Market Access and Agricultural Production

The Case of Banana Production in Uganda

Fredrick Bagamba

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Abstract

This study investigates the effects of factor and commodity markets on the development of the banana sub-sector in central and southwestern Uganda. The study analyses smallholder household response to production constraints (crop pests and diseases, soil constraints) and development of product markets and off-farm employment opportunities. The study was carried out in central region, Masaka and southwest, which have divergent production constraints and opportunities. Various analytical tools were employed in this study. Cost benefit analysis was used to assess the competitiveness of banana production versus other crop enterprises. The stochastic production frontier was used to analyze the technical and productive efficiency of banana farmers. Production functions were estimated for the important crops to analyze the allocative efficiency of farmers in each study region. Finally, labour supply and demand functions were estimated to determine the factors that influence labour allocation decisions and to assess the farmers' response to changes in economic conditions. A multinomial logit model was fitted to identify factors that influence farmers' labour supply decisions between farm and off-farm work.

Results for the cost benefit analysis show that banana is the most profitable of all the crops grown, in terms of gross margin. However, imperfections in labour and food markets cause farmers in the central region to allocate more land and labour to the less profitable annual crops (sweet potatoes, maize and cassava) but are more satisfying in terms of household food requirements. High food prices and limitations in access to the off-farm labour market induce farmers to rely on own farm production for their household food needs. Results from the technical efficiency analysis show that banana farmers in Uganda are technically inefficient, and output can be increased by 30 in the southwest and 58% in the central region. Improved roads, formal education and access to credit are some of the factors that improve technical efficiency. Agricultural extension visits significantly increases banana productivity in the southwest. Results confirm that pest (banana weevil) and disease (Sigatoka) infestation contribute to the low banana production in the central region.

Farm size is positively related to farm productivity. However, production is more efficient on smaller plots (decreasing returns to scale). The low productivity on small farms puts to question the sustainability of smallholder agriculture, given the imperfections in labour and food markets and limited access to purchased inputs. Analysis of the marginal products of labour shows that farmers are allocatively inefficient and production and consumption decisions are nonseparable. Findings from labour supply analysis show that farmers respond positively to changes in shadow wage rates and negatively to changes in shadow income. This implies that the farmers are responsive to economic incentives. Access to off-farm opportunities takes away the most productive labour from farm production. Thus improved road access and high wage rates are associated with lower farm labour productivity and lower labour supply. Education and road access have a positive effect on time allocated to off-farm activities while farm size is negatively related to work hours in off-farm activities. The study reveals that policies that promote income diversification into off-farm activities can contribute to sustained development in the rural sector. In particular, policies that reduce transaction costs are likely to improve productivity and efficiency in both the off-farm sector and farm sector. Investment in road infrastructure, education and financial institutions that are suited to smallholder production needs could help in alleviating the bottlenecks in the labour, food and financial markets, and improve resource allocation between the farm and nonfarm sectors.

Key words: Smallholder poor farmers, market access, bananas, productivity, efficiency, labour demand, labour supply, Uganda.

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Dedicated

To

My wife
Christine

And

Children
Daisy and Denise

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Chapter 1 Introduction

1.1 Background

One major body of thought that has dominated the landscape of rural development thinking for the last 50 years is the agricultural growth paradigm based on small-farm production efficiency. Lending support to this paradigm and its widespread acceptance was the seminal work by Schultz (1964), who proposed that farmers in least developed countries act consistently according to microeconomic principles. According to Schultz, farmers in traditional agriculture act rationally in their allocation of traditional resources and get the most economic value possible from the resources. In such circumstances, transforming agriculture is only possible through innovation and investment in high-income streams – mainly physical capital and improved production methods and investment in human capital (Becker, 1964; Schultz, 1964).

Theories that preceded Schultz's propositions were based on the dual model (Fei and Ranis, 1964; Lewis, 1954), which emphasized a modern sector consisting of large-scale 'modern agriculture' (plantations, estates, commercial farms and ranches) in additional to manufacturing industry (Ellis and Biggs, 2001). According to the dual-economy theories, the subsistence sector possessed negligible prospects for rising productivity or growth, and could play only a passive role in the process of economic development, supplying resources to the modern sector of the economy, until the latter eventually expanded to take its place.

In the 1960s, small-farm agriculture became the central focus of an agriculture-centered development strategy because of a number of interlocking assumptions (Ellis and Biggs, 2001). First, small farmers are rational economic agents making efficient farm decisions (Schultz, 1964). Second, small farmers are as capable as big farmers of taking advantage of high yielding varieties because input combinations in agriculture are scale neutral (Lipton and Longhurst, 1989). Third, there exists an inverse relationship between farm size and economic efficiency, hence small farmers are more efficient than large farmers because of the intensity of their use of abundant labour in a largely capital scarce economy (Berry and Cline, 1979). Moreover, rising agricultural output in the small-farm sector results in rural growth linkages that spur the growth of labour-intensive nonfarm activities in rural areas (Johnston and Kilby, 1975; Mellor, 1976). A crucial attribute of the small-farm strategy is that both growth and equity goals appear to be achieved simultaneously since most of the rural poor are poor small farmers. The paradox is the emerging evidence that the rural poor tend to depend on nonfarm (and often non-rural) sources of income in order to sustain their livelihoods, which puts the validity of the small-farm first orthodoxy into question (Ellis, 1998).

Ideas that have characterised the rural development thinking right from the 1960s can be summarised as modernisation for the 1960s, state intervention for the 1970s, market liberalisation for the 1980s, and participation and empowerment for the 1990s, although the ideas and their practical effect on rural policies did not undergo these transitions in such uncluttered manner (Ellis and Biggs, 2001). In Africa, postcolonial governments had a leading role in development, with most of the economic activities initiated and executed by the state. In the agricultural sector, government policies resulted in a range of government-controlled specialised institutions in input supply, marketing, credit and extension. Competition was curtailed by government policies, which led to monopolistic tendencies and inefficiency within these institutions. Although governments subsidised the inputs and credit to farmers, the agricultural exports were heavily taxed to support government expenditure and service external debts. Coupled with inefficiency and high costs in the government-controlled institutions, farmers ended up receiving low prices for their produce, and, in most cases, payment was delayed. Investment in the agricultural sector did not yield the expected results but instead budget deficits and external debts mounted. Internal and external pressure (mainly from donor agencies and international financial institutions) brought about changes in policy through Structural Adjustment Programmes, which meant reduction in government participation in production, trade and financing of commercial activities.

Market orientated reforms presume that elimination of state intervention induces significant private entry into the marketing system, leading to more competitive and efficient markets. Whereas there is evidence of trader entry in the liberalised sub-Saharan African food markets (Beynon et al., 1992; Coulter, 1994), complaints are still widely heard from peasant producers and consumers about traders' market power (Barrett, 1997). While entry into small-scale trading appears reasonably barrier free, enterprise expansion has been difficult and rare (Bryceson, 1993; Duncan and Jones, 1993; Steel and Webster, 1992). Barriers to movement within the food-marketing chain, in the Sub-Saharan Africa case, include access to working capital, market information, inter-seasonal storage, credit, transport and a reliable network of customers and suppliers (Barrett, 1997; Beynon et al., 1992; Bryceson, 1993; Coulter, 1994; Santorum and Tibaijuka, 1992).

Liberalisation strategies targeted more on improving prices of agricultural products but the benefits could have been curtailed because reduction in government revenues resulted in reduced investment in infrastructure. Empirical evidence suggests that liberalisation led to higher variance in prices although there was improvement in expected (mean) prices (Barrett, 1997). Higher variability in prices undermines investment in agricultural production, especially in quasi-fixed capital (Reardon et al., 1999). Liberalisation eliminated public input distribution systems thereby increasing variable input costs for cash constrained small farmers. Investments, by small farmers, in such costly inputs were further hindered by imperfections in factor markets. In particular access to credit was restricted to those having sufficient collateral (Baland and Platteau, 1996). Hence, smallholder farmers have increasingly relied on cash crop and nonfarm earnings (through labour markets or small to medium-scale enterprises) to finance their production and smooth consumption (Reardon et al., 1999). Others could have chosen subsistence production if transaction costs caused a wide gap between selling and purchase price (price band) (Sadoulet and Janvry, 1995).

