practices seems to be absent for farms that specialise in tobacco-leaf production. This is especially the case with the widespread mono-cropping system that is followed by tobacco farmers. It is also possible that the same farmers are not eager to apply farm practices such as crop rotation, possibly because of limited access to land.

Secondly, the low level of education within this sample might be a substantial constraint on efficiency. As noted in Section 6.5.4, the degree to which production factors are appropriately used increases with education. Studies testing the effect of education on farm efficiency report a positive relationship (Stefanou & Saxena, 1988). In the present sample, the correlation between productivity and the education variable for tobacco farms was negative, and was positive for those that farmed only alternative crops.

Out of 30 households that specialised in tobacco leaf, 21 heads of households had only a primary level education, and only 8 had a secondary level education. This was slightly different from households that only grew alternative crops. At least 26 heads of households specialised in alternative farming had a secondary education, 23 had a primary education, and 3 had a tertiary level education. As education is a control variable, the result does not necessarily imply that highly-educated persons will attain higher productivity. But based on the current analysis, an improvement in human capital could improve productivity in West Nile. This in turn may assist farmers in not being overly dependent on tobacco-farming. hence facilitating farm transition to other crops.

However, improving human capital remains a long-term task for Uganda and requires various policy instruments, such as agricultural support for farmers. It is a challenge which is central to the wellbeing of current tobacco-farm households and the future competitiveness of alternative agriculture in the West Nile sub-region and in Uganda as a whole.

6.7 Concluding remarks

This chapter aimed at developing separate frontiers for the different crops at a farm-plot level and a global frontier for households in order to examine farm efficiencies in tobacco and other farm crops. On average, tobacco and alternative farming differed in productivity, allocative efficiency, and cost efficiency. The chapter therefore concludes that the internal organisation of tobacco-farm units makes them inherently less efficient than alternative farms. This was the result of inefficient management practices and the overuse of farm inputs.

On the other hand, farm efficiency benefits from agricultural support, particularly from the public sector, which led to a sub-optimal reduction in cost inefficiency, allocative inefficiency, and technical inefficiency in all farms. It is reasonable to suggest that private training courses and extension services may not be sufficient for efficiency and, for this reason, the study partly disagrees with Natarajan's more revisionist view that support from the tobacco industry is not entirely bad. The study further rejects the hypothesis that tobacco-leaf farmers and farms are more efficient in using farm resources, given their comparative advantage from vertical integration, when compared to alternative farms, all other things kept equal.

The implication of these results for Article 17 policy is that encouraging governments to provide well-defined land markets could improve the scale efficiencies of alternative farming because most farms that specialised in alternative farming experienced increasing returns to scale. In addition, a change in farm management practices is needed, especially for tobacco farmers wishing to transition to alternative farming, and for this robust agricultural extension systems are crucial. Provision of crop alternatives alone will not lead to a decrease in farmer dependence on tobacco, but potential farmer transitions can be achieved by assisting farmers to reallocate inputs between farm production systems, that is, tobacco and alternative farming, largely by creating efficient and unbiased factor markets.

Chapter 7
Conclusion and future research avenues

7.1 Objective of the chapter

This chapter synthesises the results from the previous chapters in order to address the issues laid out in Chapter 1. The objective is to assess the outlook for tobacco and alternative farming. The other objective is to examine what can be done to provide a more level playing field for tobacco farmers transitioning to alternative crops, and for farmers specialised in alternative crops to be competitive, on the assumption that alternative farming is a priority for the international development community.

The urgency of the topic derives from the fact that tobacco leaf is one of the most popular crops that smallholder farmers produce, but the future of the crop remains unclear. The chapter first summarises the key findings of the thesis. It then draws on the key results to assess the outlook for tobacco and alternative farming and suggests the policy implications of the findings for Article 17 of the FCTC. A critical reflection of the strengths and limitations of the study is presented, and new avenues for research are suggested in the final section of the chapter.

7.2 Main findings

7.2.1 Profitability, viability, and efficiency: which types of farms are feasible?

Comparative profitability by type of farm

The descriptive results presented in Chapter 4 found that farms that specialised in alternative farming made higher profits than farms that specialised in the production of tobacco leaf. The analysis demonstrated that the profit margin advantage of tobacco-leaf farms tends to disappear as a result of higher farm expenditure. However, farms that specialised in alternative crops did better than tobacco farms because of lower input requirements.

Coffee farms and rice farms had gross margins that were 30% and 27% higher than those of tobacco farms. The trend was similar for other crops, except for sorghum farms, whose gross margin was 3% less than those of tobacco farms. This finding was surprising because tobacco farms have the advantage of forward price guarantees which could have offset fluctuating seasonal prices. Testing the viability of crop enterprises found a strong viability of non-tobacco crops in scenarios where shocks were applied to the gross profit margins. Hypothesis one in chapter 1 is not supported: there was no evidence in the data for the view that tobacco-leaf farms had higher profits than farms that specialised in other crops.

Comparative cost, allocative and technical efficiency

Unlike the profitability analysis, which was a descriptive analysis, the analysis of cost, allocative, and technical efficiency at the plot and household levels was based on a modelling exercise. The overall results in Chapter 6, comparing efficiency across crops, showed that farms specializing in the production of tobacco leaf were cost inefficient, or allocatively inefficient, and mostly operated under increasing returns to scale. Hypothesis 3, that tobacco leaf farms are more efficient, is therefore not supported by this study. The efficiency advantage of farms specialising in alternative crops can be attributed mostly to proper farm management practices. On a global frontier, farms that specialised in only alternative crops appeared efficient and showed that they should potentially continue to farm alternative crops.

7.2.2 Why were some farms cost, allocative, and technically efficient?

The second step in the analysis of efficiency in the previous sub-section also permitted an assessment of the determinants of cost, allocative, and technical inefficiencies. In effect, the Tobit regression analysis presented in Chapter 6 explained the reason that some farmers were more inefficient than others in terms of differences in access to agricultural support services, differences in cropping system practices, and differences in other factors, such as household characteristics.

Hypothesis 3 also posits that farm efficiency (i.e. cost efficiency, allocative efficiency, and technical efficiency) is mainly associated with land tenure. In other words, the competitiveness of tobacco-leaf or alternative farms is helped by well-defined land rights. Results on this in Chapter 6 were mixed. First, a number of farm households that specialised in tobacco and other crops operated under increasing returns to scale, leading to the conclusion that vibrant land markets were necessary to enable farm households to acquire extra land and improve the scale efficiency of farms. The analysis showed that farm households that rented extra land achieved higher efficiency. But the land tenure system variable did not seem to have much influence on efficiency in the sample, except slightly on technical efficiency.

With respect to hypothesis 3, agricultural support in form of extension services and training, both from the public sector, seemed strongly to explain cost and allocative efficiencies, but only slightly to explain technical efficiency across farms. This result meant that relatively greater inefficiencies were prevented because some households had access to these services, and hence agricultural support was a prime determinant of differences in farm efficiencies within the sample. Farm households which relied on mixed cropping avoided farm inefficiencies.

7.2.3 What incentives affect the supply of tobacco leaf?

The analysis of the two-step decision-making process in Chapter 5 identified factors that influenced farmers' production decisions on farming tobacco leaf. It was established that farm households make independent decisions regarding the choice and amount of tobacco they desire to farm. The analysis links the tobacco-leaf output response to three domains of potential determinants: (1) selected household composition factors, (2) relative prices and farm outputs, and (3) access to resources. In particular, tobacco farmers respond to price and output incentives. The value of tobacco production and the availability of farm resources also significantly influence the supply of tobacco. Hypothesis 2 is not rejected, economic incentives are important in tobacco output supply.

7.2.4 What is the outlook for tobacco leaf and alternative farming?

What then is the outlook for tobacco-leaf and alternative farming? Summarising the empirical results of the hypotheses tested, the thesis concludes that: (a) farm households that specialised in alternative farming had higher profits; (b) these farms were more cost-efficient, allocatively efficient, and technically efficient, at least within the normal range of production; (c) the competitiveness of alternative farming was largely determined by better farm management practices and perhaps by agricultural support; and (d) tobacco-leaf production was driven by economic incentives and some household attributes.

From (a) and (b) the study concludes that alternative farming can succeed in tobacco-farming communities. These crop enterprises could actually be more competitive for low-end markets, even when forward prices in some of these crop enterprises are not guaranteed. As alternative crops gain hold, farms that specialise in such crops may need to be associated with institutions that provide the necessary factors of production in order to be able to compete in high-value markets.

From (c), the study concludes that the key to assisting farmers specialising in alternative farming and farmers willing to transition from tobacco to other crops is to develop robust institutions that address issues of imperfect factor markets and the challenges of vertical integration, and that overcome the disproportionately high costs that farmers experience in securing quality farm inputs at the same time that they face lower output prices.

From (d), the study concludes that the transition from tobacco to alternative farming is potentially viable but that farmers need to be provided with high-value export crop alternatives, equivalent to tobacco, not just subsistence crops. In addition, these should be supported by functioning market policies.

7.3 Policy implications

The thesis has important policy implications for reforming Uganda's agricultural economy in support of Article 17 of FCTC. These policy implications relate to four central observations outlined in this thesis. First, output prices are a crucial factor to provide incentives for tobacco-farm households to transition to other crops. Secondly, crop diversification is a desirable strategy in the transformation of agriculture for the development of alternative crops. Thirdly, as a result of the increased cost of agricultural production, agricultural support policies related to inputs are important for incentivising diversification to alternative-crop farming. Finally, the creation of an agricultural support framework would improve farm efficiency.

7.3.1 A price policy strategy

The findings from Chapter 5 demonstrated that tobacco-farm households are capable of responding to input availability, prices of alternative crops, and outputs from alternative crops relative to tobacco. In short, economic incentives play an important role in farmers' decision-making processes. The elasticity estimates indicate significant cross-price relationships between tobacco, a cash crop, and a food crop. The signs of the cross-price elasticities reveal important substitution possibilities between the two crops. For example coffee is a substitute crop for tobacco and there is a substitution but essentially a complementary production relationship between tobacco and cassava because cassava is a food crop. The price response relationships between tobacco and its substitute crops could be asymmetric. A change in the price of coffee substantially affects the production of tobacco-leaf. These results show that output and input prices offer good prospects for guiding tobacco farmers' choices. In other words, policies promoting alternative farming should make alternative farming more attractive to tobacco farmers.

The Ugandan government fully supports the development of alternative livelihoods to tobacco farming. This is seen by the lack of support that the government provides to tobacco farming. In order for the government to encourage alternative farming, it should adopt a policy in which a premium price is paid for alternative crops. The policy should support an enabling environment for the expansion of an alternative cash-crop system. This should involve developing a widespread and reliable cash-crop base or export crops that will reduce farmers' dependence on tobacco leaf and improve returns to farmers.

7.3.2 A crop diversification strategy

The policy implication of this research further emphasises the need to design policies that promote crop diversification for tobacco-farm households. The results of Chapter 4 and Chapter 6 indicate that diversified farms perform better and have lower costs of production and better profits, perhaps due to scale economies and output complementarity. The government of Uganda gives priority to only four export crops (i.e. coffee, cotton, tea and sugarcane), rather than supporting a wide spectrum of both food and cash crops. This targeted approach is problematic.

Chapter 5 shows that tobacco-farm households are capable of responding to both export and food crop prices and outputs from alternative crops. However, the expansion of one or two alternative crops could lead to overproduction, hence crop diversity should be expanded to promote the crop base and improve the incomes of farm households.

7.3.3 An agricultural support policy

The findings in Chapter 4 indicate that both tobacco and alternative crop farms are sensitive to the cost of inputs. Farm profitability falls if the cost of fertiliser and other production costs increase.

Agricultural policies that create incentives to invest in alternative farming should focus on the reduction of input costs. The government of Uganda should devote more resources to improving the agricultural input market, with a particular focus on the prices of farm inputs like fertilisers. The evidence on the sensitivity of farm profitability to fertiliser price indicates that the decline in the cost of these inputs would have a positive effect on the farm profitability for alternative crops. This can in turn reduce dependency on tobacco farming. Warr and Yusuf (2014) reported that, in Indonesia, input subsidies such as fertiliser had a large and positive impact on food sufficiency.

Chapter 6 further demonstrates that efficiency in alternative farms can benefit from agricultural support, which should ultimately improve output performance and profitability. The development of alternative farming in tobacco-farming communities should be successful with a harmonised agricultural support framework involving the provision of training support, extension service delivery, and provision of farm inputs. Therefore, it would be expected that government policies that support input subsidies and the provision of good extension services would have a significant impact on the development of alternative farming. The 2016 National Agricultural Extension Policy of Uganda is a positive step towards improving the extension delivery in Uganda, but issues of poor implementation and underfunding of the programme remain a stumbling block.

7.4 Strengths and limitations of the study

This study makes a contribution to the evidence base about the economic functioning of tobacco and other crop enterprises. One of the main strengths of the study is a quantitative methodological design capable of addressing a wide range of questions through the use of a farm household survey. The farm household survey contained crop budget information, which enabled the findings of crop enterprises to be compared and discussed with reference to previous research. Furthermore, the findings provided a unique and detailed investigation of the farming structure.

However, the study has a number of limitations. First, although the response rate was respectable for a farm household survey (68%), farm input data for some crop enterprises were not available, particularly for crops that were not popular in the study area. Some farm households did not complete parts of the questionnaire. Although profitability and efficiency results from such farms were positive, the level of efficiency might have been different if complete data were present or if the response rate had been higher.

Secondly, as mentioned in Chapter 3, a limitation of this quantitative study is that it is cross-sectional in design. Even if cross-sectional studies can highlight associations between several factors in the production of tobacco leaf and other crop enterprises, the design cannot illuminate causal pathways, as this can only be achieved by using longitudinal or panel studies. In addition, even if the results are statistically significant and broadly plausible, the West Nile sub-region has a long association with tobacco-leaf production and the findings might not be transferable to the general population outside the region.

In conclusion, despite these limitations, the study design ensured that the study was comprehensive. The farm household survey provided a rich sampling frame for the quantitative interview and allowed the researcher to explore explanations of the findings identified in the analysis of the survey data.

7.5 Avenues for future research

Although three research topics in this thesis address some questions about policy reforms for the development of an alternative farm economy in Uganda, many questions remain unanswered. Future studies at the farm household level will be required to address them. So far, the study has identified issues related to the structure of the farm decision process – profitability, factors associated with tobacco supply, and farm efficiency. To an extent, the data have enabled some of these issues to be empirically established; however, the results are tentative.

The assumption of independence in the decision-making process has yet to be established as an appropriate characterisation of a decision-making process in farming tobacco and other crops. The robustness of the results on farm profitability, efficiency and tobacco-supply response achieved in this study would require building a broad and reliable database at the household level. Specifically, the database should incorporate data on the biophysical variables (i.e. slope, soil texture, climate, soil types), farm technology, human capital, and commodity and factor prices.

Notwithstanding these caveats, the study recommends that any future research endeavour on the Ugandan farm economy should elicit the future of tobacco farming, and how tobacco farmers understand the meaning, and implications, of the changes in tobacco-leaf farming. In addition, research is needed on what the current tobacco-farming environment attributes to alternative farming, and how farmers see the future. Further research should investigate future responses to the current situation, and the change to a post-tobacco farming era, so as to help tobacco farmers adjust to the rapid increase in tobacco-control measures and to make a successful transition to a different farming environment. In particular, research is needed to explore the implications of changes for the welfare of tobacco-farm households across the different sectors of the economy. Policy scenarios can be developed with positive mathematical programming models to determine the implications to farmers. In conclusion, this thesis has demonstrated that with proper support, innovation, and persistence, the alternative livelihoods agenda may be within reach after all.

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Appendices

Appendix A: Survey Information Letter & Consent Form

Dear Head of Household,

Your district has been identified for a research study that is looking at the economics of tobacco leaf production and feasible alternatives in tobacco farming communities of Arua and Maracha districts in the West Nile sub-region. I would like to invite you to take part in the research by completing a farm household questionnaire. However, before you decide whether or not you wish to take part please take some time to read the following information carefully.

Why is this study being carried out?

There has been a lot of interest in the production of tobacco leaf and alternative livelihoods particularly in less developed countries like Uganda. You will probably remember seeing adverts on TV about the dangers of smoking and how smoking can cause cancer. In this regard, the World Health Organisation has set out regulations on how tobacco smoking can be reduced but also on how tobacco farmers can be assisted to transition to other livelihoods because these regulations could in the near future affect the incomes of households that farm tobacco leaf. This study will look at the economics of tobacco leaf production and investigate productivity and production behaviour within these farms in comparison to alternative crops.

Why have I been selected for the study?

You have been selected to participate in the study because you are farmer of either tobacco leaf or an alternative crop or you farm both tobacco and other crops.

Do I have to take part in the study?

It is up to you whether you decide to take part as your participation is completely voluntary. If you are willing to take part in the study please proceed to complete the consent form then complete the survey questionnaire. If you decide to take part in the study entered into a draw and you will get farming tools – a hoe and panga, as a way of showing that we appreciate you taking part in the study.

What will I have to do?

All you have to do is to answer the questionnaire. If you need assistance, the field assistant/or myself will guide through the questionnaire. If you can complete it independently, please return the completed questionnaire to the field assistant or myself. The questionnaire takes about 40 minutes to complete.

What will happen to the information that I provide?

The data that you provide will be kept strictly confidential. Your identity will not be disclosed and your consent form will be kept separately from the questionnaire to keep your responses confidential. The data will be securely kept away and only my supervisory committee and I will be allowed to look at the responses that you provide. All the data collected from the farm households will be analysed hence it will be impossible to identify you as an individual in the report. The study will be written up as my PhD thesis and parts of it may be published in different economics journals.

Thank you for reading this information sheet. If you would like to take part in the study please fill in the attached consent form and proceed to complete the questionnaire.

FARM HOUSEHOLD SURVEY

<u>CONSENT FORM</u>

Thank you for agreeing to take part in this study.

If anything about this study is still unclear and you have any questions, please do not hesitate to contact the researcher **before** signing this form.

Catherine Namome (the researcher) can be contacted directly on 0758468115

<u>CONSENT</u>

- I confirm that I have read and understand the information in the letter.
- I understand that taking part in this study will not affect my household in any way.
- I understand that my participation is voluntary and I am free to withdraw at any time.
- I understand that all of the information that I give will be held in the strictest confidence.
- I have been given the researcher's contact details in case I wish to inquire for any further questions about the study.

I ____ (*write name*) agree to take part in the study.

Signed: ______________________________ Date: ________________________________

If you would like to receive farm tools as a gift please complete your contact details:

Contact telephone number: ____

Or email address: ____

Appendix B: Survey Questionnaire

UNIVERSITY OF CAPE TOWN :: FACULTY OF COMMERCE
SCHOOL OF ECONOMICS

FARM HOUSEHOLD QUESTIONNAIRE

STUDY TITLE: The Economics of Tobacco Leaf Production and Feasible Alternatives in Uganda

PART 0: GENERAL INFORMATION

QUESTIONNAIRE NO: …………………… **Plot#.....................................** **FARM HOUSEHOLD ID: ………………………**

	Name/Description	Code	Type of farmer (Please t*ick the right alternative)*		Name/Date		Sign
District			*Tobacco farmer(local cultivar)[7]=1*		Date of Interview		
Sub country			*Tobacco farmer (improved cultivar)=2*		Interviewed by		
LC1			*Non-tobacco farmer (traditional)[8]=3*		Date checked		
Village			*Non-tobacco farmer (low input)[9]=4*		Checked by		
Telephone contact			*Non-tobacco farmer (High input)[10]=5*		Date entered		

Farm Household IDs start from 001

[7] Assuming all tobacco farmers use high inputs
[8] Traditional: farmers do not use any improved farm practices
[9] Low input: farmers use local and some improved farm practices
[10] High input: farmers use improved practices

PART 1: FARMER'S HOUSEHOLD

Q1.1 ☐	Farmer's (respondent) name________________________________			*A. Head of household?*		*B. ☐ Yes*	*☐ No*
Q1.2 ☐	Age of farmer			*C. ____________________*			
Q1.3 ☐	Gender of farmer			*D. ☐ Male=1*		*E. ☐ Female=2*	
Q1.4 ☐	How many are you in this household?			*F. Adults__________ __*		*G. Children___________*	
Q1.5 ☐	What is your level of education?	*Primary* ☐	*Secondary* ☐	*Diploma* ☐		*Degree* ☐	*Other, pls.specify ________*
Q1.6 ☐	What is your current occupation?	*Farming* ☐	*Teaching* ☐	*Agric. officer* ☐		*Business* ☐	*Other, pls. specify _________*
Q1.7 ☐	What are your other sources of income?	____					
Q1.8 ☐	If you selected farming, what crops do you normally grow?	*Tobacco* ☐ *Coffee* ☐	*Maize* ☐	*Cassava* ☐	*Sweet potatoes* ☐	*Bananas* ☐	*Other, pls. specify* ☐ ____________________
Q1.9 ☐	For how long have you been farming?	2 year ☐	4 years ☐	6 years ☐		8 years ☐	>8years ☐
Q1.10 ☐	Please rank the above crops in terms of their importance as cash crops.	1 ☐	2 ☐	3 ☐		4 ☐	5 ☐

PART 2: STRUCTURE OF LAND TENURE AND ACCESS TO FINANCE

Structure of land tenure								
Q2.1 ☐	Do you own land in this area?	*Yes*	*No*	*Other, please specify;____*				
Q2.2 ☐	If yes, how much land (total) do you have?	______________________________*acres*						
Q2.3 ☐	Tenure of land?	*Communal* ☐	*Private* ☐	*Freehold* ☐	*Family/clan* ☐	*Other, please specify;__________________*		
Q2.4 ☐	How much of this land is occupied by farming?	________________________________*acres*						
Q2.5 ☐	How did you obtain this land?	*Family inheritance* ☐	*Purchased* ☐	*Renting* ☐	*Other, please specify;_________________*			
Q2.6 ☐	If you rent land, what was the cost of renting last season?	__________________________________*Ush*						
Q2.7 ☐	What is your farm size	*<1 acre*	*2*	*3*	*4*	*5*	*>5*	*Other, specify________________*

Access to finance							
Q2.8	Do you have financial institutions in your area	*Yes* ☐	*No* ☐	*If yes, please list these institutions?*__________			
Q2.9	How do you normally finance your input costs?	*Do not buy inputs* ☐	*Own finances* ☐	*Loan from banks* ☐	*Money lenders* ☐	*Tobacco leaf companies* ☐	*Interested in financing but no access* ☐
Q2.10	If you access finance, what are the terms?	__________					
Q2.11	What types of collateral do you normally provide?	__________					
Q2.12	When are you expected to pay back the loan?	__________					
Q2.13	Would getting some form of credit/loan improve your tobacco / non-tobacco production?	__________					
Q2.14	Have there been experiences where you have failed to pay back the loan? And what were the consequences?	__________					

PART 3: CROP PRODUCTION AND MARKETING SEASON 2013/2014

Q 3.1. Area Planted and Harvested

Area planted (acres)	Qty of seedlings/seeds planted	Cropping system	Qty harvested	Unit price (UGX)	Value of production

Cropping systems: 1. Mono cropping. 2. Intercropping. 3. Mixed cropping. 4. Relay cropping.

Q 3.2. Tobacco Production and sales

Product form	Qty lost	Qty sold	Qty consumed	Unit price (UGX)	Total value	Where sold (market)
Flue/ Fire cured						
Air cured						
Other (specify)						

Market outlet (where sold codes): 1. Farm gate 2. Local market 3. BATU 4. Local vendors 5. Town market 6. Retail stall 7. Cooperative 8.Other (specify)

Q 3.3. Non-Tobacco Production and sales

Product form	Qty lost	Qty sold	Qty consumed	Unit price (UGX)	Total value	Where sold (market)
Maize Grain						
Milled Rice						
Coffee						
Cotton						
Ground Nuts						
Sorghum						
Millet						

Q 3.3. Non-Tobacco Production and sales						
Product form	**Qty lost**	**Qty sold**	**Qty consumed**	**Unit price (UGX)**	**Total value**	**Where sold (market)**
Simsim						
Sunflower						
Other (specify)__________						

PART 4: CROP PRODUCTION COSTS: TOTAL VARIABLE AND FIXED COSTS INCURRED SEASON 2013/2014 *(please tick only inputs that apply to a specific farmer)*

Q4.1 Variable Costs						
Item	**Used Input (Yes=2, No=1)**	**Input Type (e.g LAN, NPK)**	**Input Source**	**Qty applied**	**Unit cost (UGX)**	**Total Cost (UGX)**
Seedlings						
Inorganic Fertiliser						
Animal manure						
Compost manure						
Mulch						
Inorganic insecticides						
Organic pesticides						
Herbicides						
Bags						
Baling (Hessian) cloth						
Jute twine						
Fuel wood						
Other Costs (specify)		Transportation costs (inputs to farm)				
		Transportation costs (outputs to home)				
		Transportation costs (outputs to market)				
		Market fees				
		Loading fees				
		Water for irrigation				
		Land rental				

Q4.2 Fixed Costs				
Item	**Used Input (Yes=2, No=1)**	**Input Source**	**Unit cost (UGX)**	**Total Cost (UGX)**
Kiln (for firing Tobacco)				
Hoes				
Wire mesh				
Thermometer				
Sticks for drying leaves				
Saws				
Fuel pipes				
Pangas				
Clipping shears				
Axe				
Rakes				
Slashers				
Wheelbarrows				
Drying shed				
Baler				
Drums				
Buckets				
Knapsack Sprayer				
Tractor				
Ox plough and oxen				
Watering can				
Polythene sheets				
Tarpaulins				
Weighing scale				
Drying mats				
Irrigation machinery (water pumps, pipes)				
Other (specify)				
Loan payments (interest on loan, insurance premiums)	Year incurred		Total amount incurred	

PART 5: LABOUR USE ON TOBACCO /NON TOBACCO ENTERPRISES SEASON 2013/2014

Q 5.1. What is the source of your farm labour supply	**Exchange**	**Family**	**Hired**

Q 5.2. Did you hire labour to work on your tobacco/non tobacco farm in the season of 2013/2014? Yes ☐ **No** ☐

Q 5.3. If yes, please use table below to specify for which activity did you require hired labour?

Farm activity	**No. of labourers**	**Man-days each labourer worked**	**Hours worked per day (average)**	**Payment terms (unit of work) e.g. day, area planted, Qty harvested?**	**Units of work done in total**	**Rate paid per unit of work**	**Other costs incurred e.g. food, beer, kind payment) estimated value**

Farm activity Codes: 1. Ploughing. 2. Planting 3. Weeding. 4. Harvesting. 5. Applying Fertiliser. 6. Curing Tobacco. 7. Marketing. 8. Applying growth hormones. 9. Other (specify)

Q5.4. If you answered *'No'* in Q 5.1, we assume that you utilise family/exchange labour on your farm. Please detail your family labour use in the case of tobacco or non-tobacco enterprises *(tick the applicable farm activity depending on the enterprise)*

Farm activity	**Family/exchange labour**												**Other labour(Labour exchange & Donation)**	
	Men				**Women**				**Children**					
	#	Hrs worked/ day	Days	Estd cost/day (UGX)	No.	Hrs worked/ day	Days	Estd cost /day (UGX)	#	Hrs worked /day	Days	Estd cost/da y (UGX)	Total Hrs worked	Total Estd Cost (UGX)

Q5.4. If you answered *'No'* in Q 5.1, we assume that you utilise family/exchange labour on your farm. Please detail your family labour use in the case of tobacco or non-tobacco enterprises *(tick the applicable farm activity depending on the enterprise)*

Farm activity	Family/exchange labour												Other labour(Labour exchange & Donation)	
	Men				Women				Children					
	#	Hrs worked/ day	Days	Estd cost/day (UGX)	No.	Hrs worked/ day	Days	Estd cost /day (UGX)	#	Hrs worked /day	Days	Estd cost/day (UGX)	Total Hrs worked	Total Estd Cost (UGX)
Bush clearing														
Making ridges														
1st Ploughing														
2nd Ploughing														
Nursery setup & management														
Planting seedlings														
Gap filling														
Watering/irrigation														
Thinning														
1st Weeding														
2nd Weeding														
3rd Weeding														
Applying inorganic fertiliser (basal)														
Applying fertiliser (top dressing)														
Applying hormones														
Topping														
Applying insecticides														
Applying herbicides														
Watering/irrigation														
Protecting crop														

Q5.4. If you answered *'No'* in Q 5.1, we assume that you utilise family/exchange labour on your farm. Please detail your family labour use in the case of tobacco or non-tobacco enterprises *(tick the applicable farm activity depending on the enterprise)*														
Farm activity	**Family/exchange labour**												**Other labour(Labour exchange & Donation)**	
	Men				**Women**				**Children**					
	#	Hrs worked/ day	Days	Estd cost/day (UGX)	No.	Hrs worked/ day	Days	Estd cost /day (UGX)	#	Hrs worked /day	Days	Estd cost/da y (UGX)	Total Hrs worked	Total Estd Cost (UGX)
against livestock														
Pruning														
Uprooting diseased plants														
Harvesting														
Curing tobacco (managing the kiln (keep the fire burning)														
Stringing														
Collecting firewood for curing														
Sorting														
Bagging														
Baling														
Grading/Sorting														
Transporting to home														
Transporting to market e.g. BATU, cooperative														
Marketing														
Other (specify)														

#=number (quantity)

Technical support and membership to farmer groups				
	Are you part of a farmer group?	*Yes* ☐	*No* ☐	*If yes, please specify what kind of group.*

PART 6: TECHNICAL SUPPORT *(The second section to be answered by non-tobacco farmers only)*