Economic performance deteriorated rapidly in the sub-Saharan Africa (SSA) in the late 1970s and early 1980s and has continued to decline or stagnate in the past two decades, despite the development ideas and efforts put in place during the same period (Akyüz and Gore, 2001; Belshaw et al., 1999; Reardon et al., 1999). Two lines of arguments advanced to explain Africa's poor performance (Akyüz and Gore, 2001). The first line of argument points at mistakes in Africa's development policies: inward-oriented (import substitution) strategies (Stiglitz, 1998; World-Bank, 1981), anti-export bias, lack of openness, and inter-sectoral price distortions (in favour of the urban sector) (World-Bank, 1981). However, evidence from Asia does not support the claim that the import substitution strategy hurts economic development since most of the successful East Asian economies have had a long history of protection from external competitors of the domestic industries producing for the home market (Amsden, 1989; Shin, 1996). The second line of arguments stresses the effect of deep rooted institutional and structural constraints including geographic factors, demographic factors and culture (Bloom and Sachs, 1998; Easterly and Levine, 1997; Sachs and Warner, 1997; Temple, 1998). However, according to Akyüz and Gore (2001), neither of the two arguments consistently explains Africa's economic trends. For example, they do not explain the various episodes of rapid but un-sustained growth in the immediate post-independence period. Nor can they provide a satisfactory explanation as to why most countries have had a poor response to structural adjustment programmes, even where the adjustment policies have been vigorously implemented.

Nevertheless, the factors highlighted explain why the growth rate of the SSA region has lagged behind that of other tropical regions (i.e. Latin America and South and East Asia). In particular the climatic conditions and location of most of the SSA countries have had a negative effect on the productivity and growth of the agricultural sector, which in turn has affected the overall economic development (Bloom and Sachs, 1998). The climate for SSA is quite different from that of other parts of the tropical world for a number of reasons. Africa is a large land mass and much of the interior of SSA becomes extremely hot, as the temperature is not moderated by proximity to the sea. Secondly, the region does not receive the great monsoon rains that provide the vital seasonal precipitation to South and East Asia. Relatively higher precipitation occurs in the East African highlands, due to high altitude, cooler night temperatures and high fertile soils mainly of volcanic origin. As a result, most of the population is settled in these areas. But the highlands are economically disadvantaged, by being landlocked and isolated from the international markets. The highland areas have higher transport costs when compared to lowland areas which are in close proximity to the sea and hence to the export market. Most parts of Africa have very poor soils. The soil problems are compounded in the rain forest environments, where torrential rains leach the soils of nutrients. Tropical rain forest soils have limited fertility, which depends on the rapid decomposition of dead plant materials. Clearing the forests for agriculture production breaks the nutrient replenishment cycle and the soils are quickly depleted. This is why shifting cultivation dominated the traditional agricultural systems in rain forest areas (Boserup, 1965). The region is also infested with a host of pests and diseases, which cause much damage to humans, crops and livestock.

1.2 Problem Statement and study objectives

1.2.1 Problem statement

High population pressure has been associated with high agricultural intensification where land is intensively cultivated through the use of abundant labour in production (Boserup, 1965; Brush and Turner, 1987; Pingali et al., 1987; Ruttan, 1984). The driving forces behind intensification include increases in prices and demand for food (Boserup, 1965; Brush and Turner, 1987; Schultz, 1964) and development of markets and specialization (Tiffen, 1988). However, there is still limited empirical evidence linking rural market development and improvement in agricultural production. Such empirical evidence would motivate appropriate policy formulation and intervention to stimulate investment and growth in agricultural production.

The agricultural system that has developed over the years and characterizes most of SSA depends on labour as the major variable input, with no or insufficient use of purchased inputs (such as artificial fertilizer) (Reardon et al., 1999). In a situation where factor and credit markets are non-existent or partially exist, labour can hardly be substituted with capital inputs. High transaction costs in both the labour and input factor markets can lead farmers to follow intensification methods that involve more use of family labour and less capital. Also where land constraints increasingly bind and labour/land ratios are rising, one might expect farmers to choose production methods that are as labour intensive as possible (Reardon et al., 1999). The seasonality of agricultural production in developing countries further constrains the use of purchased inputs (including hired labour) in times when output is out of season and purchases must be funded from savings and/or loans. Moreover, financial institutions require collateral in form of land or other fixed assets as a condition of offering loans, which constrain small poor farmers' access to credit (Binswanger and Rosenzweig, 1986).

Agriculture in Uganda is dominated by smallholder farmers and characterised by low use of inorganic fertilizers, organic matter and agrarian capital such as soil conservation structures. The soils once considered the most fertile in the tropics (Chenery, 1960) now have the highest rate of nutrient depletion (Nkonya et al., 2004; Stoorvogel and Smaling, 1990;

Wortmann and Kaizzi, 1998). Soil erosion is also a major problem in the highland areas (Bagoora, 1988; Magunda and Tenywa, 1999; Nkonya et al., 2004; Tukahirwa, 1996). Market liberalization and structural adjustment policies contributed to the stabilising of the economy and reducing poverty in the 1990s, but sustainable development is yet to be achieved (Collier and Reinikka, 2001). Effective development strategies are needed if the country is to achieve sustained rural development. In particular, there is need for further empirical evidence on the effects of factor and product markets (labour, credit and food) on agricultural production, and changes in factor use in response to market opportunities (credit, product and labour markets) to come up with appropriate policies and strategies for achieving sustained development in the rural farm sector. In this study, the effects of factor and product market on the development of the banana sub-sector in central and southwestern Uganda are investigated. In particular, we analyse the impact of improvement in market (labour and food) opportunities on resource allocation between bananas and other crops, and between agriculture and non-farm enterprises.

1.2.2 Study objectives

Banana provides suitable options for subsistence and income generation in the mid- and high elevation areas of East Africa. In Uganda, production has been on the decline in the Central region, which is the traditional growing area, and increasing in the southwest of the country (Gold et al., 1999). Imperfections in factor markets (labour, and credit) and product markets are hypothesised to be some of the reasons behind the decline of banana production in the Central region. Biophysical constraints, including pests, diseases and decline in soil fertility and poor agronomic practices have also been cited as major causes of the decline in banana production in the region. On the other hand, increased access to product markets has contributed to an increase in banana production in southwestern Uganda.

Since the early 1990s, the National Agricultural Research Organisation (NARO), through its research programme, the National Banana Research Programme (NBRP), has conducted research to address the biophysical constraints (more specifically the main pests and diseases: banana weevil, nematodes, Sigatoka and Fusarium wilt). Limited research has been done in the area of socioeconomics and little is known about the socioeconomic factors that influenced the shift in banana production from the Central region to the southwest of the country. This study analyses resource allocation behaviour by banana smallholder farmers in Uganda, and in particular the household response to production constraints (pests and disease build up, declining soil fertility and market imperfections) and access to off-farm employment opportunities. The general objective is to better understand the dynamics of banana production in three study regions and the economic factors behind the shift of banana production from central to the southwest Uganda. Bananas are the most important staple for smallholder farmers in southern Uganda, both for food and cash income generation (Bagamba et al., 1999). Therefore understanding the dynamics of banana production in the region leads to an understanding of the smallholder agricultural production dynamics in general.

The specific objectives are:
(1) Characterisation of the banana production systems and assessment of the performance of the banana sub-sector
(2) Determining the factors influencing productivity and technical efficiency of banana production
(3) Testing for separability condition between production and consumption decisions for smallholder farmers and whether resources are allocated efficiently between farm enterprises
(4) Assessing the effects of economic factors on smallholder resource allocation decisions and implications for household welfare and employment
(5) Analysing demand for farm labour and supply of household labour, and determine the factors that influence time allocation between farm production and off-farm employment

The above objectives are aimed at answering the following research questions:
(1) What are the characteristics of the different study regions and how do they influence the banana production dynamics?
(2) What influences banana productivity and technical efficiency of banana farmers in the study regions?
(3) How efficient are smallholder farmers in using farm resources?
(4) How changes in economic factors impact on resource allocation decisions of smallholder farmers?
(5) What are the factors that influence family labour supply and farm household labour demand in the study regions?

1.3 Theoretical framework

Agricultural household models, which link consumption and production, date back to early twentieth century Russian economists (Chayanov, 1923), have been used extensively to explain farm household production behavior in the less-developed countries' rural economies (Taylor and Adelman, 2003). The models can be divided into two classes: the unitary and collective (or bargaining) household models (Hart, 1992). Unitary models in general represent a household as a single individual and as a unit of decision making in the production and consumption decisions. Critiques of the unitary models of the household initially focus on the failure of the models to take into account intra-household inequality and conflict. The problem essentially involves how to aggregate preferences. Neoclassical theory requires that preferences are exogenous and fixed, and hence the individual's preference orderings are consistent. Under these assumptions, economic behaviour can be deduced as a set of responses to wages and prices, and infer the preferences from observed behaviour. This convenient procedure breaks down if the basic unit of analysis is a group of individual household members with inconsistent preferences. The need to come up with a justification for equating the household to an individual with a consistent preference ordering has remained a central theme in the neoclassical literature (Hart, 1992).