Q 6.1 ☐				Extension contact group	Farmer association/ cooperative	Other, specify;
Q 6.2 ☐	What are the functions of this group?	____________				
Q 6.3 ☐	When and why did you become a member (any benefits)?	____________				
Q 6.4 ☐	Does the group address your crop related issues?	Yes ☐	No ☐	*If yes, please identify the related issues addressed.* ____________		
Q 6.5 ☐	Did you receive assistance from an extension officer about your crop last season?	Yes ☐	No ☐	*If yes, how many times last season?* Once a month ☐	Thrice a month ☐	Other, specify;________
Q 6.16 ☐	Who provides the extension services?	Farmer groups ☐		Government ☐	Cooperatives ☐	Other, specify;__________
Q 6.7 ☐	Which kind of information is provided by extension agents?			____________ ____________		
Q6.8 ☐	Do you pay for extension services?	Yes	No	*If yes, how much does it cost per season?* ____________		
Q 6.9 ☐	Have you received any training on the crop you are growing?	Yes ☐	No ☐	*If yes, who provided the training?* NAADS ☐	Extension officer from government ☐	Other, specify: ____________
Q 6.10 ☐	Apart from extension services, how else do you obtain your information about the crop you grow?	Radio ☐	Neighbour ☐	Family ☐	Newspapers ☐	Other, specify;________
Q 6.11 ☐	What kind of information do you get?	Prices ☐	Production ☐	Marketing channels ☐		Other, specify;__________ __________

Reasons for cultivating tobacco and non-tobacco crops

Q 6.12 ☐	Do you have any reason for cultivating tobacco or non-tobacco crops?	Yes ☐	No ☐	*If yes, please select the preferred reason.*				
				Profitable ☐	Available market ☐	Available technology ☐	Available farm inputs ☐	Farming experience ☐
				Suitability in the area ☐	Resistance to pests ☐	Others, specify; ____________		
Q 6.13	Are you previously a tobacco grower?	Yes ☐	No ☐	*If yes, why did you shift from tobacco to non-tobacco crops?* Reasons:____________				
Q 6.14	If no, why not grow tobacco?	Reasons:____________ ____________						
Q 6.15 ☐	Will you continue to grow non-tobacco crops in season 2014?	Yes ☐	No ☐	Why?____________ ____________				

Q 6.16	If given the opportunity, can you grow tobacco during the next season?	*Yes*	*No*	*Why?*____________________

Appendix C: Enterprise budgets for Tobacco leaf, Cassava, Coffee, Maize, Sweet potato, Rice, Sunflower, Sorghum and Beans

Enterprise Budget: Tobacco Leaf					Uganda currency converted to USD
Crop: Tobacco	**Unit**	**Price or cost/unit**	**Quantity**	**Value or cost / harvested area**	
1. Value of production:					
Tobacco leaf	Kg	2 805	128126	359 393 430	
Total value of production				359 393 430	130215
2. Variable Costs					
Pre-harvest Farm Activities					
Seedling cost	per seedling	350	225596	78 958 600	
Fertiliser N,P,K 11:22:22	20kg bags	117 605	216	25 402 680	
Insecticides/Pesticides	Litre	15 683	376	5 896 710	
Hired Labour					
Land preparation	Man-days	1 844	741	1 366 761	
Transplanting	Man-days	2 106.72	1178	2 481 449	
Weeding	Man-days	1 652.54	734	1 212 140	
Fertiliser application	Man-days	880.00	170	149 490	
Harvesting	Man-days	1 826.00	1562	2 851 299	
Family labour					
Land preparation	Man-days	2 000	1 475	2 949 750	
Transplanting	Man-days	2 000	1 541	3 082 500	
Weeding	Man-days	2 000	1 502	3 003 750	
Fertiliser application	Man-days	900	531	477 900	
Harvesting	Man-days	2 000	3 512	7 024 500	
Total pre-harvest cost per harvested area				134 857 528	48861
Pre-harvested cost per kg				1 052.5383	0.381

Post-Harvest					
Hired labour: curing	Man-days	1 321	1140	1 505 029	
Family labour: curing	Man-days	1 500	2712	4 068 563	
Hired Loading labour	Man-days	1 905	83	158 571	
Family Loading labour	Man-days	1 000	246	246 375	
Transport cost	Vehicle hire per trip	16 534	85	1 405 381	
Jute twine	per roll	8 752	116	1 015 264	
Fire wood	per cubic metre	5 633	810	4 562 449	
Fuel pipes	per piece	69 886	54	3 773 864	
Total post-harvest cost per harvested area				16 735 495	6064
Post-harvested cost per kg				131	0.047
Farm Expenditure (total variable costs)				151 593 023	54925
Gross Profit				207 800 407	75290
Gross Profit Margin (%)				57.82	57.82

Enterprise Budget: Cassava					Uganda currency converted to USD
Crop: Cassava	**Unit**	**Price or cost/unit**	**Quantity**	**Value or cost / harvested area**	
1. Value of production:					
Cassava	Kg	906.06	62132	56 295 320	
Total value of production				**56 295 320**	20397
2. Variable Costs					
Preharvest Farm Activities					
Cassava stem cuttings	per bag of cuttings	9 571	435	4 165 392	
Fertiliser N,P,K 11:22:22	20kg bags	115 026	60	6 901 560	
Insecticides/Pesticides	2 Ltr Bottle	16 643	126	2 096 969	
Hired Labour					
Land preparation	Man-days	0	0	0	
Planting	Man-days	1 860	410	761 763	
Weeding	Man-days	1 548	325	503 383	
Fertiliser application	Man-days	841	191	160 923	
Harvesting	Man-days	1 737.50	653	1 133 719	
Family labour					
Land preparation	Man-days	2 000	375	749 250	
Planting	Man-days	1 694	588	996 672	
Weeding	Man-days	1 480	536	792 540	
Fertiliser application	Man-days	885	397	351 345	
Harvesting	Man-days	1 474	896	1 320 184	
Total pre-harvest cost per harvested area				**19 933 699**	7222

Pre-harvested cost per kg				320.8282	0.116
Post-Harvest					
Hired Loading labour	Man-days	1 973	33	64 360	
Family Loading labour	Man-days	1 132	128	145 179	
Transport cost	Vehicle hire per trip	0	0	0	
Packaging bags	per roll	6 000	230	1 380 000	
Total post-harvest cost per harvested area				**1 589 539**	576
Post-harvested cost per kg				26	0.009
Farm Expenditure (total variable costs)				**21 523 239**	7798
Gross Profit				**34 772 081**	12599
Gross Profit Margin (%)				61.77	61.77

Enterprise Budget: Coffee					Uganda currency converted to USD
Crop: Coffee	**Unit**	**Price or cost/unit**	**Quantity**	**Value or cost / harvested area**	
1. Value of production:					
Coffee	Kg	4 929	31 725	156 372 525	
Total value of production				**156 372 525**	56657
2. Variable Costs					
Preharvest Farm Activities					
Seedling cost	per seedling	300	18040	5 412 000	
Fertiliser N,P,K 11:22:22	20kg bags	100 474	27	2712798	
Insecticides/Pesticides	Litre	17 809	41	730 164	
Hired Labour					
Land preparation	Man-days	1 781	295	525 092	
Transplanting	Man-days	1 981	219	434 484	
Weeding	Man-days	1 556	224	348 405	
Fertiliser application	Man-days	833.33	77	63 750	
Harvesting	Man-days	1 895	404	765 237	
Family labour					
Land preparation	Man-days	1 635	266	434 128	
Transplanting	Man-days	1 816	228	414 769	
Weeding	Man-days	1 431	398	569 804	
Fertiliser application	Man-days	913	109	99 668	
Harvesting	Man-days	1 868	1 546	2 888 112	
Total pre-harvest cost per harvested area				**15 398 412**	5579
Pre-harvested cost per kg				485.3715	0.176

Post-Harvest					
Hired labour: postharvest (cherry sorting, pulping, drying)	Man-days	0	0	0	
Family labour: postharvest (cherry sorting, pulping, drying)	Man-days	1 545	1598	2 467 717	
Hired Loading labour	Man-days	0	0	0	
Family Loading labour	Man-days	1 000	91	91 125	
Storage	per night	0	0	0	
Transport costs	Vehicle hire per trip	9 000	27	243 000	
Total post-harvest cost per harvested area				**2 801 842**	1015
Post-harvested cost per kg				88	0.032
Farm Expenditure (total variable costs)				**18 200 254**	6594
Gross Profit				**138 172 271**	50062
Gross Profit Margin (%)				88.36	88.36

Enterprise Budget: Maize					Uganda currency converted to USD
Crop: Maize	**Unit**	**Price or Cost/unit**	**Quantity**	**Value or Cost / harvested area**	
1. Value of production:					
Maize	Kg	2 125	4870	10 348 750	
Total value of production				**10 348 750**	3750
2. Variable Costs					
Preharvest Farm Activities					
Planting seeds	kgs	800	160	128 000	
Fertiliser N,P,K 11:22:22	20kg bags	108 367	6	650 202	
Insecticides/Pesticides	Litre	15 113	20	302 267	
Hired Labour					
Land preparation	Man-days	0	0	0	
Planting	Man-days	0	0	0	
Weeding	Man-days	0	0	0	
Fertiliser application	Man-days	0	0	0	
Harvesting	Man-days	0	0	0	
Family labour					
Land preparation	Man-days	1 980	36	71 280	
Transplanting	Man-days	1 863	60	111 052	
Weeding	Man-days	1 767	45	79 500	
Fertiliser application	Man-days	1 000	18	18 000	
Harvesting	Man-days	1 375	71	97 453	
Total pre-harvest cost per harvested area				**1 457 753**	528

Pre-harvested cost per kg				299	0.108
Post-Harvest					
Hired Loading labour	Man-days	0	0	0	
Family Loading labour	Man-days	0	0	0	
Agrochemicals for storage	Bottle	11 500	18	207 000	
Packaging bags	Bags	11 000	27	297 000	
Storage	per night	0	0	0	
Transport cost	Vehicle hire per trip	0	0	0	
Total post-harvest cost per harvested area				**504 000**	183
Post-harvested cost per kg				103	0.037
Farm Expenditure (total variable costs)				**1 961 753**	711
Gross Profit				**8 386 997**	3039
Gross Profit Margin (%)				81.04	81.04

Enterprise Budget: Beans					Uganda currency converted to USD
Crop: Beans	**Unit**	**Price or Cost/unit**	**Quantity**	**Value or Cost / harvested area**	
1. Value of production:					
Beans	Kg	2 444	10027	24 505 988	
Total value of production				**24 505 988**	8879
2. Variable Costs					
Preharvest Farm Activities					
Seeds	kgs	2 000	276	552 000	
Fertiliser N,P,K 11:22:22	20kg bags	108 367	14	1 517 138	
Insecticides/Pesticides	2 Litre Bottle	19 005	30	570 150	
Hired Labour					
Land preparation	Man-days	1 508	60	89 934	
Planting	Man-days	1 757	41	71 164	
Weeding	Man-days	1 640	42	68 265	
Fertiliser application	Man-days	0	0	0	
Harvesting	Man-days	1 600	107	171 000	
Family labour					
Land preparation	Man-days	1 873	111	208 575	
Planting	Man-days	1 730	74	128 453	
Weeding	Man-days	1 750	56	98 438	
Fertiliser application	Man-days	900	10	9 113	
Harvesting	Man-days	1 750	120	210 656	
Total pre-harvest cost per harvested area				**3 694 885**	1339

Pre-harvested cost per kg				368.4936	0.134
Post-Harvest					
Hired Loading labour	Man-days	0	0	0	
Family Loading labour	Man-days	0	0	0	
Agro-chemicals for storage	Bottles	9 440	31	292 640	
Storage	per night	0	0	0	
Packaging bags	Bags	11 000	80	880 000	
Transport cost	Vehicle hire per trip			0	
Total post-harvest cost per harvested area				**1 172 640**	425
Post-harvested cost per kg				117	0.042
Farm Expenditure (total variable costs)				**4 867 525**	1764
Gross Profit				**19 638 463**	7115
Gross Profit Margin (%)				80.14	80.14

Enterprise Budget: Sweet Potatoes					Uganda currency converted to USD
Crop: Sweet potatoes	**Unit**	**Price or Cost/unit**	**Quantity**	**Value or Cost / harvested area**	
1. Value of production:					
Sweet potatoes	Kg	914	8130	7 430 820	
Total value of production				**7 430 820**	2692
2. Variable Costs					
Preharvest Farm Activities					
Sweet potato cuttings	per bag of cuttings	6 000	191	1 146 000	
Fertiliser N,P,K 11:22:22	20kg bags	103 500	3	310 500	
Insecticides/Pesticides	Litre	0	0	0	
Hired Labour					
Land preparation	Man-days	1 938	33	112 821	
Planting	Man-days	1 517	26	158 899	
Weeding	Man-days	0	0	90 653	
Fertiliser application	Man-days	0	0	0	
Harvesting	Man-days	1 813	41	156 825	
Family labour					
Land preparation	Man-days	1 929	59	63 211	
Planting	Man-days	1 744	91	39 244	
Weeding	Man-days	1 580	57	0	
Fertiliser application	Man-days	0	0	0	
Harvesting	Man-days	1 700	92	73 406	
Total pre-harvest cost per harvested area				**2 151 559**	780

Pre-harvested cost per kg				264.6444	0.096
Post-Harvest					
Hired Loading labour	Man-days	0	0	0	
Family Loading labour	Man-days	0	0	0	
Transport cost	Vehicle hire per trip	0	0	0	
Agro-chemicals for storage	Bottles	0	0	0	
Storage	per night	0	0	0	
Packaging bags	Bags	0	0	0	
Total post-harvest cost per harvested area				**0**	0
Post-harvested cost per kg				0	0.000
Farm Expenditure (total variable costs)				**2 151 559**	780
Gross Profit				**5 279 261**	1913
Gross Profit Margin (%)				71.05	71.05

Enterprise Budget: Sorghum					Uganda currency converted to USD
Crop: Sorghum	**Unit**	**Price or Cost/unit**	**Quantity**	**Value or Cost / harvested area**	
1. Value of production:					
Sorghum	Kg	2 360	1547	3 650 920	
Total value of production				**3 650 920**	1323
2. Variable Costs					
Preharvest Farm Activities					
Seeds cost	kgs	971	68	66 057	
Fertiliser N,P,K 11:22:22	20kg bags	118 100	10	1 181 000	
Insecticides/Pesticides	Litre	2 840	40	113 600	
Hired Labour					
Land preparation	Man-days	0	0	0	
Transplanting	Man-days	0	0	0	
Weeding	Man-days	0	0	0	
Fertiliser application	Man-days	0	0	0	
Harvesting	Man-days	0	0	0	
Family labour					
Land preparation	Man-days	2 500	41	101 250	
Transplanting	Man-days	2 000	51	101 250	
Weeding	Man-days	1 450.00	21	30 994	
Fertiliser application	Man-days	800.00	7	5 400	
Harvesting	Man-days	1 500.00	39	59 063	
Total pre-harvest cost per harvested area				**1 658 613**	601

Pre-harvested cost per kg				1 072.1483	0.388
Post-Harvest					
Hired Loading labour	Man-days	1 500	6	8 438	
Family Loading labour	Man-days	0	0	0	
Transport cost	Vehicle hire per trip	0	0	0	
Total post-harvest cost per harvested area				**8 438**	3
Post-harvested cost per kg				5	0.002
Farm Expenditure (total variable costs)				**1 667 051**	604
Gross Profit				**1 983 869**	719
Gross Profit Margin (%)				54.34	54.34

Enterprise Budget: Rice					Uganda currency converted to USD
Crop: Rice	**Unit**	**Price or Cost/unit**	**Quantity**	**Value or Cost / harvested area**	
1. Value of production:					
Rice	Kg	2 300	5943	13 668 900	
Total value of production				**13 668 900**	4953
2. Variable Costs					
Preharvest Farm Activities					
Seeds cost	kgs	1 200	119	142 800	
Fertiliser N,P,K 11:22:22	20kg bags	118 100	9	1 062 900	
Insecticides/Pesticides	Litre	13 120	13	170 560	
Hired Labour					
Land preparation	Man-days	0	0	0	
Planting	Man-days	0	0	0	
Weeding	Man-days	0	0	0	
Fertiliser application	Man-days	0	0	0	
Harvesting	Man-days	0	0	0	
Family labour					
Land preparation	Man-days	1 914	107	204 589	
Planting	Man-days	1 819	78	141 180	
Weeding	Man-days	1 500	71	106 313	
Fertiliser application	Man-days	0	0	0	
Harvesting	Man-days	1 813	172	311 977	
Total pre-harvest cost per harvested area				**2 140 319**	775

Pre-harvested cost per kg				360.1411	0.130
Post-Harvest					
Hired labour: drying	Man-days	0	0	0	
Family labour: drying	Man-days	0	0	0	
Hired Loading labour	Man-days	0	0	0	
Family Loading labour	Man-days	0	0	0	
Transport cost	Vehicle hire per trip	0	0	0	
Packaging bags	Bags	11 000	43	473 000	
Storage	per night	0	0	0	
Total post-harvest cost per harvested area				**0**	0
Post-harvested cost per kg				0	0.000
Farm Expenditure (total variable costs)				**2 140 319**	775
Gross Profit				**11 528 581**	4177
Gross Profit Margin (%)				84.34	84.34

Enterprise Budget: Sunflower					Uganda currency converted to USD
Crop: Sunflower	**Unit**	**Price or Cost/unit**	**Quantity**	**Value or Cost / harvested area**	
1. Value of production:					
Sunflower	Kg	1 265	6890	8 715 850	
Total value of production				**8 715 850**	3158
2. Variable Costs					
Preharvest Farm Activities					
Sunflower seeds	kgs	67 500	11	756 000	
Fertiliser N,P,K 11:22:22	20kg bags	0	0	0	
Insecticides/Pesticides	Litre	0	0	0	
Hired Labour					
Land preparation	Man-days	0	0	0	
Planting	Man-days	0	0	0	
Weeding	Man-days	0	0	0	
Fertiliser application	Man-days	0	0	0	
Harvesting	Man-days	0	0	0	
Family labour					
Land preparation	Man-days	1 371	38	52 457	
Planting	Man-days	0	0	0	
Weeding	Man-days	0	0	0	
Fertiliser application	Man-days	0	0	0	
Harvesting	Man-days	1 925	73	140 766	
Total pre-harvest cost per harvested area				**949 223**	344

Pre-harvested cost per kg				137.7682	0.050
Post Harvest					
Hired labour: drying	Man-days	0	0	0	
Family labour: drying	Man-days	0	0	0	
Hired Loading labour	Man-days	0	0	0	
Family Loading labour	Man-days	0	0	0	
Transport cost	Vehicle hire per trip	0	0	0	
Total post-harvest cost per harvested area				**0**	0
Post-harvested cost per kg				0	0.000
Farm Expenditure (total variable costs)				**949 223**	344
Gross Profit				**7 766 627**	2814
Gross Profit Margin (%)				89.11	89.11

Appendix D: Supplementary results for Chapter 4

Total Variance Explained

Total Variance Explained						
Component		Initial Eigenvalues			Extraction Sums of Squared Loadings	
		Total	**% of Variance**	**Cumulative %**	**Total**	**% of Variance**
Dimension	1	5.546	23.109	23.109	5.546	23.109
	2	2.598	10.825	33.933	2.598	10.825
	3	2.322	9.673	43.606	2.322	9.673
	4	1.675	6.980	50.586		
	5	1.641	6.837	57.423		
	6	1.295	5.396	62.819		
	7	1.162	4.840	67.659		
	8	.981	4.086	71.745		
	9	.970	4.042	75.787		
	10	.903	3.764	79.551		
	11	.757	3.155	82.707		
	12	.637	2.655	85.362		
	13	.565	2.356	87.718		
	14	.534	2.223	89.941		
	15	.449	1.872	91.814		
	16	.384	1.602	93.416		
	17	.372	1.552	94.967		
	18	.265	1.104	96.072		
	19	.248	1.035	97.107		
	20	.175	.731	97.838		
	21	.162	.675	98.513		
	22	.141	.588	99.100		
	23	.130	.544	99.644		
	24	.085	.356	100.000		
Extraction Method: Principal Component Analysis.						

Final Cluster Centers

	Cluster		
	1	2	3
Ward Method	1	3	4

Two-sample t test with equal variances

```
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
 tobacco |      73     48.9589    1.485398    12.69125    45.99782    51.91999
nontobac |      53    43.60377    1.436953    10.46117    40.72032    46.48723
---------+--------------------------------------------------------------------
combined |     126    46.70635    1.074026    12.05591    44.58072    48.83198
---------+--------------------------------------------------------------------
    diff |            5.355131    2.130796                1.137688    9.572573
------------------------------------------------------------------------------
    diff = mean(tobacco) - mean(nontobac)                         t =   2.5132
Ho: diff = 0                                     degrees of freedom =      124

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.9934         Pr(|T| > |t|) = 0.0132          Pr(T > t) = 0.0066
```

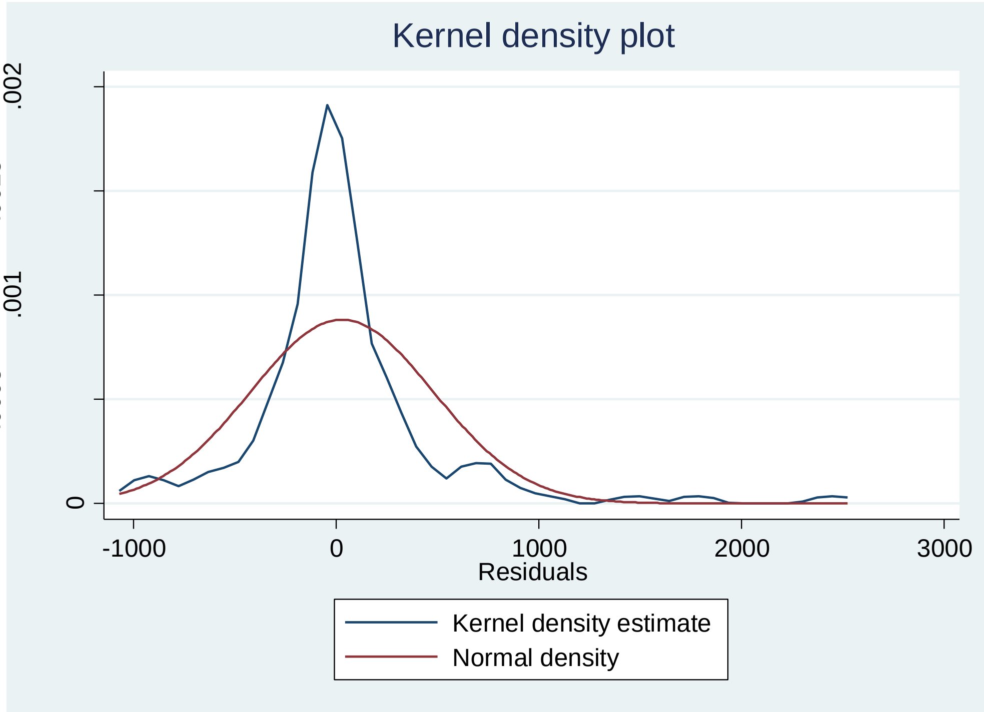
Two-sample t test with equal variances

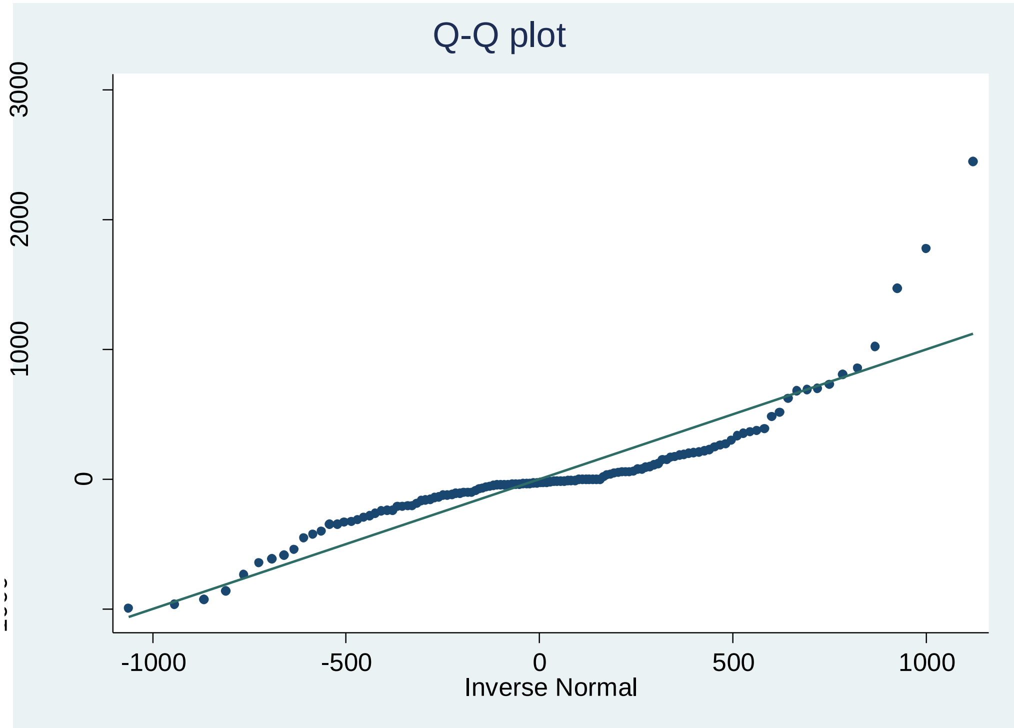
```
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
 tobacco |      73    10.63014    .4843466    4.138259     9.66461    11.59566
nontobac |      53    8.773585    .4576725    3.331906    7.855198    9.691972
---------+--------------------------------------------------------------------
combined |     126    9.849206     .348797    3.915237    9.158894    10.53952
---------+--------------------------------------------------------------------
    diff |            1.856552    .6895249                .4917892    3.221315
------------------------------------------------------------------------------
    diff = mean(tobacco) - mean(nontobac)                         t =   2.6925
Ho: diff = 0                                     degrees of freedom =      124

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.9960         Pr(|T| > |t|) = 0.0081          Pr(T > t) = 0.0040
```

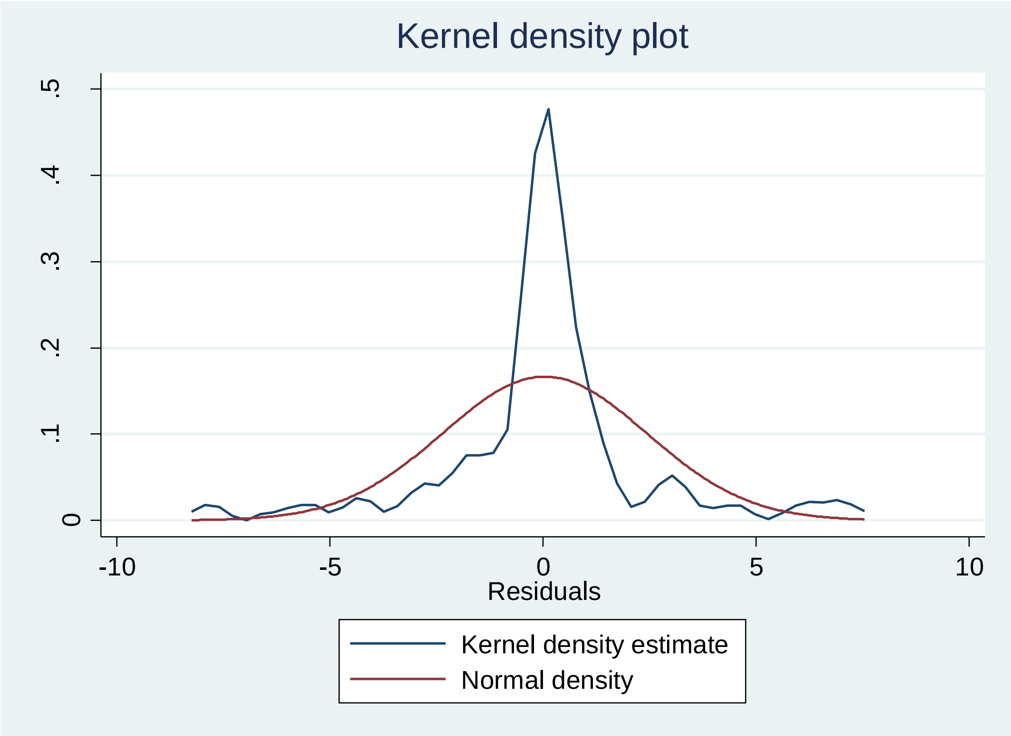
Appendix E: Supplementary results for Chapter 5

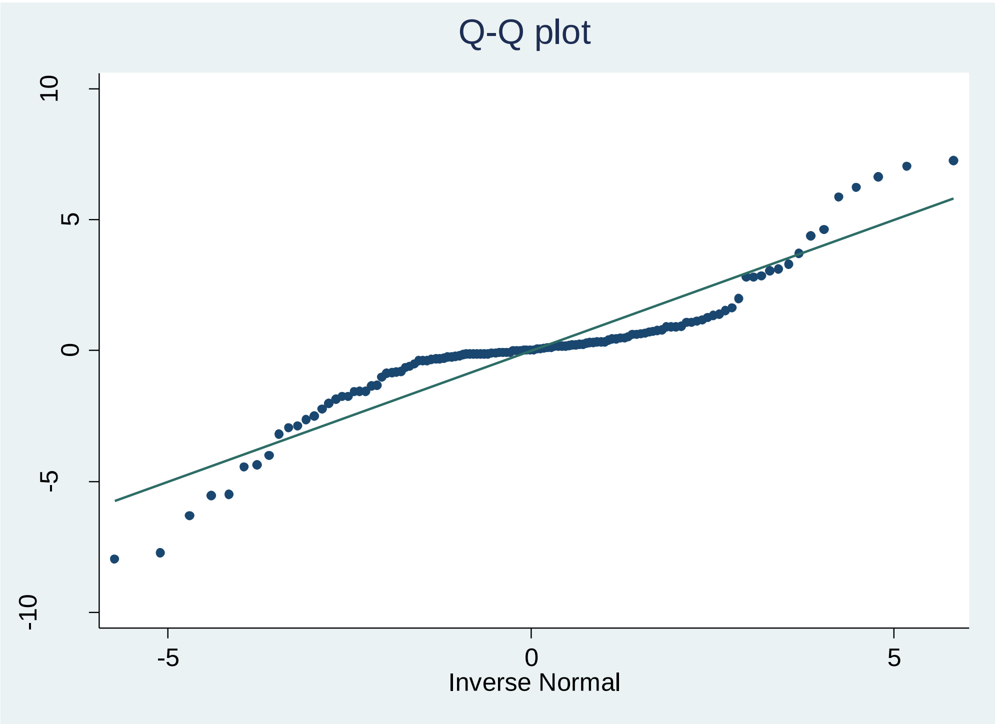
Distribution of the error term - untransformed dependent variable