The discovery of housework, out of the efforts to analyze the implications of the growing labour force participation of married women in the United States (Mincer, 1962) and from Becker's celebrated notion (Becker, 1965) that the household is a unit not only of consumption but also of production, transformed the household from an analytical nuisance to an object of interest (Hart, 1992). Hence, the combination of labour and capital in the production of home goods depends not only on the household technology and the prices of the market goods (inputs in the production of home goods), but also on the shadow price of time – the foregone earnings in the labour market of the domestic worker. To Becker and others who share the same view on the theory of household behaviour, the commodities produced within the household (Z–goods), rather than the market goods, are the arguments of the household's utility function (Pollack and Wachter, 1975). The market goods and time are not desired for their own sake, but only as inputs in the production of Z-goods. The theory of labour supply based on the household as unit of analysis as depicted in Mincer's paper (1962) and is summarized in his introduction to his collections of labour supply studies (Gronau, 2003; Mincer, 1993) in which he recasts the following expressions: the household or family is specified as the appropriate decision unit in the analysis of consumer demand, and income from individual household members is pooled; the complement to market activities is not merely leisure but all non market activities, including leisure, housework, child care and schooling; and in determining labour supply of household members, the family income is common to all members, but the substitution which determines the allocation of labour between the market and the non-market depends on individual market wages and household productivities, which differ among family members.

Another category of neoclassical household theories draws from Chayanov's *Theory of Peasant Economy* (1966) and appeared about the same time as Becker's influential article. The Chayanov peasant model is a theory of household utility maximization, first proposed in the 1920s by the Russian agricultural economist, A.V. Chayanov (Thorner et al., 1966) and resurfaced in the 1960s (Mellor, 1963; Nakajima, 1970; Sen, 1966). The model focuses on the subjective decision between farm work and income required to meet the consumption needs of the household (tradeoff between drudgery and income from work). The household is assumed to maximize utility from income subject to a land and labour constraint. The labour market is assumed to be absent and allocation of time between leisure and work on the family farm is determined purely by preferences.

Subsequent development of the farm household model focused on the impact for the logic of the model of relaxing the key assumptions: absence of the labour market and flexible land access, key assumptions in the Chayanov farm household model (Barnum and Squire, 1979a; Singh et al., 1986). The Barnum-Squire (1979a) household model incorporates a perfectly competitive labour market in the Chayanov's peasant household model, providing a framework for generating predictions about the responses of the farm household to changes in domestic (family size and structure) and market (output prices, input prices, wage rates, and technology) variables (Ellis, 1993; Hart, 1992).

Farm household models are designed to capture interactions between three different spheres of the farm household: the farm firm, the worker household and the consumer household (Berg, 2001; Sadoulet and Janvry, 1995). The decisions made by the household can be modeled under two different model assumptions: separable and nonseparable household models(Alderman et al., 1995; Chiappori, 1992).

Under perfect market conditions, production and consumption decisions are assumed to be made separately (Benjamin, 1992; Janvry et al., 1992). On the production side, the household chooses the level of labour and other inputs that maximize farm profits given the current configuration of capital and land. Optimal input choice depends on input prices, output prices, and wage rates, as well as the physical characteristics of the farm technology.

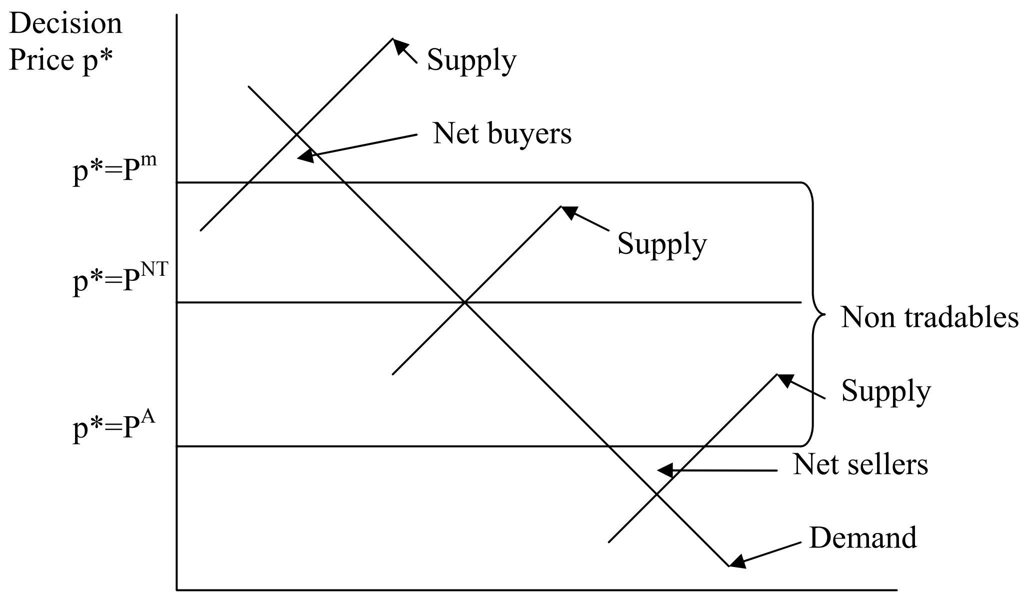
On the consumption side, the household maximizes utility over consumption goods and leisure time in the presence of a budget and time constraint. The budget includes profits from the farm. Optimal choices depend on the prices of the goods consumed, wages, total time available, and the characteristics of the family members who are consumers and workers, such as their gender, age, education and ethnicity/cultural values and norms.

In developing countries, perfect market conditions rarely exist. Not all products and factors of production can be traded on markets because of the high cost of transactions, shallow markets, and risks and uncertainty about markets and weather conditions. Limited access to credit is a frequent cause of market failure, as the household cannot satisfy an annual cash income constraint, with expenditure greater than revenue at certain periods of the year (Sadoulet and Janvry, 1995; Stiglitz and Weiss, 1981). Family and hired labour may be imperfect substitutes in agricultural production (Jacoby, 1993; Skoufias, 1994) while binding constraints in off-farm employment may prevent adjustment in the agricultural labour market (Benjamin, 1992; Ozane, 1992; Singh et al., 1986). Farmers may have a preference towards working off-farm (Lopez, 1986).

Under any of these circumstances, the production and consumption decisions cannot be treated as separable. Not only production decisions affect consumption decisions, but also consumption decisions (preferences) affect production decisions (Janvry et al., 1991; Strauss, 1986). Production and consumption decisions are no longer taken in response to exogenous prices, which are taken to be the same for all households. Prices (p*) are endogenised, being determined by the household's demand and supply conditions.

The quantity produced for a non-tradable commodity corresponds to an unobservable internal shadow price, the decision price P^{NT}, at which supply equals demand (Figure 1.1). The households face two prices under conditions of market imperfections: the buying price P^{m}, and the selling price P^{A}, which is below the buying price. Goods whose equilibrium price falls between the buying price and selling price will not be traded on the market (non-tradables). Households facing an equilibrium price that is above the buying market price produce less than they demand from the market (net buyers) and those whose equilibrium price is below the selling price produce more than they are able to consume (net sellers).

Figure 1.1 Household supply and demand under market imperfections



A household approach is required to analyze farm household behavior in a situation where there is need to estimate the production and consumption decisions simultaneously. The full structural model uses non-observable implicit prices and is quite complex to estimate, and for that reason it is not usually used. Simpler approaches to the estimation of a reduced form have been reported in literature (Berg, 2001; Sadoulet and Janvry, 1995).

The most widely used approach, which is applicable to all household decisions under all market failures, is the fully reduced form of the model (Behrman et al., 1997; Benjamin, 1992; Iqbal, 1986; Lopez, 1986; Saha, 1994). Production and consumption decisions are assumed to be functions of the decision prices p*, decision income y*, and household characteristics associated with the production and consumption decisions. The endogenous variables p* and y* themselves are functions of the exogenous prices, household characteristics and exogenous income and credit if the credit constraint is binding (Sadoulet and Janvry, 1995). Substituting these variables of the endogenous prices and income gives the fully reduced forms of the model. Separability is rejected if the parameters for the household time endowments and consumption preferences are jointly significantly different from zero in the input demand equations (Benjamin, 1992).

A second approach relies on a variation of the explicit form of the solution to the production and consumption problem and focuses on the estimation of input demand functions when some inputs are nontradable (Lambert and Magnac, 1992; Sadoulet and Janvry, 1995). The household's production decisions on inputs correspond to a cost minimization problem, where the household minimizes the cost of tradable inputs, conditional on the choice of nontradable inputs. The solution is a set of demand functions for the nontradable inputs, which are a function of exogenous prices, household resource endowment, amounts available of nontradable inputs, and output level. Appropriate instruments are used to correct the potential bias arising from including quantities of nontradables and output level in the right-hand side variables.

The third approach focuses on the labour allocation decisions of farm households under labour market imperfections (Abdulai and Regmi, 2000; Jacoby, 1993; Mishra and Goodwin, 1997; Newman and Gertler, 1994; Skoufias, 1994). Estimates of shadow wage rates of family members are derived by estimating the marginal productivity of labour from estimates of a farm production function. Substituting the endogenous wage rates in the standard labour supply functions and correcting for endogeneity allows a straight forward estimation of the farm household labour supply. Nonseparability is rejected if the shadow wage rates are not significantly different from the market wage rate. We adopt this approach for our study as there is no need for imputing the value of time for farm or self-employed workers from the wage rates earned by a small group of wage earners.

1.4 Outline of the study

This study is composed of five chapters, 2 to 6, which address the five specific objectives outlined in section 1.2. Chapter 2 describes the survey methodology used to select the study sites and to generate the data used in the study. The chapter also characterizes the household production systems followed by smallholder farmers in Uganda and assesses the performance of the banana sub-sector in particular.

The core of the study comprises of chapters 3 to 5. The factors influencing productivity and technical efficiency of banana are determined in chapter 3. An agricultural production function, incorporating soil nutrients and organic matter is formulated and used to determine the factors influencing banana productivity in three different regions: Central region, Masaka and the southwest. The stochastic production frontier is used to estimate the technical efficiency in banana production for the three regions and analyze the factors influencing efficiency within the banana sub-sector.

Chapter 4 presents the theory of the household model used to specify the labour demand and supply functions. A two stage least squares procedure is used to estimate the production function and labour equations simultaneously to correct for the bias that arises from labour input being an endogenous variable. The marginal products obtained are compared with the market (village) wage rates to determine whether resources employed on farm are allocated efficiently.

Chapter 5 provides estimates of smallholder household labour supply and demand for hired labour. We simulate the likely impact of changes in wage rate and road access on smallholder labour supply decisions and draw policy implications for household welfare employment and welfare. The factors influencing time allocation decisions between farm production and off-farm employment are determined. The findings are summarized and discussed in Chapter 6. Finally, we provide a brief summary at the end of the book. The present study contributes to the on-going debate about the separability of production and consumption decisions in developing countries. Findings contribute to the current debate, from a microeconomic perspective, on why Africa's economic growth has been slow, and particularly on the causes of decline in agricultural productivity and growth.

The study reveals that changes in economic conditions contribute to the shift in banana production from the central to the southwest. In particular, development of the labour market favors the nonfarm sector in the central region while road improvement and increased household incomes favor banana production in the southwest. Disease (Sigatoka) and pest (weevils) pressure appear contribute to differences in banana productivity. Soil nutrients appear not to have any effect on differences in banana production. Findings from the study confirm imperfections in the labour and food markets. Marginal value products of labour are lower than market wage rate implying that more labour is utilized in farm production than is optimal. Improvement in the labour market conditions is likely to benefit household members through higher employment levels and incomes. Consistent with theory, results show that factors influencing access to off-farm opportunities affect farm production and consumption decisions. Inconsistent with findings from literature, large farm sizes are associated with higher farm productivity and efficiency. Households with small farm sizes are more likely to have their members seek for off-farm wage employment (push factor). Higher nonlabour income is associated with higher use of outside labour in the southwest. Investment in education is likely to affect farm production in favor of the nonfarm sector. We find gender differences in terms of benefits of development of the nonfarm sector, with men more likely to benefit than women.

CHAPTER 2 Banana production characteristics and performance

2.1 Background

A remarkable diversity of bananas and plantains (*Musa spp.)* exists in the East Africa Great Lakes plateau with at least 84 locally evolved unique clones (Karamura, 1998). The endemic clones have been collectively termed the East African highland banana (*Musa* genome group AAA-EA) consisting of both cooking (*Matooke)* and beer (*Mbidde*) bananas (INIBAP, 1986; Karamura, 1998). The non-endemic types grown in Uganda include the exotic beer bananas (*Kayinja* ABB, *Kivuvu* ABB and *Kisubi* AB), the roasting (*Gonja*) and the dessert bananas (*Sukalindizi* AB, *Cavendish* AAA and *Gros michel* AAA).

The highland cooking banana (*Musa* genome group AAA-EA) is the most important staple crop in East African Great Lakes Region (Uganda, Tanzania, Burundi and Eastern Zaire). In Uganda, the crop has traditional roots in the country's central region, where the Baganda consider it as their main dish. Between 1900 and 1930, banana cultivation moved further to non-traditional growing areas in the east and southwest of the country. During the last 20 to 50 years, banana has replaced millet as the key staple in much of southwestern Uganda (Gold et al., 1999). During the same time, a decline in highland cooking banana production favoured some other banana cultivars (mainly of the beer types ABB and AB) and annual food crops (cassava, sweet potatoes and maize) in central region. The decline has been associated to low levels of N and K, but more important to reduced management. The low levels of N and K most likely resulted from reductions in mulching or use of organic amendments and from discontinuation of soil conservation practices. Farmers attributed the decline in plantation management, productivity and stand size to a number of socioeconomic factors, ranging from resource availability (declining farm sizes, outward labour flow, declining household incomes) to infrastructure and institutional factors (access to quality roads, credit facilities and extension services).

Up to 1970s, farmers in central Uganda depended mainly on cheap migrant labour from the southwest of the country and beyond (e.g. Rwanda). Decline in coffee and cotton prices, in addition to deterioration in the marketing infrastructure, crippled farmers' income and capacity to pay for hired labour and agricultural inputs. Traditionally, farmers derived their income from coffee and cotton. Bananas were mainly grown for home consumption. With the decline in farm incomes from coffee and cotton and increased need for cash for tradable goods and services, farmers diversified their sources of income, diverting some of the family labour into better paying activities, taking advantage of the close proximity to urban job markets (Kampala, Jinja and Entebbe). Management of major perennial crops (coffee and banana) declined and most farmers diversified into production of annual crops. On the other hand, banana production in the southwest of the country increased through both acreage expansion and yield per unit area (Gold et al., 1999).

Much of the increase in banana production in the southwest was attributed to increased access to markets in the 1980s and increase in rural population, which put pressure on the existing cultivable land forcing farmers to migrate to drier grassland areas, formerly considered suitable for millet production and grazing cattle. With time, bananas replaced millet as the major food in the region. However, farmers now complain of low farm gate prices for bananas, which fluctuate between seasons of high and low supply. There is increased tendency to intercrop bananas with coffee (Ssennyonga et al., 1999).

Banana is the major staple food crop over much of Uganda. The country is currently the world's largest producer and consumer of bananas (10.5 million tonnes in per annum), accounting for approximately 10% of total global production (FAOSTAT, 2006). Cooking banana production is approximated at 29.5% of the world banana production while production of dessert bananas is estimated to be 0.85% of world production. Production is mainly by smallholder farmers with total number of plots up to 2,695,000 averaging 0.24 ha, making it the most widely cultivated crop (Table 2.1). The Uganda National Household Survey (UNHS) report (1995-96) puts the national average yield for bananas at 14.9 tonnes per ha, well above that reported by the National Bureau of Statistics. Yields are highest in Western Uganda, estimated at 26.4 tonnes per ha and lowest in Central region where it is estimated at 5.5 tonnes per hectare. The yield in central region is consistent with statistics reported elsewhere (MAAIF, 1992). This is the region where production has been on the decline over the last 30 years.