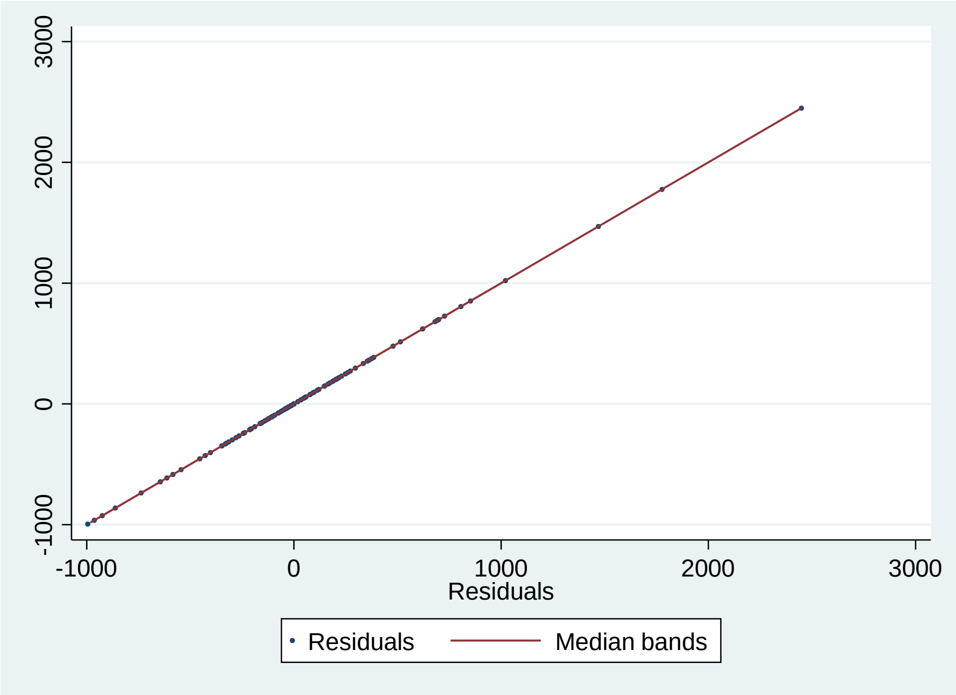
Distribution of the error term - transformed dependent variable



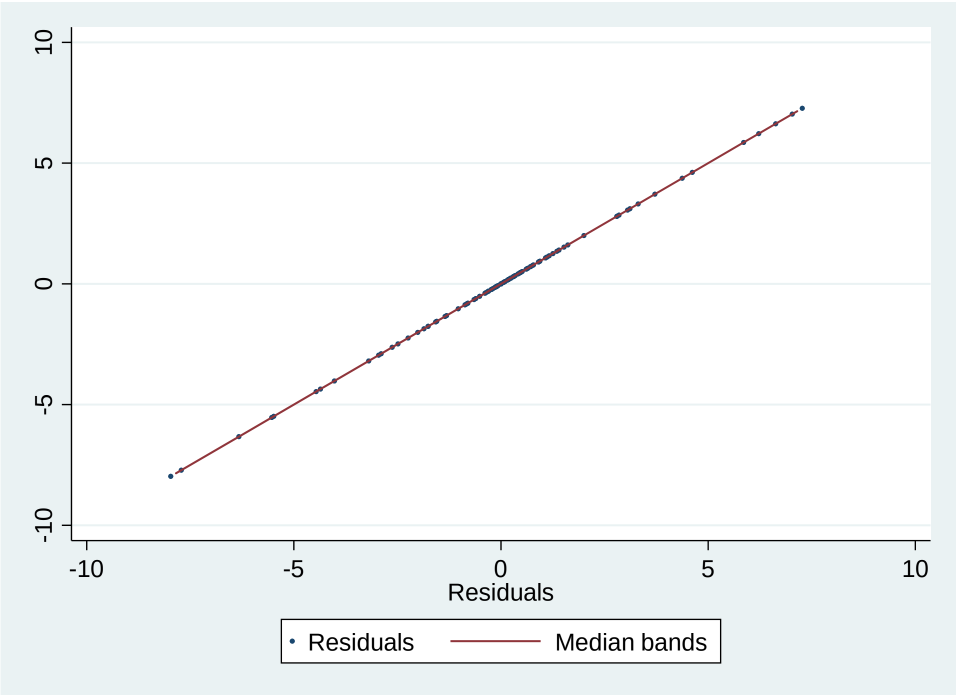


Plot for heteroscedasticity of residuals

Untransformed dependent variable



Transformed dependent variable



Tobit Model - unrestricted

```
Tobit regression                                  Number of obs   =        125
                                                  F(  14,    111) =       9.31
                                                  Prob > F        =     0.0000
Log pseudolikelihood = -616.32732                 Pseudo R2       =     0.1144

------------------------------------------------------------------------------------
                   |               Robust
           tobacco |      Coef.   Std. Err.       t    P>|t|     [95% Conf. Interval]
-------------------+----------------------------------------------------------------
            logage |   514.4667   527.5498     0.98   0.332    -530.9085    1559.842
                   |
              educ |
                2  |   27.53429   319.5218     0.09   0.931    -605.6195    660.6881
                3  |   325.5672   581.8339     0.56   0.577    -827.3755     1478.51
                   |
           rgender |  -138.4798   416.3633    -0.33   0.740    -963.5314    686.5718
extension_services |  -69.85535   281.4615    -0.25   0.804    -627.5902    487.8795
           farmexp |   33.45084   21.38241     1.56   0.121    -8.919825    75.82151
 loghousehold_size |   262.0096   267.7418     0.98   0.330    -268.5386    792.5578
       wtfertprice |   11.89656   30.65268     0.39   0.699    -48.84377    72.63689
       ycoffeeytob |   1403.565   394.7926     3.56   0.001     621.2571    2185.873
      ycassavaytob |  -688.1302    192.744    -3.57   0.001    -1070.065   -306.1952
 relcoffe_tob_10th |  -761.1822   553.8568    -1.37   0.172    -1858.686     336.322
  relcass_tob_10th |   5144.254   2198.276     2.34   0.021     788.2234    9500.285
           logland |  -178.8994   156.1587    -1.15   0.254    -488.3382    130.5395
           lincome |   1864.132   355.2501     5.25   0.000      1160.18    2568.084
             _cons |  -15642.99   4156.143    -3.76   0.000    -23878.67   -7407.315
-------------------+----------------------------------------------------------------
            /sigma |   1015.155   133.6806                      750.2579    1280.052
------------------------------------------------------------------------------------
```

```
          53  left-censored observations at tobacco <= 0
          72     uncensored observations
           0 right-censored observations
```

Tobit Model - restricted

```
Tobit regression                                  Number of obs     =        125
                                                F(  14,    111)   =      17.45
                                                Prob > F          =     0.0000
Log pseudolikelihood = -210.57195               Pseudo R2         =     0.2687
```

tobacco1	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
logage	-.153481	1.583559	-0.10	0.923	-3.291409	2.984447
educ						
2	-.7387573	.7512708	-0.98	0.328	-2.22745	.7499359
3	.9671715	1.682537	0.57	0.567	-2.366888	4.301231
rgender	-.6240217	1.294462	-0.48	0.631	-3.189084	1.941041
extension_services	-.5338684	.9742724	-0.55	0.585	-2.464454	1.396717
farmexp	.124484	.0642094	1.94	0.055	-.0027513	.2517193
loghousehold_size	.9527491	.8026474	1.19	0.238	-.6377503	2.543248
wtfertprice	.0765602	.0914861	0.84	0.404	-.1047255	.257846
ycoffeeytob	6.671273	1.159293	5.75	0.000	4.374057	8.968489
ycassavaytob	-3.078916	.6401394	-4.81	0.000	-4.347395	-1.810437
relcoffe_tob_10th	-4.279181	1.638227	-2.61	0.010	-7.525437	-1.032924
relcass_tob_10th	8.263116	8.199612	1.01	0.316	-7.984961	24.51119
logland	-.265854	.436488	-0.61	0.544	-1.130784	.5990762
lincome	3.77577	.494364	7.64	0.000	2.796154	4.755385
_cons	-22.482	7.325363	-3.07	0.003	-36.9977	-7.966304

```
      /sigma |   3.228075   .3683038                      2.498257    3.957894
------------------------------------------------------------------------------
      53  left-censored observations at tobacco1 <= 0
      72     uncensored observations
       0 right-censored observations
```

Heteroscedastic Double Hurdle Model

```
Cragg hurdle regression                         Number of obs     =        125
                                                Wald chi2(14)     =     423.67
                                                Prob > chi2       =     0.0000
Log pseudolikelihood = -495.38624               Pseudo R2         =     0.2034
```

tobacco	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
tobacco						
logage	.1966508	.2050742	0.96	0.338	-.2052873	.5985889
educ						
2	-.1857028	.1143901	-1.62	0.105	-.4099032	.0384976
3	-.0903483	.1649309	-0.55	0.584	-.413607	.2329103
rgender	.0081636	.1722959	0.05	0.962	-.3295301	.3458573
extension_services	.0233077	.1604776	0.15	0.885	-.2912227	.337838
farmexp	.0017145	.0082518	0.21	0.835	-.0144588	.0178877
loghousehold_size	-.0927506	.1038588	-0.89	0.372	-.2963101	.110809
wtfertprice	.012167	.0075316	1.62	0.106	-.0025946	.0269287
ycoffeeytob	-1.633881	.1816599	-8.99	0.000	-1.989928	-1.277835
ycassavaytob	.4647973	.1362599	3.41	0.001	.1977329	.7318617
relcoffe_tob_10th	-.3399793	.219369	-1.55	0.121	-.7699346	.089976
relcass_tob_10th	2.693976	1.130505	2.38	0.017	.478226	4.909726
logland	.0313006	.0590601	0.53	0.596	-.084455	.1470562
_cons	6.531705	.7567201	8.63	0.000	5.048561	8.014849
selection_ll						
logage	-.1793509	.4681365	-0.38	0.702	-1.096882	.7381798

```
                   |
              educ |
                 2 |  -.2709496     .31922    -0.85   0.396    -.8966093    .3547102
                 3 |  -.0451304   .3239122    -0.14   0.889    -.6799867    .5897259
                   |
           rgender |  -1.085188   .6301057    -1.72   0.085    -2.320173    .1497964
extension_services |   .2038768   .2965962     0.69   0.492     -.377441    .7851946
           farmexp |   .0077987   .0244092     0.32   0.749    -.0400425      .05564
 loghousehold_size |   .7473795   .4930474     1.52   0.130    -.2189757    1.713735
       ycoffeeytob |   2.083647   .6726819     3.10   0.002     .7652145    3.402079
      ycassavaytob |  -.9073983     .39021    -2.33   0.020    -1.672196   -.1426007
 relcoffe_tob_10th |  -1.208429   .6120861    -1.97   0.048    -2.408096   -.0087628
           lincome |   .8278926   .2372105     3.49   0.000     .3629687    1.292817
           logland |   .0764047   .2247323     0.34   0.734    -.3640624    .5168719
             _cons |  -3.523437   2.383709    -1.48   0.139     -8.19542    1.148546
-------------------+----------------------------------------------------------------
lnsigma            |
             _cons |    -1.1024   .1138769    -9.68   0.000    -1.325595   -.8792057
-------------------+----------------------------------------------------------------
lnsigma_ll         |
           logland |  -.3127962   .2156556    -1.45   0.147    -.7354734     .109881
-------------------+----------------------------------------------------------------
            /sigma |    .332073   .0378155                      .2656448    .4151125
------------------------------------------------------------------------------------
```

Box-Cox Heteroscedastic Double-Hurdle Model

```
Cragg hurdle regression                           Number of obs     =        125
                                                  Wald chi2(14)     =     386.41
                                                  Prob > chi2       =     0.0000
Log pseudolikelihood = -73.144263                 Pseudo R2         =     0.6279

------------------------------------------------------------------------------------
                   |               Robust
          tobacco1 |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------------+----------------------------------------------------------------
tobacco1           |
            logage |   .2891348   .2990417     0.97   0.334    -.2969762    .8752459
                   |
              educ |
                2  |   -.262905   .1678375    -1.57   0.117    -.5918604    .0660505
                3  |  -.1298268   .2409048    -0.54   0.590    -.6019915     .342338
                   |
           rgender |   .0055606   .2512009     0.02   0.982    -.4867841    .4979053
extension_services |   .0368785   .2360964     0.16   0.876    -.4258619    .4996189
           farmexp |   .0020536   .0120144     0.17   0.864    -.0214942    .0256014
 loghousehold_size |  -.1309699   .1496839    -0.87   0.382     -.424345    .1624051
       wtfertprice |   .0176889   .0109662     1.61   0.107    -.0038045    .0391824
       ycoffeeytob |  -2.307821   .2672299    -8.64   0.000    -2.831582    -1.78406
      ycassavaytob |   .6796568   .1988494     3.42   0.001     .2899192    1.069395
 relcoffe_tob_10th |  -.4950948   .3183648    -1.56   0.120    -1.119078    .1288888
  relcass_tob_10th |   3.939554   1.647307     2.39   0.017     .7108918    7.168216
           logland |   .0445194   .0866186     0.51   0.607    -.1252498    .2142887
             _cons |   7.560144   1.103644     6.85   0.000      5.39704    9.723247
-------------------+----------------------------------------------------------------
selection_ll       |
            logage |  -.1793509   .4681365    -0.38   0.702    -1.096882    .7381798
```

educ						
2	-.2709496	.31922	-0.85	0.396	-.8966093	.3547102
3	-.0451304	.3239122	-0.14	0.889	-.6799867	.5897259
rgender	-1.085188	.6301057	-1.72	0.085	-2.320173	.1497964
extension_services	.2038768	.2965962	0.69	0.492	-.377441	.7851946
farmexp	.0077987	.0244092	0.32	0.749	-.0400425	.05564
loghousehold_size	.7473795	.4930474	1.52	0.130	-.2189757	1.713735
ycoffeeytob	2.083647	.6726819	3.10	0.002	.7652145	3.402079
ycassavaytob	-.9073983	.39021	-2.33	0.020	-1.672196	-.1426007
relcoffe_tob_10th	-1.208429	.6120861	-1.97	0.048	-2.408096	-.0087628
lincome	.8278926	.2372105	3.49	0.000	.3629687	1.292817
logland	.0764047	.2247323	0.34	0.734	-.3640624	.5168719
_cons	-3.523437	2.383709	-1.48	0.139	-8.19542	1.148546
lnsigma						
_cons	-.7217137	.1167267	-6.18	0.000	-.9504938	-.4929336
lnsigma_ll						
logland	-.3127962	.2156556	-1.45	0.147	-.7354734	.109881
/sigma	.4859188	.0567197			.3865501	.6108318