Table 2.1 Number of plots and size for main food crops in Uganda, 1995

Crop	Number of plots (x 000)	Plot area (ha)	Area (x 000 ha)	Yield (MT/ha)	Production (x 000 MT)
Bananas	2,695	0.24	646.8	14.6	9458
Maize	1,001	0.26	260.3	1.4	369
Finger millet	856	0.27	231.1	0.6	136
Sorghum	805	0.27	217.4	0.7	131
Cassava	1,790	0.19	340.1	8.1	2746
Sweet potato	2,078	0.14	290.9	10.3	2990
Potatoes	183	0.14	25.6	8.0	204
Beans	1,360	0.17	231.2	0.9	199
Groundnuts	795	0.20	159.0	0.6	94

Source: Uganda National Household Survey (UNHS), 1995-96

Despite the decline in banana production in central region, expenditure on banana is still higher than on other food crops, among the rural and urban population in both central and western Uganda (Table 2.2). In central Uganda, expenditure on bananas is followed closely, in the rural areas, by cassava and sweet potatoes among the roots and tubers. Maize follows at only 4.8% of total expenditure. Expenditure within the urban population is quite skewed to bananas among the food crops. Expenditure on sweet potatoes and cassava is close to that of cereals (bread, rice and maize), ranging from 3.7% for maize to 6.1% for millet. The low expenditure on these commodities within the urban areas implies better market opportunities for bananas than for sweet potato, cassava and maize. Therefore, access to commodity markets cannot be the driving force behind farmers' decision to reduce banana production in favour of annual crops (cassava, sweet potatoes and maize).

Rural household monthly income in Central Uganda is slightly higher than that of Western Uganda as per the 1997 and 1999 household budget surveys (Table 2.3). However, urban household incomes (excluding Kampala) are higher for Western Uganda. Most of the income among rural households is derived from crop production, and the proportion derived is higher for households in Western Uganda. The proportion of income derived from the various sources for urban households is almost the same for both Central and Western Uganda. Urban dwellers derive more income from own enterprises (other than crops), followed closely by salaries and wages. The proportion of households owning land and cattle is higher in Western Uganda than in Central Uganda. Expenditure on purchased food items is more in Central Uganda than Western Uganda among rural households, implying that more households follow a self-sufficiency strategy in terms of food in Western Uganda than in Central Uganda.

Table 2.2 Monthly household expenditure on food items in Uganda, 1993/1994

Monthly expenditure per household	Central rural		Central urban		Western rural		Western urban	
	U.Sh	%	U.Sh	%	U.Sh	%	U.Sh	%
Bananas	6384	16.8	10853	16.1	6694	20.8	7385	17.3
Sweet potato	4290	11.3	3299	4.9	4621	14.3	2529	5.9
Potatoes	637	1.7	1399	2.1	469	1.5	1275	3.0
Cassava	4924	12.9	3029	4.5	2444	7.6	1055	2.5
Subtotal	16235	42.7	18580	27.5	14228	44.2	12244	28.7
Other foods	21807	57.3	48944	72.5	17978	55.8	30358	71.3
Total food expenditure	38042	100	67524	100	32206	100	42602	100

Source: Uganda National Household Survey (UNHS), 1993/94. Central urban excludes Kampala
Note: other foods include rice, maize, bread, millet, sorghum, sesame, meats, fish, milk, eggs, oils, fruits, vegetables, sugar, coffee and tea.

Table 2.3 Household characteristics for Central and Western Uganda

Characteristic	Rural households		Urban households	
	Central	Western	Central	Western
Monthly household income (x 000 U.Sh)				
1997	112.6	84.2	160.2	163.4
1999	143.4	127.7	229.7	302.3
Source of income (%)				
Crop farming	46	57	8	8
Other enterprises	23	19	42	40
Salaries and wages	11	11	31	36
Transfers	13	12	8	6
Property income	7	6	11	10
Proportion of households possessing				
Land (%)	72	84	-	-
Cattle (%)	17	22	-	-
Expenditure on food (%)				
Home produced	49	59	11	12
Purchased	46	38	89	85
Free	5	3	7	3

The aim of this chapter is to characterise the banana production systems in Uganda and assess the performance and current competitiveness of the banana sub-sector. Analysing the current resource constraints and productivity of the banana production system versus other production systems will shed more light on the possible causes of the shift of in banana production from the traditional growing areas of Central Uganda to the country's southwest. Section 2.2 has details of the survey methodology and types of data collected. Section 2.3 explores the demographic characteristics and resource constraints in the study region. Results from a cost benefit analysis are also presented to provide a clear perception of the competitiveness of bananas versus other crop enterprises. The chapter ends with concluding remarks.

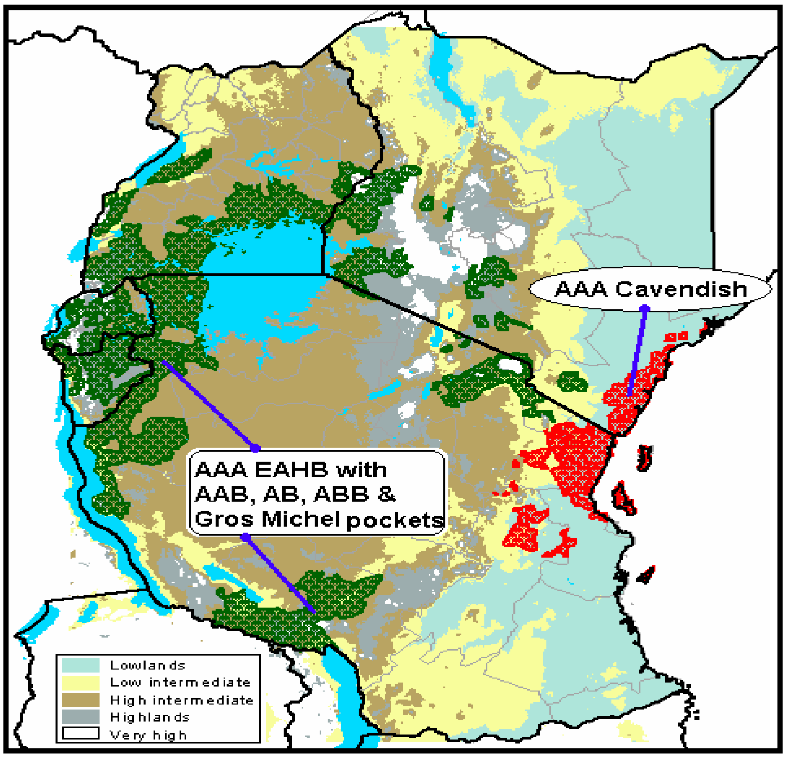
2.2 Data and survey methodology

Data used for this study was collected from study sites for the IFPRI/NARO project that was implemented in 2003-2004 to assess the economic impact of improved banana technology on smallholders in Uganda (Smale, 2006).

2.2.1 Sample survey design

The population domain was purposively selected to cover major banana producing areas (Smale et al., 2006). The areas correspond roughly to the central and southwest geographical zones in Uganda, and the Kagera region of Tanzania, for which the East African highland bananas (*Musa* AAA-EA) is the dominant genomic group (Figure 2.1). This group includes two major use classes (cooking bananas, or *Matooke*, and beer bananas, or *Mbidde* (Karamura and Pickersgill, 1999).

Figure 2.1 Principal banana growing areas of East Africa showing the terrain and genome differentiation



Source: (Smale et al., 2006)

Note: The AAA-EA is the dominant genomic group in the highland areas of Rwanda, Western Tanzania, DRC, Burundi and Kenya. The AAA dessert banana dominates the lowland coastal areas of Kenya and Tanzania.

Stratification

Two factors were used as stratifying variables; elevation and exposure to new banana cultivars. Elevation was selected as a stratifying variable to represent the numerous, correlated factors that affect severity of most pests and diseases of bananas in the Lake Victoria region (Speijer et al., 1994), and the fact that elevation is related to soil quality and climate (Tushemereirwe et al., 2001).

The second stratifying variable was institutional: previous exposure to new banana cultivars (exposed versus not exposed). Exposed areas in Uganda were based on sub-counties or local council 3s (LC3s) where researchers, extension, or other programmes had introduced improved planting material in at least one community. Areas with no exposure were those where no organised programme designed to diffuse improved planting material had been conducted. The exposure variable was used in predicting impacts of improved banana varieties, which was the main objective of the IFPRI/NARO project (Smale, 2006).