Dummy and categorical variables - conditional level ($E[y_i|x, y_i > 0]$)

```
Conditional marginal effects                    Number of obs     =        125
Model VCE: Robust

------------------------------------------------------------------------------------
                   |            Delta-method
                   |      ey/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------------+----------------------------------------------------------------
              educ |
                2  |  -.0298952   .0193854    -1.54   0.123    -.0678899    .0080994
                3  |  -.0146511   .0273683    -0.54   0.592    -.0682919    .0389897
                   |
           rgender |     .00063   .0284597     0.02   0.982      -.05515      .05641
extension_services |   .0041782   .0267333     0.16   0.876    -.0482181    .0565744
------------------------------------------------------------------------------------
Note: ey/dx for factor levels is the discrete change from the base level.
```

Dummy and categorical variables - Probability $P[y_i > 0 | x]$

```
Conditional marginal effects                        Number of obs     =        125
Model VCE    : Robust
------------------------------------------------------------------------------------
                   |            Delta-method
                   |      ey/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------------+----------------------------------------------------------------
              educ |
                2  |  -.1871631   .2210208    -0.85   0.397     -.620356    .2460297
                3  |  -.0255139   .1889987    -0.13   0.893    -.3959446    .3449168
           rgender |  -.7003527    .425359    -1.65   0.100    -1.534041    .1333357
extension_services |   .1315769   .1772788     0.74   0.458    -.2158832     .479037
------------------------------------------------------------------------------------
Note: ey/dx for factor levels is the discrete change from the base level.
```

Dummy and categorical variables - unconditional level ($E[y_i|x]$)

```
Conditional marginal effects                      Number of obs     =        125
Model VCE    : Robust

------------------------------------------------------------------------------------
                   |            Delta-method
                   |      ey/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------------+----------------------------------------------------------------
              educ |
                2  |  -.2170584   .2168496    -1.00   0.317    -.6420757     .207959
                3  |   -.040165   .1895171    -0.21   0.832    -.4116116    .3312816
           rgender |  -.6997227   .4235545    -1.65   0.099    -1.529874    .1304289
extension_services |    .135755   .1753119     0.77   0.439      -.20785    .4793601
------------------------------------------------------------------------------------
Note: ey/dx for factor levels is the discrete change from the base level.
```

Continuous variables - conditional level ($E[y_i|x, y_i > 0]$)

Conditional marginal effects Number of obs = 125
Model VCE : Robust

	ey/dx	Delta-method Std. Err.	z	P>|z|	[95% Conf.	Interval]
logage	.1249186	.1286568	0.97	0.332	-.1272442	.3770813
farmexp	.0024048	.0140857	0.17	0.864	-.0252027	.0300122
loghousehold_size	-.0328706	.0375842	-0.87	0.382	-.1065343	.0407931
wtfertprice	.081751	.050792	1.61	0.108	-.0177995	.1813016
ycoffeeytob	-.155482	.0165119	-9.42	0.000	-.1878447	-.1231193
ycassavaytob	.0575595	.0163623	3.52	0.000	.02549	.0896291
relcoffe_tob_10th	-.1016943	.0655468	-1.55	0.121	-.2301637	.0267752
relcass_tob_10th	.166738	.0695018	2.40	0.016	.030517	.302959
logland	.0070327	.0137042	0.51	0.608	-.019827	.0338925

Continuous variables - unconditional level ($E[y_i|x]$)

Conditional marginal effects Number of obs = 125
Model VCE : Robust

	ey/ex	Delta-method Std. Err.	z	P>|z|	[95% Conf.	Interval]
logage	-.31648	1.159685	-0.27	0.785	-2.58942	1.95646
farmexp	.0544269	.1558357	0.35	0.727	-.2510055	.3598594
loghousehold_size	1.035638	.5777522	1.79	0.073	-.096735	2.168012
wtfertprice	.081751	.050792	1.61	0.108	-.0177995	.1813016
logland	.2010626	.2182884	0.92	0.357	-.2267747	.6289
ycoffeeytob	.6441732	.2182317	2.95	0.003	.216447	1.071899
ycassavaytob	-.3801907	.1523172	-2.50	0.013	-.6787269	-.0816545
relcoffe_tob_10th	-1.515632	.5108429	-2.97	0.003	-2.516865	-.5143979
relcass_tob_10th	.166738	.0695018	2.40	0.016	.030517	.302959
lincome	3.45178	.7892925	4.37	0.000	1.904795	4.998765

Continuous variables - Probability P[$y_i > 0 | x$]

```
Conditional marginal effects                      Number of obs     =        125
Model VCE    : Robust

------------------------------------------------------------------------------------
                  |            Delta-method
                  |      ey/ex   Std. Err.      z    P>|z|     [95% Conf. Interval]
------------------+-----------------------------------------------------------------
           logage |  -.4413985   1.174135    -0.38   0.707    -2.742662    1.859865
          farmexp |   .0520222   .1584071     0.33   0.743      -.25845    .3624944
loghousehold_size |   1.068509   .5818748     1.84   0.066    -.0719446    2.208963
      wtfertprice |          0  (omitted)
          logland |   .1940299   .2184481     0.89   0.374    -.2341205    .6221804
      ycoffeeytob |   .7996552    .219752     3.64   0.000     .3689492    1.230361
     ycassavaytob |  -.4377502   .1526462    -2.87   0.004    -.7369312   -.1385692
relcoffe_tob_10th |  -1.413937   .5117047    -2.76   0.006     -2.41686   -.4110145
 relcass_tob_10th |          0  (omitted)
          lincome |    3.45178   .7892925     4.37   0.000     1.904795    4.998765
------------------------------------------------------------------------------------
```

Appendix F: Supplementary results for Chapter 6

One-way ANOVA and Post hoc tests - Overall economic, allocative and technical efficiency

Education

Educ	Mean	Std. Dev.	Freq.
Primary	.17790541	.27215277	74
Secondary	.34688889	.38183065	45
Tertiary	.22714286	.28158565	7
Total	.24099206	.32370482	126

Summary of CE

Analysis of Variance

Source	SS	df	MS	F	Prob > F
Between groups	.800493356	2	.400246678	4.00	0.0207
Within groups	12.2976077	123	.099980551		
Total	13.0981011	125	.104784809		

Bartlett's test for equal variances: chi2(2) = 6.4829 Prob>chi2 = 0.039

Pairwise comparisons of means with equal variances

ce	Contrast	Std. Err.	Tukey t	Tukey P>|t|	Tukey [95% Conf.	Interval]
educ						
Secondary vs Primary	.1689835	.0597736	2.83	0.015	.0271753	.3107916
Tertiary vs Primary	.0492375	.1250361	0.39	0.918	-.247401	.3458759
Tertiary vs Secondary	-.119746	.1284707	-0.93	0.621	-.4245329	.1850408

Educ	Summary of AE Mean	Std. Dev.	Freq.
Primary	.24045946	.28304655	74
Secondary	.37644444	.38616504	45
Tertiary	.32142856	.35685797	7
Total	.29352381	.33102473	126

Analysis of Variance

Source	SS	df	MS	F	Prob > F
Between groups	.523234221	2	.261617111	2.44	0.0911
Within groups	13.1739372	123	.10710518		
Total	13.6971714	125	.109577371		

Bartlett's test for equal variances: chi2(2) = 5.4180 Prob>chi2 = 0.067

Pairwise comparisons of means with equal variances

ae	Contrast	Std. Err.	Tukey t	Tukey P>|t|	Tukey [95% Conf.	Interval]
educ						
Secondary vs Primary	.135985	.0618667	2.20	0.075	-.0107889	.2827588
Tertiary vs Primary	.0809691	.1294145	0.63	0.806	-.2260567	.3879949
Tertiary vs Secondary	-.0550159	.1329694	-0.41	0.910	-.3704754	.2604437

Educ	Summary of TE Mean	Std. Dev.	Freq.
Primary	.58974324	.28348652	74
Secondary	.75977778	.2641925	45
Tertiary	.65142857	.31227278	7
Total	.65389682	.287498	126

Analysis of Variance

Source	SS	df	MS	F	Prob > F
Between groups	.809088023	2	.404544011	5.23	0.0066
Within groups	9.52279967	123	.077421136		
Total	10.3318877	125	.082655102		

Bartlett's test for equal variances: chi2(2) = 0.4384 Prob>chi2 = 0.803

Pairwise comparisons of means with equal variances

te	Contrast	Std. Err.	Tukey t	Tukey P>|t|	Tukey [95% Conf.	Interval]
educ						
Secondary vs Primary	.1700345	.0525994	3.23	0.004	.0452464	.2948226
Tertiary vs Primary	.0616853	.1100291	0.56	0.841	-.1993501	.3227208
Tertiary vs Secondary	-.1083492	.1130515	-0.96	0.604	-.376555	.1598566

Farming experience category

farmexpcat	Summary of CE Mean	Std. Dev.	Freq.
2-4	.07	0	1
4-8	.26396826	.32927359	63
8-10	.2382353	.35500415	17
>10	.21366667	.31127743	45
Total	.24099206	.32370482	126

Analysis of Variance

Source	SS	df	MS	F	Prob > F
Between groups	.096226	3	.032075333	0.30	0.8246
Within groups	13.0018751	122	.106572747		
Total	13.0981011	125	.104784809		

Bartlett's test for equal variances: chi2(2) = 0.4338 Prob>chi2 = 0.805

note: Bartlett's test performed on cells with positive variance:
1 single-observation cells not used

Pairwise comparisons of means with equal variances

ce	Contrast	Std. Err.	t	Tukey P>|t|	Tukey [95% Conf. Interval]

farmexpcat						
4-8 vs 2-4	.1939683	.3290355	0.59	0.935	-.6631019	1.051038
8-10 vs 2-4	.1682353	.3359192	0.50	0.959	-.7067656	1.043236
>10 vs 2-4	.1436667	.3300622	0.44	0.972	-.7160777	1.003411
8-10 vs 4-8	-.025733	.0892223	-0.29	0.992	-.2581387	.2066728
>10 vs 4-8	-.0503016	.0637175	-0.79	0.859	-.2162725	.1156693
>10 vs 8-10	-.0245686	.0929369	-0.26	0.993	-.2666502	.217513

	Summary of AE		
farmexpcat	Mean	Std. Dev.	Freq.
2-4	.07	0	1
4-8	.30539683	.34492087	63
8-10	.29882353	.35392235	17
>10	.27986667	.31075843	45
Total	.29352381	.33102473	126

Analysis of Variance

Source	SS	df	MS	F	Prob > F
Between groups	.067714682	3	.022571561	0.20	0.8948
Within groups	13.6294567	122	.111716858		
Total	13.6971714	125	.109577371		

Bartlett's test for equal variances: chi2(2) = 0.6689 Prob>chi2 = 0.716

note: Bartlett's test performed on cells with positive variance:
1 single-observation cells not used

Pairwise comparisons of means with equal variances

ae	Contrast	Std. Err.	t	Tukey P>|t|	Tukey [95% Conf.	Interval]
farmexpcat						
4-8 vs 2-4	.2353968	.336883	0.70	0.897	-.6421144	1.112908
8-10 vs 2-4	.2288235	.3439309	0.67	0.910	-.667046	1.124693
>10 vs 2-4	.2098667	.3379341	0.62	0.925	-.6703825	1.090116
8-10 vs 4-8	-.0065733	.0913502	-0.07	1.000	-.2445219	.2313753
>10 vs 4-8	-.0255302	.0652371	-0.39	0.980	-.1954595	.1443992
>10 vs 8-10	-.0189569	.0951534	-0.20	0.997	-.2668121	.2288984

farmexpcat	Summary of TE Mean	Std. Dev.	Freq.
2-4	1	0	1
4-8	.71285714	.25680687	63
8-10	.62	.27280946	17
>10	.57646667	.31709187	45

```
------------+-----------------------------------
      Total |   .65389682     .287498        126

                        Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      .628122726      3   .209374242      2.63     0.0530
 Within groups      9.70376497    122   .079539057
------------------------------------------------------------------------
    Total           10.3318877    125   .082655102

Bartlett's test for equal variances:  chi2(2) =   2.3304  Prob>chi2 = 0.312

note: Bartlett's test performed on cells with positive variance:
      1 single-observation cells not used
```

```
Pairwise comparisons of means with equal variances


------------------------------------------------------------------------------
             |                            Tukey                Tukey
          te |   Contrast   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  farmexpcat |
```

4-8 vs 2-4	-.2871429	.2842562	-1.01	0.744	-1.027572	.4532863
8-10 vs 2-4	-.38	.2902031	-1.31	0.559	-1.13592	.3759196
>10 vs 2-4	-.4235333	.2851431	-1.49	0.449	-1.166273	.3192061
8-10 vs 4-8	-.0928571	.0770798	-1.20	0.625	-.2936342	.1079199
>10 vs 4-8	-.1363905	.055046	-2.48	0.069	-.279774	.006993
>10 vs 8-10	-.0435333	.0802889	-0.54	0.948	-.2526694	.1656027

Training variable

Train category	Summary of CE Mean	Std. Dev.	Freq.
no training	.50333334	.43316664	3
Private	.09263158	.22201614	57
Public	.42109091	.33999277	55
Both	.03772727	.04568171	11
Total	.24099206	.32370482	126

Analysis of Variance

Source	SS	df	MS	F	Prob > F
Between groups	3.6995264	3	1.23317547	16.01	0.0000
Within groups	9.3985747	122	.077037498		
Total	13.0981011	125	.104784809		

Bartlett's test for equal variances: chi2(3) = 34.9594 Prob>chi2 = 0.000

Pairwise comparisons of means with equal variances

ce	Contrast	Std. Err.	Tukey t	Tukey P>|t|	Tukey [95% Conf.	Interval]
traincat						
Private vs no training	-.4107018	.1644102	-2.50	0.065	-.8389566	.0175531
Public vs no training	-.0822424	.1645596	-0.50	0.959	-.5108864	.3464015
Both vs no training	-.4656061	.1807832	-2.58	0.054	-.9365094	.0052972
Public vs Private	.3284593	.0524616	6.26	0.000	.1918077	.465111
Both vs Private	-.0549043	.0914054	-0.60	0.932	-.2929966	.183188
Both vs Public	-.3833636	.0916738	-4.18	0.000	-.6221552	-.1445721

Train category	Summary of AE Mean	Std. Dev.	Freq.
no traini	.52666668	.44455971	3
Private	.14403509	.23888027	57
Public	.46872727	.34467942	55
Both	.12854545	.16321542	11
Total	.29352381	.33102473	126

Analysis of Variance

Source	SS	df	MS	F	Prob > F
Between groups	3.42452921	3	1.14150974	13.56	0.0000
Within groups	10.2726422	122	.084201985		
Total	13.6971714	125	.109577371		

Bartlett's test for equal variances: chi2(3) = 12.1508 Prob>chi2 = 0.007

Pairwise comparisons of means with equal variances

ae	Contrast	Std. Err.	Tukey t	Tukey P>|t|	Tukey [95% Conf.	Interval]
traincat						
Private vs no training	-.3826316	.1718853	-2.23	0.122	-.8303576	.0650944
Public vs no training	-.0579394	.1720415	-0.34	0.987	-.5060723	.3901935
Both vs no training	-.3981212	.1890028	-2.11	0.157	-.8904348	.0941924
Public vs Private	.3246922	.0548468	5.92	0.000	.1818275	.4675569
Both vs Private	-.0154896	.0955613	-0.16	0.998	-.2644071	.2334279
Both vs Public	-.3401818	.0958419	-3.55	0.003	-.5898304	-.0905333

Train category	Summary of TE Mean	Std. Dev.	Freq.
no traini	.82333332	.26388129	3
Private	.5277193	.25905059	57

Public	.83363636	.19895434	55
Both	.36281818	.24386341	11
Total	.65389682	.287498	126

Analysis of Variance

Source	SS	df	MS	F	Prob > F
Between groups	3.70245114	3	1.23415038	22.71	0.0000
Within groups	6.62943655	122	.054339644		
Total	10.3318877	125	.082655102		

Bartlett's test for equal variances: chi2(3) = 3.6401 Prob>chi2 = 0.303

Pairwise comparisons of means with equal variances

te	Contrast	Std. Err.	Tukey t	Tukey P>|t|	Tukey [95% Conf.	Interval]
traincat						
Private vs no training	-.295614	.1380816	-2.14	0.146	-.6552885	.0640604
Public vs no training	.010303	.1382071	0.07	1.000	-.3496982	.3703043
Both vs no training	-.4605151	.1518327	-3.03	0.015	-.8560084	-.0650219
Public vs Private	.3059171	.0440604	6.94	0.000	.1911487	.4206854
Both vs Private	-.1649011	.0767678	-2.15	0.144	-.3648655	.0350633
Both vs Public	-.4708182	.0769933	-6.12	0.000	-.6713699	-.2702665

Extension services

| Summary of CE

extn_cat	Mean	Std. Dev.	Freq.
no extens	.23	.15524174	3
One sourc	.33565217	.38110163	46
Two sourc	.16872882	.25570153	59
Three sou	.23777778	.34309244	18
Total	.24099206	.32370482	126

Analysis of Variance

Source	SS	df	MS	F	Prob > F
Between groups	.720829768	3	.240276589	2.37	0.0740
Within groups	12.3772713	122	.101453044		
Total	13.0981011	125	.104784809		

Bartlett's test for equal variances: chi2(3) = 9.0879 Prob>chi2 = 0.028

Pairwise comparisons of means with equal variances

ce	Contrast	Std. Err.	t	Tukey P>|t|	Tukey [95% Conf.	Interval]
extn_cat						
One source vs no extension	.1056522	.1897977	0.56	0.945	-.3887321	.6000364
Two sources vs no extension	-.0612712	.1885132	-0.33	0.988	-.5523095	.4297671
Three sources vs no extension	.0077778	.1986302	0.04	1.000	-.5096133	.5251688
Two sources vs One source	-.1669234	.0626502	-2.66	0.043	-.3301142	-.0037325
Three sources vs One source	-.0978744	.0885538	-1.11	0.687	-.328539	.1327902

```
 Three sources vs Two sources|  .069049   .0857661     0.81   0.852    -.1543542    .2924521
---------------------------------------------------------------------------------------------


            |            Summary of AE
   extn_cat |        Mean   Std. Dev.       Freq.
------------+------------------------------------
  no extens |   .31333333   .12701707           3
  One sourc |   .37173913   .37403686          46
  Two sourc |   .21515254   .28429009          59
  Three sou |   .34722222   .34168795          18
------------+------------------------------------
      Total |   .29352381   .33102473         126


                        Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      .696873149      3    .23229105      2.18     0.0938
 Within groups      13.0002982    122   .106559822
------------------------------------------------------------------------
    Total           13.6971714    125   .109577371

Bartlett's test for equal variances:  chi2(3) =   5.6376  Prob>chi2 = 0.131

Pairwise comparisons of means with equal variances

---------------------------------------------------------------------------------------------
                             |                              Tukey                    Tukey
                          ae |Contrast   Std. Err.      t    P>|t|     [95% Conf. Interval]
-----------------------------+-------------------------------------------------------------
                     extn_cat|
```

```
 One source vs no extension  | .0584058    .194516     0.30   0.991    -.4482685    .5650801
 Two sources vs no extension |-.0981808   .1931995    -0.51   0.957    -.6014259    .4050643
Three sources vs no extension|.0338889    .203568     0.17   0.998    -.4963641    .5641419
 Two sources vs One source   | -.1565866   .0642076    -2.44   0.075    -.3238343    .0106611
 Three sources vs One source |-.0245169   .0907552    -0.27   0.993    -.2609157    .2118818
 Three sources vs Two sources|.1320697   .0878982     1.50   0.439    -.0968871    .3610264
---------------------------------------------------------------------------------------------

            |          Summary of TE
   extn_cat |        Mean   Std. Dev.       Freq.
------------+------------------------------------
  no extens |   .71333333   .35949038           3
  One sourc |   .69586957   .30353895          46
  Two sourc |   .64984745   .24603755          59
  Three sou |         .55   .35391923          18
------------+------------------------------------
      Total |   .65389682     .287498         126

                        Analysis of Variance
    Source              SS         df      MS            F     Prob > F
------------------------------------------------------------------------
Between groups      .286906147      3   .095635382      1.16     0.3273
 Within groups      10.0449815    122   .082335914
------------------------------------------------------------------------
    Total           10.3318877    125   .082655102

Bartlett's test for equal variances:  chi2(3) =   4.4535  Prob>chi2 = 0.216

Pairwise comparisons of means with equal variances

---------------------------------------------------------------------------------------------
                             |                             Tukey                 Tukey
                          te |   Contrast   Std. Err.      t    P>|t|     [95% Conf. Interval]
```

extn_cat						
One source vs no extension	-.0174638	.1709831	-0.10	1.000	-.4628397	.4279122
Two sources vs no extension	-.0634859	.1698259	-0.37	0.982	-.5058475	.3788758
Three sources vs no extension	-.1633333	.17894	-0.91	0.798	-.6294354	.3027687
Two sources vs One source	-.0460221	.0564397	-0.82	0.847	-.1930359	.1009917
Three sources vs One source	-.1458696	.0797755	-1.83	0.265	-.3536684	.0619293
Three sources vs Two sources	-.0998475	.0772641	-1.29	0.570	-.3011046	.1014097

Land tenure system

landten	Summary of CE Mean	Std. Dev.	Freq.
mailo	.42142858	.35399758	7
leasehold	.10807692	.18325232	13
freehold	.265	.36960149	20
customary	.24081395	.32319441	86
Total	.24099206	.32370482	126

Analysis of Variance

Source	SS	df	MS	F	Prob > F
Between groups	.469095339	3	.156365113	1.51	0.2152
Within groups	12.6290058	122	.103516441		
Total	13.0981011	125	.104784809		

Bartlett's test for equal variances: chi2(3) = 6.1176 Prob>chi2 = 0.106

Pairwise comparisons of means with equal variances

ce	Contrast	Std. Err.	Tukey t	Tukey P>|t|	Tukey [95% Conf.	Interval]
landten						
leasehold vs mailo	-.3133517	.1508339	-2.08	0.166	-.7062431	.0795398
freehold vs mailo	-.1564286	.1412936	-1.11	0.686	-.5244695	.2116124
customary vs mailo	-.1806146	.1264585	-1.43	0.484	-.510013	.1487838
freehold vs leasehold	.1569231	.1146238	1.37	0.521	-.1416486	.4554947
customary vs leasehold	.132737	.0957417	1.39	0.510	-.1166506	.3821247
customary vs freehold	-.024186	.0798718	-0.30	0.990	-.2322357	.1838636

landten	Summary of TE Mean	Std. Dev.	Freq.
mailo	.75714286	.31526255	7
leasehold	.53161538	.3431602	13
freehold	.5835	.30610069	20
customary	.68034884	.26819417	86
Total	.65389682	.287498	126

Analysis of Variance

Source	SS	df	MS	F	Prob > F
Between groups	.428293218	3	.142764406	1.76	0.1587
Within groups	9.90359448	122	.081177004		
Total	10.3318877	125	.082655102		

Bartlett's test for equal variances: chi2(3) = 1.8162 Prob>chi2 = 0.611

Pairwise comparisons of means with equal variances

over : landten

	Number of Comparisons
landten	6

te	Contrast	Std. Err.	Tukey t	Tukey P>|t|	Tukey [95% Conf.	Interval]
landten						
leasehold vs mailo	-.2255275	.1335706	-1.69	0.334	-.5734515	.1223965
freehold vs mailo	-.1736429	.1251222	-1.39	0.509	-.4995606	.1522749
customary vs mailo	-.076794	.111985	-0.69	0.902	-.3684919	.2149039
freehold vs leasehold	.0518846	.1015049	0.51	0.956	-.2125147	.316284
customary vs leasehold	.1487335	.0847839	1.75	0.301	-.0721112	.3695781
customary vs freehold	.0968488	.0707303	1.37	0.521	-.087389	.2810867

landten	Summary of AE Mean	Std. Dev.	Freq.

mailo	.46	.34219877	7
leasehold	.16876923	.20336263	13
freehold	.331	.37513366	20
customary	.29011628	.33253215	86
Total	.29352381	.33102473	126

Analysis of Variance

Source	SS	df	MS	F	Prob > F
Between groups	.425416287	3	.141805429	1.30	0.2764
Within groups	13.2717551	122	.108784878		
Total	13.6971714	125	.109577371		

Bartlett's test for equal variances: chi2(3) = 4.7225 Prob>chi2 = 0.193

Pairwise comparisons of means with equal variances

ae	Contrast	Std. Err.	Tukey t	Tukey P>|t|	Tukey [95% Conf.	Interval]
landten						
leasehold vs mailo	-.2912308	.1546246	-1.88	0.241	-.6939962	.1115346
freehold vs mailo	-.129	.1448445	-0.89	0.810	-.5062904	.2482904
customary vs mailo	-.1698837	.1296366	-1.31	0.558	-.5075604	.167793
freehold vs leasehold	.1622308	.1175045	1.38	0.514	-.1438444	.468306
customary vs leasehold	.121347	.0981479	1.24	0.605	-.1343081	.3770022
customary vs freehold	-.0408837	.0818791	-0.50	0.959	-.254162	.1723945

Tobit regression model – Cost efficiency

```
Tobit regression                                  Number of obs   =        126
                                                  LR chi2(5)      =      26.92
                                                  Prob > chi2     =     0.0001
Log likelihood = -66.795293                       Pseudo R2       =     0.1677

------------------------------------------------------------------------------
          ce |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     educnew |   .0892152   .0663543     1.34   0.181    -.0421506    .2205811
   tenurenew |   .0068348   .0704738     0.10   0.923    -.1326866    .1463563
train_public |   .1199925   .0831808     1.44   0.152    -.0446859    .2846709
 public_extn |   .1151191   .0784663     1.47   0.145    -.0402256    .2704638
      noloan |   .1639014   .0842207     1.95   0.054    -.0028357    .3306385
       _cons |   .0140829   .0724627     0.19   0.846     -.129376    .1575419
-------------+----------------------------------------------------------------
      /sigma |   .3464372    .026398                      .2941754     .398699
------------------------------------------------------------------------------
  Obs. summary:         18  left-censored observations at ce<=0
                        97     uncensored observations
                        11 right-censored observations at ce>=1
```

Marginal effects – Cost efficiency model

```
Conditional marginal effects                      Number of obs   =        126
Model VCE    : OIM

Expression   : E(ce*|ce>0), predict(ystar(0,.))
dy/dx w.r.t. : educnew tenurenew train_public public_extn noloan
at           : educnew         =    .4126984 (mean)
               tenurenew       =    .6825397 (mean)
               train_public    =    .5238095 (mean)
               public_extn     =    .3650794 (mean)
               noloan          =    .3730159 (mean)

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     educnew |   .0659111   .0491358     1.34   0.180    -.0303933    .1622156
   tenurenew |   .0050495   .0520614     0.10   0.923    -.0969889    .1070879
train_public |    .088649   .0614288     1.44   0.149    -.0317493    .2090473
 public_extn |   .0850486   .0581433     1.46   0.144    -.0289103    .1990074
      noloan |   .1210884   .0625041     1.94   0.053    -.0014175    .2435942
------------------------------------------------------------------------------
```

Tobit regression model – Allocative efficiency

```
Tobit regression                                  Number of obs   =        126
                                                  LR chi2(5)      =      22.22
                                                  Prob > chi2     =     0.0005
Log likelihood = -68.406534                       Pseudo R2       =     0.1397

------------------------------------------------------------------------------
          ae |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     educnew |   .0552534   .0679406     0.81   0.418     -.079253    .1897597
   tenurenew |  -.0014425   .0718803    -0.02   0.984    -.1437485    .1408635
train_public |   .1375219   .0851325     1.62   0.109    -.0310203    .3060641
 public_extn |   .1070131   .0805146     1.33   0.186    -.0523869    .2664131
      noloan |   .1348435   .0864092     1.56   0.121    -.0362263    .3059132
       _cons |   .0990335   .0734846     1.35   0.180    -.0464487    .2445157
-------------+----------------------------------------------------------------
      /sigma |   .3554603   .0266186                      .3027618    .4081588
------------------------------------------------------------------------------
  Obs. summary:         15  left-censored observations at ae<=0
                       100     uncensored observations
                        11 right-censored observations at ae>=1
```

Marginal effects – Allocative efficiency model

```
Conditional marginal effects                      Number of obs   =        126
Model VCE    : OIM

Expression   : E(ae*|ae>0), predict(ystar(0,.))
dy/dx w.r.t. : educnew tenurenew train_public public_extn noloan
at           : educnew         =    .4126984 (mean)
               tenurenew       =    .6825397 (mean)
               train_public    =    .5238095 (mean)
               public_extn     =    .3650794 (mean)
               noloan          =    .3730159 (mean)

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     educnew |   .0434522   .0534872     0.81   0.417    -.0613808    .1482853
   tenurenew |  -.0011344   .0565287    -0.02   0.984    -.1119286    .1096598
train_public |   .1081496   .0669611     1.62   0.106    -.0230918     .239391
 public_extn |    .084157   .0634567     1.33   0.185    -.0402158    .2085297
      noloan |   .1060433   .0681169     1.56   0.120    -.0274633    .2395499
------------------------------------------------------------------------------
```