Sampling

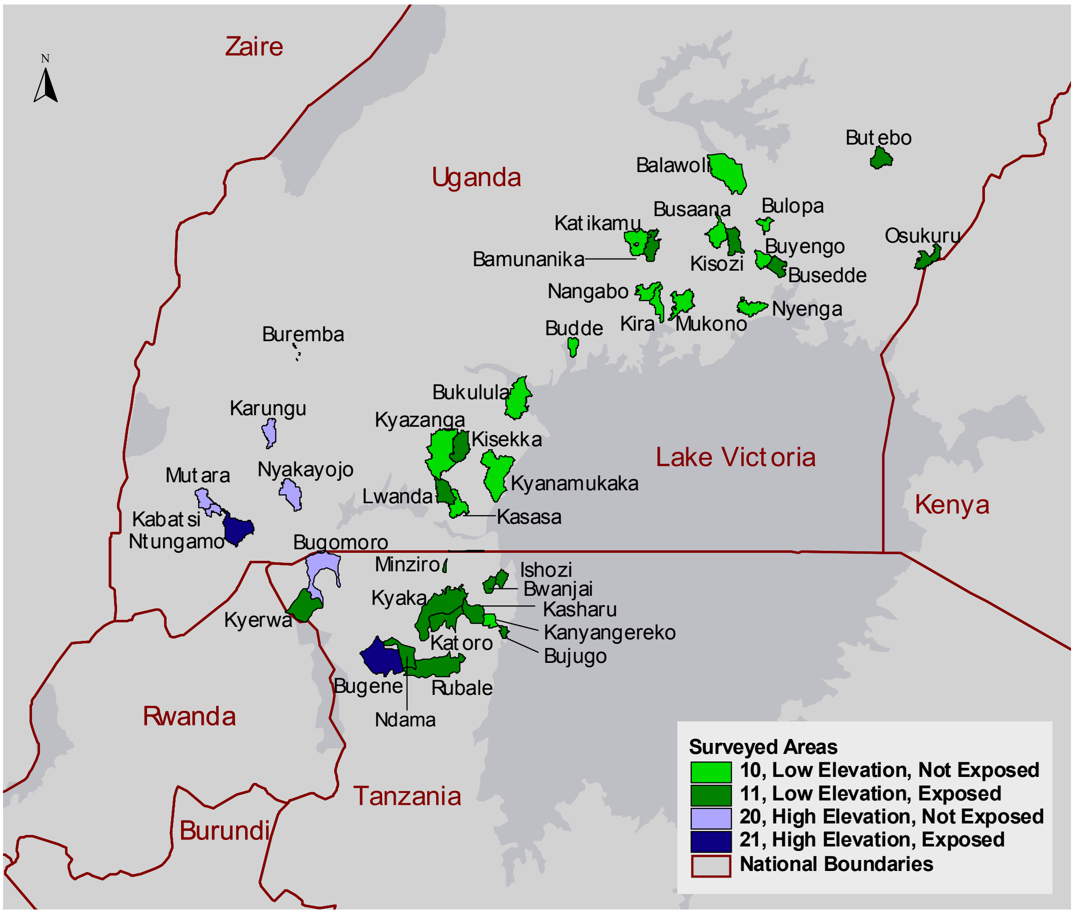
The LC3 was the primary sampling unit (PSU). The total number of PSUs was fixed at 27 for Uganda. The sample consists of 5 PSUs sample from high elevation (> 1200 meters) and 22 from low elevation (<1200 meters) (Figure 2.2). The PSUs were allocated in the two elevation levels proportionate to the probability based on the population of the PSUs in the survey domain.

The secondary sampling unit (SSU) was the village. One SSU was selected per PSU except for three PSUs (Ntungamo, Kisekka and Bamunanika) where 2 additional SSUs were selected from each PSU. The probability of selection of an SSU is denoted as ($1/M_p$) where M_p represents the number of villages in the p^{th} PSU (p = 1,…,27).

The number of households selected from each PSU was 20, which is the minimum sample size for conducting hypothesis tests on variables measured at community level (e.g. physical capital). The reason for keeping the sample small was to conform to the limited available budget (Smale et al., 2006). For this particular study, two more villages were selected in each of three PSU (Ntungamo, Bamunanika and Kisekka) to increase the sample from 20 to 60 for the purpose of generating variables for biophysical analysis (Rufino, 2003) to complement the economic analyses in Chapter 3.

The probability of selection (sampling fraction) of a household is denoted as ($20/H_s$), where H_s is the number of households in the s^{th} village (s = 1,…,33 SSUs in the sample). Where the households were systematically ordered, random numbers were used for selection. Otherwise, a random start with systematic random sampling from the compiled list was employed.

Figure 2.2 Sites sampled for survey



Source: (Smale et al., 2006)

This study uses the sample from Uganda as the focus is on the shift of production of Uganda's bananas from the central region to the country's southwest. The sample was post stratified into three strata based on differences in regional production characteristics. The final sample comprises three regions: central, Masaka and the southwest (Figure 2.3). The central region is where production decline has been most experienced. Production in Masaka is higher than that of the central region although the region has been hit by pest outbreak in the mid-1970s (Gold et al., 1999). Production is highest in the southwest, which is located furthest from the market centres (Kampala, Entebbe and Jinja). Both the central region and Masaka fall under the low elevation stratum while the southwest is located in the high elevation stratum. A few areas in Masaka are located above 1200 meters

Unit of observation

The basic unit of observation is the farm household, and is defined according to the culture of which the household was a part. Thus it includes female-headed, child-headed, male-headed households with more than one wife as well as male-headed with no wife. Some data was obtained at the village level (e.g. wage rates and location of village from the tarmac road). The village wage rate paid to casual labour was obtained from key informant interviews while distance from tarmac road was taken from the car odometer mileage reading.

Figure 2.3: Map of Uganda showing study regions: central, Masaka and southwest

2.2.2 Data and survey instruments

A set of 10 structured, pre-tested questionnaires were used as instruments to collect the data for the IFPRI project, some of which were not applicable for this study. Six of the instruments were single visit administered at the beginning of the study; one was administered three times; while three were collected monthly. The single visit questionnaires comprised the household, banana plot, labour, expenditure, income and banana cultivar schedules. The seventh instrument (general plot schedule) was collected three times, to capture production seasonality. The monthly schedules comprised the expenditure, labour, production, and income. The instruments most applicable for this study are attached as Appendix 2.1.

2.3 Household characteristics and production

2.3.1 Demographic characteristics

Demographic characteristics of respondents are provided in Table 2.4. Household heads average 45 years of age with approximately 6 years of formal education. Education level is slightly higher in the central region and lower in the southwest. Most households were male headed, the proportion being slightly higher in the southwest and lower in Masaka. Most household heads could neither read nor write English, implying that they depend on the local language to access information. The family size averaged 6 persons of which approximately 3 were adults (15-64 years), which implies that half of the household members were dependants. The proportion of household members with post primary education was highest for the central region and lowest for the southwest.

Table 2.4 Demographic characteristics by region

Variable	central		Masaka		southwest		Overall	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Farmer characteristics								
Age (Years)	46.0	1.27	43.5	1.81	42.8	1.53	44.8	0.95
Education (years)	6.66	0.37	4.84	0.36	4.83	0.38	5.9	0.25
Gender (Male) (%)	76.3		73.2		82.5		76	
Knows English (%)	49.56		43.6		41.9		46.8	
Does not know English (%)	50.44		56.4		58.1		53.2	
Household characteristics								
Family size	5.96	0.19	5.33	0.27	6.273	0.3	5.82	0.14
Male (> 64 years)	0.124	0.03	0.096	0.03	0.163	0.05	0.122	0.02
Male (15-64 years)	1.353	0.08	1.085	0.08	1.555	0.14	1.304	0.05
Male (5-14 years)	1.07	0.08	1.054	0.13	0.983	0.12	1.052	0.06
Female (> 64 years)	0.117	0.02	0.111	0.03	0.106	0.04	0.114	0.02
Female (15-64 years)	1.416	0.07	1.083	0.07	1.688	0.14	1.359	0.05
Female (5-14 years)	1.056	0.08	1.072	0.12	1.044	0.14	1.059	0.06
Babies (<5 years)	0.824	0.09	0.827	0.1	0.733	0.08	0.811	0.06
proportion not educated	0.233	0.02	0.24	0.03	0.307	0.03	0.243	0.01
Proportion primary educated	0.567	0.01	0.623	0.03	0.58	0.03	0.586	0.02
Proportion post-primary	0.214	0.02	0.138	0.03	0.112	0.02	0.179	0.01
N	340		178		140		658	

SE = standard error

2.3.2 Resource constraints and markets

Land

The average farm size was approximately 4 acres with central region having the highest land access (4 acres owned) and southwest the lowest (2.5 acres) (Table 2.5). Cropped area accounted for the biggest proportion (58% for the central region and 63.6% for the southwest region). The proportion under fallow was 8.5% for central Uganda and only 3% for the southwest. This implied that the southwest is much more constrained in terms of land access than the central region. The proportion under pasture was highest in Masaka (37%) followed by the southwest (21%) and lowest in the central region (19%). However the standard error (SE) for Masaka was quite high implying that there was high variability in land ownership.

The largest proportion of land under cultivation was allocated to bananas. The proportion was highest for the southwest (51.3%), followed by that of Masaka (36.7%) and lowest for the central region (19.3%). The large proportion of land allocated to bananas for the southwest and Masaka shows the importance farmers attach to the crop. Farmers in the two regions derive most of the cash income from bananas and the crop is also the most important source of food for the households (Bagamba et al., 1999; Bagamba et al., 2003).

Crop production was more diversified in the central region with significant proportions of land allocated to bananas, coffee, maize, cassava, sweet potato and beans. In Masaka, the most important crops in terms of land allocation were bananas, coffee, maize and beans. The southwest was the least diversified in terms of crop production, with only three important crops: bananas, millet and beans.

Table 2.5 Household land access and utilisation

Variable	central		Masaka		southwest		Overall	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Land resources (acres)								
Land owned	4.030	0.448	3.550	0.602	2.549	0.269	3.704	0.320
Cultivated	2.328	0.362	2.089	0.174	1.621	0.139	2.169	0.212
Fallow	0.343	0.044	0.257	0.044	0.080	0.025	0.285	0.029
Natural pasture	0.763	0.181	0.994	0.564	0.534	0.157	0.811	0.208
Improved pasture	0.007	0.003	0.004	0.004	0.0001	0.0001	0.005	0.002
Forested	0.137	0.041	0.020	0.008	0.063	0.024	0.091	0.023
Swamp	0.118	0.026	0.012	0.008	0.048	0.017	0.076	0.015
Water	0.013	0.005	0.007	0.005	0.002	0.001	0.010	0.003
N	340		180		140		660	
Major crops (acres)								
bananas	0.450	0.044	0.766	0.096	0.832	0.077	0.601	0.043
Coffee	0.239	0.037	0.361	0.055	0.062	0.014	0.262	0.029
Maize	0.279	0.053	0.195	0.032	0.028	0.010	0.223	0.031
Millet	0.015	0.006	0.013	0.004	0.249	0.033	0.040	0.006
Cassava	0.283	0.027	0.135	0.016	0.037	0.012	0.205	0.016
Sweet potato	0.391	0.069	0.149	0.018	0.073	0.015	0.273	0.039
Beans	0.270	0.025	0.253	0.026	0.310	0.047	0.268	0.017
N	305		170		131		606	

SE = standard error

Labour use and wages

Farmers in the central region used more family labour (in terms of work hours per year) in farm production than farmers in Masaka and the southwest (Table 2.6). However, the proportion of male hours out of the total family hours used in farm production was higher for the southwest (38.2%) compared to Masaka (31.3%) and the central region (28.4%). Hired labour used (in terms of hours used per year) was highest in the Masaka, followed by the southwest and lowest in the central region. The proportion of farmers that used outside labour was highest for Masaka (74%), followed by the southwest (55%) and lowest for the central region (45%).

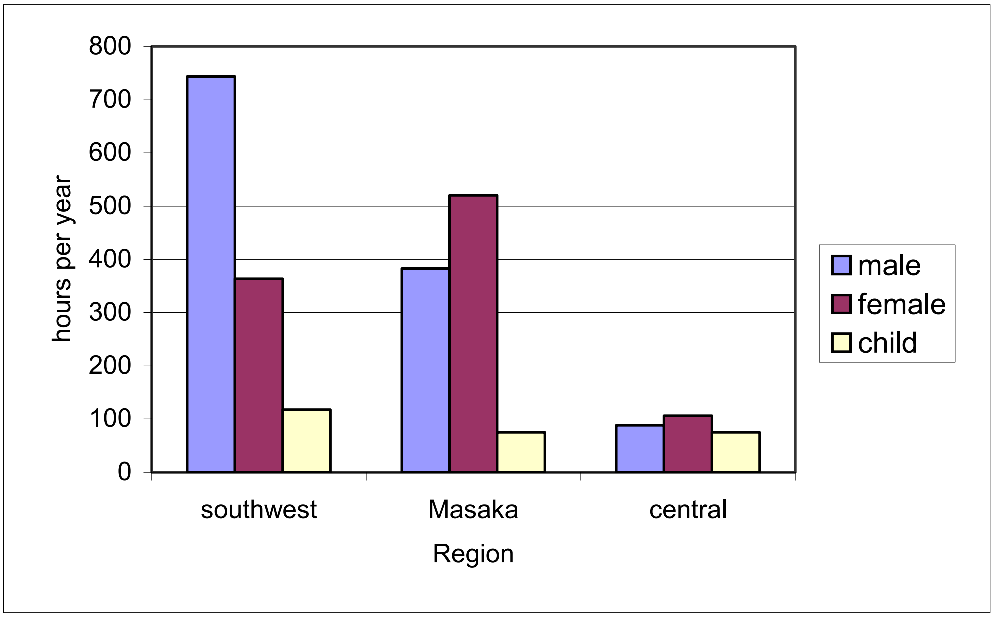
Table 2.6 Labour used in farm production (hours/year) by average household

Variable	central		Masaka		southwest		Overall	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Family labour	2540.6	135.2	1865.7	104.1	1643.1	97.6	2231.0	86.7
Male	722.0	53.9	583.9	59.7	627.9	50.9	668.5	36.7
female	1212.4	66.1	854.6	50.7	798.9	45.8	1055.1	42.7
children	741.0	91.1	439.2	83.4	359.6	51.9	604.8	59.0
Hired labour	123.4	24.6	213.3	30.3	191.6	29.1	159.1	17.5
Male	88.4	14.5	176.5	27.1	145.9	24.0	122.3	12.5
female	32.5	12.0	31.6	7.4	36.5	7.4	32.7	7.3
children	2.5	1.2	5.2	2.2	9.2	3.0	4.1	1.0
Use hired labour	0.45		0.74		0.55		0.55	
N	337		139		138		614	

SE = standard error

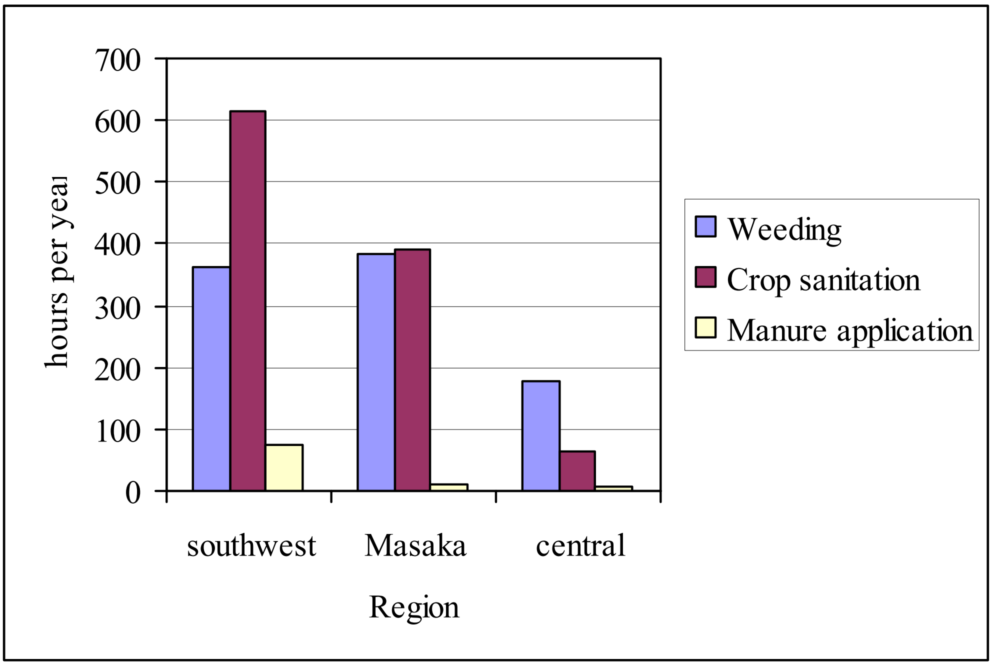
Differences were apparent in the amount of labour used in banana production, by activity and gender, and between southwest and the central region. Labour allocated to cooking bananas was relatively greater in the southwest areas (highlands) compared to Masaka and the central region (Figure 2.4). The proportion of male labour was quite high in the southwest while the proportion of female labour was larger in Masaka and the central region, illustrating the differences in importance given to bananas by gender. In the southwest, bananas have the dual purpose of sale and home consumption, explaining why men participate heavily in production. In the central region, the crop is mainly produced for home consumption, leading to more involvement of women in its production.