Tobit regression model – Technical efficiency

```
Tobit regression                                  Number of obs   =        126
                                                  LR chi2(5)      =      34.77
                                                  Prob > chi2     =     0.0000
Log likelihood = -60.186141                       Pseudo R2       =     0.2241

------------------------------------------------------------------------------
          te |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     educnew |   .1339911   .0633316     2.12   0.036     .0086096    .2593727
   tenurenew |   .0941175   .0662356     1.42   0.158    -.0370134    .2252485
train_public |   .0970132   .0782906     1.24   0.218    -.0579837    .2520101
 public_extn |   .1531506   .0759072     2.02   0.046     .0028722     .303429
      noloan |   .1462403   .0809279     1.81   0.073    -.0139778    .3064583
       _cons |    .432733   .0672125     6.44   0.000      .299668    .5657979
-------------+----------------------------------------------------------------
      /sigma |   .3227633   .0261233                      .2710453    .3744814
------------------------------------------------------------------------------
  Obs. summary:          0  left-censored observations
                        89     uncensored observations
                        37 right-censored observations at te>=1
```

Marginal effects – Technical efficiency model

```
Conditional marginal effects                      Number of obs   =        126
Model VCE    : OIM

Expression   : E(te*|te>0), predict(ystar(0,.))
dy/dx w.r.t. : educnew tenurenew train_public public_extn noloan
at           : educnew         =    .4126984 (mean)
               tenurenew       =    .6825397 (mean)
               train_public    =    .5238095 (mean)
               public_extn     =    .3650794 (mean)
               noloan          =    .3730159 (mean)

------------------------------------------------------------------------------
             |            Delta-method
             |      dy/dx   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     educnew |   .1321787   .0624567     2.12   0.034     .0097658    .2545916
   tenurenew |   .0928445   .0653372     1.42   0.155    -.0352141     .220903
train_public |    .095701   .0772206     1.24   0.215    -.0556487    .2470506
 public_extn |    .151079   .0748738     2.02   0.044      .004329     .297829
      noloan |   .1442621   .0798191     1.81   0.071    -.0121804    .3007047
------------------------------------------------------------------------------
```

Appendix G: Development of the farm household model

This appendix provides the theoretical framework for the thesis. The theoretical framework is based on the agricultural household model and it follows the theoretical construction of a farm household model from De Janvry et al. (1991), Sadoulet and De Janvry (1995) and De Janvry and Sadoulet (2006).

In constructing the theoretical model, we consider a farm household in the study area producing two crops, a cash crop, say, tobacco (q_c) and a food crop (q_f), for example cassava. This household operates on two inputs such as labour (q_l) and other variable inputs like inorganic fertilisers (q_x). The agricultural production technology is represented by $G(\boldsymbol{q}, z) = 0$ where $\boldsymbol{q}$ represents farm output for both tobacco and cassava, and it is positive (q_c, q_f>0). Farm inputs with negative values i.e. ($q_x, q_l < 0$) and (z) represents the structural characteristics of the farm household. It is assumed that this farm household consumes three commodities: a manufactured good (c_m), home time (c_l), and a farm product (c_f). The farm household has an initial endowment of time T_l as well as an endowment T_i for any commodity i, and it has a cash endowment or receives a transfer s. Tobacco is solely sold on the market and the inputs and manufactured goods are only provided by the market. This implies that this household is a price taker.

The farm household's food and labour are both provided by the household and eventually traded on the market. In the presence of markets, the three consumed goods are homogenous and are perfect substitutes between the domestic and market supply and with exogenous prices ($p_i - \overline{p_i}$). Under such conditions, this household faces a constraint of balancing demand ($q_i + T_i$) and supply (c_i) commodities known as non-tradables (NT). It is assumed that the objective function of this household is to maximise utility from the three commodities although the household cannot maximise utility unboundedly because its resources are limited. Hence this household faces three constraints in attempting to maximise its level of satisfaction. And so, the utility maximisation is assumed to be constrained by the prevailing agricultural production technology in terms of how much to produce, a cash constraint for the commodities tradable on the market (T) and the equilibrium conditions for tradables and non-tradables. This utility function is concave and is represented as follows:

$$Max_{c,q}\ U(c, z) \qquad (1.1)$$

Subject to $\sum_{i \in T} p_i c_i \leq \sum_{i \in T} p_i\,(q_i + T_i) + s$ cash income constraint

$G(q, z) = 0$ agricultural production technology

$p_i = \overline{p_i} \quad i \in T$ exogenous market prices for tradables

$q_i + T_i \geq c_i \quad i \in NT$ equilibrium for non-tradables

The Lagrangian associated with the constrained maximisation problem is represented as follows;

$$L = U(c, z) + \lambda[\sum_{i \in T} \overline{p_i}\,(q_i + T_i - c_i) + s] + \emptyset G(q, z) + \sum_{i \in NT} p_i\,(q_i + T_i - c_i)$$

Tradable and non-tradable commodities are treated as symmetrical and in writing out the first order conditions of this constrained maximisation problem by defining, for each non-tradable commodity, an endogenous price $p_i = {}^{\mu_i}/_{\lambda}$. Assuming the existence of an interior solution, the optimal set of quantities (q_i, c_i) and the endogenous prices ($p_i, i \in NT$) are given by the solution of the system:

$U_i' = \lambda p_i, \quad i \in C = [f, m, l],$ consumer goods (1.2a)

$\emptyset G_i' = \lambda p_i, i \in P = (c, f, l, x),$ producer goods (1.2b)

$\sum_i p_i\, c_i = \sum_i p_i\,(q_i + T_i) + s,$ household full income (1.2c)

$G(q, z) = 0$ (1.2d)

$q_i + T_i = c_i, \quad i \in NT$ (1.2e)

$p_i = \overline{p_i}, \; i \in T$ (1.2f)

where U_i' and G_i' represent the partial derivatives of U and G with respect to c_i and q_i respectively. Therefore, this household's decisions can be decomposed into production and consumption decisions. As a producer, the household chooses the levels of inputs and outputs that satisfy equation 1.2b and 1.2d, which is equivalent to maximising a generalised profit function defined over all tradable and non-tradable commodities. This leads to a system of input demand and output supply function

$q_i = q_i(p^* z^a), \; i \in P$ (1.3) and

to a maximum generalised profit equal to

$\pi = \sum_i p_i\, q_i, \; i \in P$ (1.4)

As a consumer, the household chooses the levels of consumption which maximise its utility under the full income constraint. This leads to a consumption system,

$$c_i = c_i(p^*, Y^*, z^h), \;\; i \in C, \tag{1.5}$$

where $\sum_{i \in C} p_i \, c_i = Y = \pi + \sum_i p_i \, T_i + s$

If markets exist and there are no non-tradable commodities, all factor and product prices are exogenous, household decisions are considered to be taken sequentially, since consumption decisions depend on the outcome of the production decisions albeit the reverse is not possible due to the recursive property of the model. This is the standard case of the separable farm household model. The fact that production and consumption are separable, however, does not always imply that there are no interactional effects. Changes in production variables do affect consumption decisions.

When one or more markets are incomplete then the model recursiveness breaks down and consumption decisions can determine production. Incomplete markets are as a result of high transaction costs (i.e. transportation costs), thin markets (i.e. isolated or remote markets) and risk (i.e. price risks particularly for perishables) and risk aversion. In the presence of incomplete markets or market failures factor or product prices are no longer determined by the market but are internally adopted to the household as shadow prices (endogenous price). When the household decides on what to produce or how to earn income from various activities whilst in the presence of market failures, then there is no longer separability between production and consumption decisions.

The household's production or income problem is solved simultaneously with its consumption decisions. This is where it becomes essential for this thesis in terms of analysing farm household behaviour. In this case we can no longer study separately the farm/firm side of the household without at the same time looking at its consumption decisions. Thus, non-separability is determined when the two sets of decisions (consumption and production) are linked through the endogenous price p_i that satisfies the equilibrium condition (1.2e) between demand and supply. Under imperfect markets, the shadow prices are equal to the marginal utility of consumption of food and home time and to the marginal productivity of labour.

Comments

Comparing the equilibrium conditions in the separable household model and the non-separable household model, we see that in the former the market is used for a transaction and the household behaves as if it were deciding sequentially, production first and consumption or work afterwards. Production decisions are identical to those of a pure producer and consumption decisions are affected by the level of income achieved from production activities. In the latter model, the market is not used for a transaction and as such the subjective equilibrium price falls within the price band. The household then behaves as if a market existed within the household for the non-tradable goods. The equilibrium of demand and supply on this fictitious market determines a shadow price that serves as the decision price for the household.

In fact, the theoretical formulations of the separable household model are equivalent to the profit maximisation and utility maximisation conditions required by the theory of production and consumer choice theory taken independently. The difference is that for the non-separable model, acting under the assumptions of market imperfections, profit maximisation and utility maximisation are solved jointly. Thus, it is important to note that the non-separable household model represents the theoretical formulation of the subsistence farm households' economy. These two farm household models are relevant in Uganda given that the country exhibits a whole continuum of subsistence to semi-commercial farms. The number of households that are not fully commercialised, however, are predominant in the study area. The non-separable model, therefore is of direct relevancy in this area. In addition, market perfections in rural farms households are also questionable. In practice, however, the specific theoretical model for studying farm household economic behaviour normally depends on the nature of the dataset and the characteristics of the rural households being studied. The results of the cross-sectional survey discussed in chapter 4 suggest that the functional factor and product markets may not exit for these tobacco and alternative farm households. This would suggest that for this type of sample, a non-separable oriented model with incomplete markets would be the appropriate model. In this instance, production and consumption decisions have to be modelled jointly.

This thesis places a theorisation of the farm household production behaviour within an empirical analysis of household decision making, which is tested using statistical analysis. Here the aim is to distinguish more clearly between the wide range of relationships theorised by previous researchers as explaining different farm household behaviours. Assuming non-separability, the present analysis focuses on the combination of production and consumption simultaneously. But because the structural model uses non-observable implicit prices, its estimation is quite complex and for that reason it is often not done. Within the literature of the non-separability model, there are two approaches used to estimate the reduced form. The first approach considers the fully reduced form of the model (Lopez, 1984; Benjamin, 1992). Using the solution of the household model derived earlier, equation 1.3 and 1.5 gives production and consumption decisions as functions of the decision prices p^* and decision income y^*, and the household characteristics z^a and z^h associated with production and consumption decisions. The endogenous p^* and y^* themselves are functions of the exogenous prices $\overline{p_l}$, the characteristics z^a and z^h, exogenous transfer s, is binding. Eliminating p^* and y^*gives the fully reduced forms: $q = q(\bar{p},\ z^a, z^h, s)$ for production, and $c = c(\bar{p},\ z^a, z^h, s)$ for consumption.

Two elements that this thesis endeavours to determine in terms of farm household production behaviour include; the technological relation that exists between a combination of inputs and the resulting levels of outputs. And secondly, the farm household's behaviour in their choice of production, given the level of market prices for tobacco, alternative crops, factors that can be traded and the availability of fixed factors whose quantity cannot be altered in the period of analysis. In order to measure the probability of crop choice between tobacco and alternative crops, since households choose tobacco or not is determined by variables which also influence production and consumption decisions, the econometric model is a switching regression with endogenous criterion which consists the probability of being a tobacco farmer or not and the production decision.

Prob (tobaccoconstrained) $= f(z^a, z^h)$, (1.6)

$q = q(\bar{p},\ z^a)$ if a tobacco constraint is not binding,

$q = q(\bar{p},\ z^a, z^h)$ if a tobacco constraint is binding.

Farm household efficiency is the other dimension that this thesis seeks to examine. Within the literature efficiency is analysed in three components: technical and allocative efficiency together with economies of scale. Although this thesis focuses on farm household technical efficiency and economies of scale and adopts a household-level approach that takes into account the role of non-farming activities. The standard analysis of technical efficiency is here extended to capture the linkage between farming and non-farming activities that characterise the majority of rural households in Uganda. Analysis of technical efficiency and economies of scale follows the theoretical formulations by Chavas et al. (2005) who show that in the presence of market imperfections or when production and consumption decisions are non-separable, a household level analysis of technical efficiency is more appropriate than a farm level analysis. This approach, initially introduced by Chavas and Aliber (1993) and has been adapted by a series of authors such as Anriquez and Daidone (2008), Fletschner (2008), Fernandez-Cornejo et al. (2007) and Fletschner and Zepeda (2002).

The use of a household level analysis of technical efficiency and economies of scale relies on the argument that production and consumption activities are jointly produced. Following the formal definition of non-separability in farm decisions discussed earlier, a necessary and sufficient condition for non-separability in inputs is for the profit function (equation 1.4) to be additively separable in outputs. Following Shumway, Pope, and Nash (1984), when a constraint on the total amount of inputs available is introduced ($\bar{x} = x_1 + x_2$) the profit maximisation problem becomes:

$$max_{x_i,\lambda,v_i}\pi = \sum_i p_i f_i(x_i, v_i) - wx_i \quad (1.7)$$

s.t. $\bar{x} = x_1 + x_2$, where x_i and v_i are the two inputs said to be non-separable in inputs. Comparing equations 1.4 and 1.7, it is possible to notice that equation 1.4 is violated since the supply of, say, tobacco is not independent of changes in the price of the cassava output. This definition can be applied to the farm and non-farm activities. In particular, three conditions can possibly lead to the non-separability between farm and off-farm production. The first refers to the presence of technical interdependencies and non-allocatable inputs within farming and non-farming technologies that usually emerge when skills acquired off-farm improve farm management (Chavas et al., 2005). By engaging in off-farm activities, for example, farmers can learn about new production techniques for example book keeping and financial management. Moreover, some inputs can be shared between farm and non-farm activities, for example, equipment infrastructure like hand hoes, pangas and possibly tractors.

The second condition refers to the imperfect substitutability between family and hired labour that is usually induced by transaction costs on the labour market. In this context, family labour can be considered as quasi-fixed allocable input in the short run since perfect substitutes do not exist. In general, the presence of multiple outputs competing for limited farm resources implies that the production of one output reduces the availability of resources and has a negative effect on the production of the other output. Finally, in the presence of non-separability such as binding credit, farming decisions are constrained. In general, while a farm production function can be entirely separated from the non-farm production function when none of the above condition applies, a non-separable household analysis does not require such assumptions. In practice, this refers to the ability of quantifying the separate amount of inputs used for farm and non-farm activities.

The challenge in obtaining data on activity specific inputs partly arises from the non-separable nature of the two production processes. Using survey data, for example, externalities between on and off-farm activities is difficult to be measured. Moreover, inputs are not usually recorded with sufficient detail and because their allocation is affected by seasonality, often, only the total quantities are available at household level can be observed. Therefore, both the inherent jointness between farm and non-farm activities and the data limitation lead the use of a household level analysis of technical efficiency and economies of scale.