Figure 2.4 Labor used in banana production by gender and region



In terms of agronomic practices, most labour is allocated to crop sanitation in the southwest, while the amount allocated to weeding and crop sanitation, in Masaka, is almost the same (Figure 2.5). In the central region, the proportion of labour allocated to weeding was higher compared to crop sanitation despite the fact that this was the area with the most severe infestation with banana pests and diseases (Speijer et al., 1994).

Figure 2.5 Labour used in banana production by type of activity and region



Concerning wages two features are highlighted in Table 2.7. First, farmers in the central region pay higher wage rates than in the southwest. Secondly, farmers in the central region pay lower farm wage rates than the going casual wage rates, while those in the southwest pay wages that are higher than the casual wage rates in their region. These findings reflect the differences in the level of development of the nonfarm sector in the two regions. Casual wage rates reflect market wage rates determined by the labour supply and demand in both on-farm and nonfarm sectors. The high casual wage rates in the central region imply that the nonfarm sector for unskilled labour is more developed and more remunerative than the farm sector. Farmers are only able to pay cheaper rates to labourers that cannot find employment in the nonfarm sector (wage or self-employment).

By contrast, farmers in the southwest paid hired labour at wage rates that were higher than the going casual wage rates. Three possible reasons could be advanced for this observed behaviour: (1) most farmers were small holders and had limited bargaining power, (2) majority employ labour at periods of peak labour demand when wages are high, and (3) farmers employ outside labour for harder tasks (e.g. land preparation and management of post-harvest banana residues) and were thus charged higher wage rates.

Table 2.7 Wage rates paid by farmers and earnings per hour from the non farm sector

Variable	central region		Masaka		southwest		Overall	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Wage rate (casual)	466.0	13.3	343.3	15.5	218.5	2.13	399.8	10.0
agricultural wage	396.5	15.1	337.3	16.2	228.3	3.8	358.8	10.2
non-agricultural wage	444.1	15.5	359.4	21.0	324.2	11.1	404.5	11.6
Salary (regular wage)	507.3	14.2	339.4	23.3	1288.4	175.3	549.5	25.1
Nonfarm self-employment	554.9	36.8	419.2	25.3	344.3	19.7	489.2	23.5

SE = standard error

The above interpretation is supported by the data showing important differences in amount and source of nonfarm income between the study regions (Table 2.8). Households in the central region obtain most of their income from nonfarm self-employment (64.3%) compared to the southwest, where self-employment off-farm as a share of the total nonfarm cash income was 29.9%. Income from crops (including subsistence production) was highest in southwest and lowest in the central region. In the central region, the income from nonfarm sources is greater (approximately one and half times) than the income from crops.

Nonfarm self-employment available in the area required limited education and skills compared to salaried jobs or activities with higher wages, which depend on more education and skills (Tschirley and Benfica, 2001). Thus nonfarm self-employment is more likely to compete directly with the farm sector for unskilled labour. Households involved in the nonfarm self-employment were less likely to invest in farm production as most of the income was used for household consumption smoothing. On the other hand, they were also less likely to accept work in the agricultural wage sector, since earnings in the nonfarm self-employment sector were higher than the agricultural wage. Salaried household members and those involved in high wage labour activities were more likely to make savings, invest in farm assets and hire labour for farm production. Findings therefore suggested that the farm sector in the central region was more likely to have limited access to both family and hired labour.

The average income derived from agricultural wage employment in the central region was close to that of the southwest. In the past, the southwest was a source of cheap labour for coffee and cotton production in the central region. Some of this labour found its way into banana production in exchange for food. Infrastructure and urban development in the southwest led to the growth of better opportunities, slowing the labour outflow to the central region, which is one of the hypothesized causes of decline in banana production in the central region (Gold et al., 1999). Benefits from infrastructure and urban development in the southwest were apparent. The share of nonfarm wage employment (including salary) in the southwest was 59.8% of the total nonfarm income compared to 28.7% for the central region. Total nonlabour earnings (rents, interest and remittances) were also greater for the southwest.

Table 2.8 Household income composition from agriculture and nonfarm employment

Variable	central		Masaka		southwest		Overall	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Income from crops (k)	498.5	36.2	541.0	38.1	849.8	50.1	555.0	25.1
Off-farm income								
Agricultural wage (k)	51.1	18.0	34.8	8.7	45.1	6.6	45.2	8.1
Non-agricultural wage (k)	71.5	11.4	34.8	7.8	73.6	17.5	63.8	8.0
Regular (salary) (k)	137.4	31.6	26.4	10.5	186.7	142.7	129.3	51.9
self-employment (k)	467.4	45.7	176.6	39.7	130.1	27.0	282.2	24.9
Not defined (k)	10.0	3.4	0.1	0.1	0.3	0.3	4.3	1.5
Total nonfarm (k)	727.4	63.9	272.4	39.2	435.5	143.9	520.5	58.7
Non labour income								
Interest and dividends (k)	9.7	6.8	0.6	0.3	19.4	8.9	11.0	4.2
land and house rent (k)	23.0	6.6	0.8	0.4	12.0	7.8	14.0	3.9
Remittances and gifts (k)	52.0	14.0	23.1	4.3	67.1	50.8	50.7	18.8
N	340		180		140		660	

SE = standard error

Input use

Use of purchased inputs was reported to be very low in Uganda (Nkonya et al., 2004). Specifically, fewer than 10% of smallholder farmers in Uganda use inorganic fertilizer, one of the most likely technologies to improve soil fertility (Pender et al., 2001). Estimates show that smallholder farmers in Uganda apply, on average, only 1 kilogram of soil nutrients per ha (NARO and FAO, 1999), which is well below the average reported for sub-Saharan Africa (Heisey and Mwangi, 1996; Weight and Kelly, 1998).

Use of organic inputs, among the sample farmers, was also low (Table 2.9). The proportion of households that used manure and the amount used was higher in the southwest compared to Masaka and the central region. Farmers in the southwest used approximately three times the amount of manure used in the central region. The trends in use of other organic amendments (grass mulch and crop residues) were similar to that of animal manure. However, the proportion of farmers that used mulch was lower and the quantity used was also lower. This could be attributed to increasing population pressure on land, which has resulted in a declining farm size and thus makes grass mulch less available (Gold et al., 1999). More farmers used crop residues in the southwest than in Masaka and the central region. The quantity used was also higher for the southwest. Generally, more farmers used crop residues than any of the other soil amendments.

Table 2.9 Amount (Tonnes/year) of organic residues used in banana production

Variable	central		Masaka		southwest		Overall	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Manure								
Proportion that use	0.25	0.03	0.25	0.05	0.27	0.04	0.26	0.03
Amount used	0.23	0.06	0.46	0.14	0.61	0.19	0.35	0.06
Grass mulch								
Proportion that use	0.15	0.03	0.09	0.04	0.09	0.02	0.12	0.02
Amount used	0.04	0.009	0.13	0.05	0.36	0.17	0.10	0.03
Crop residue								
Proportion that use	0.36	0.04	0.15	0.03	0.43	0.05	0.30	0.03
Amount used	0.13	0.03	0.19	0.06	0.32	0.11	0.17	0.03
N	340		180		140		660	

SE = standard error

Credit and information access

Farmers in central Uganda received about seven times the amount of credit received by farmers in Masaka and about five times that received by farmers in the southwest (Table 2.10). The proportion of farmers that did receive credit was also higher for the central region, being more than three times that for Masaka. The proportion of farmers that received credit was quite low in all the regions.

Farmers in the southwest were least visited by extension workers, the number of visits per farmer being about for times for Masaka and about one and half times for the central region. The proportion of farmers visited by extension was quite low (16% for the whole sample).

Livestock

The value of cattle owned by farmers was highest in the central region and lowest in Masaka (Table 2.11). More farmers owned cattle in the central region (42%) than in Masaka (30%) and the southwest (25%). The trend for value of all animals owned was similar to that of cattle, the value being highest in the central region and lowest in Masaka. The proportion of farmers that own livestock was slightly higher for the Central region.

Table 2.10 Credit access by households and number of extension visits in six months prior to interviews

Variable	central		Masaka		southwest		Overall	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Amount credit (U.Sh)	22,112	9,258	3,177	1,444	4,544	2,132	14,006	5,285
Obtained credit	0.087	0.022	0.027	0.01	0.09	0.03	0.07	0.013
Extension visits	0.48	0.19	1.34	0.52	0.345	0.067	0.75	0.2
proportion visited by extension	0.115	0.022	0.253	0.048	0.134	0.026	0.162	0.02
N	340		180		140		660	

SE = standard error

Table 2.11 Value of livestock and proportion of farmers owning animals

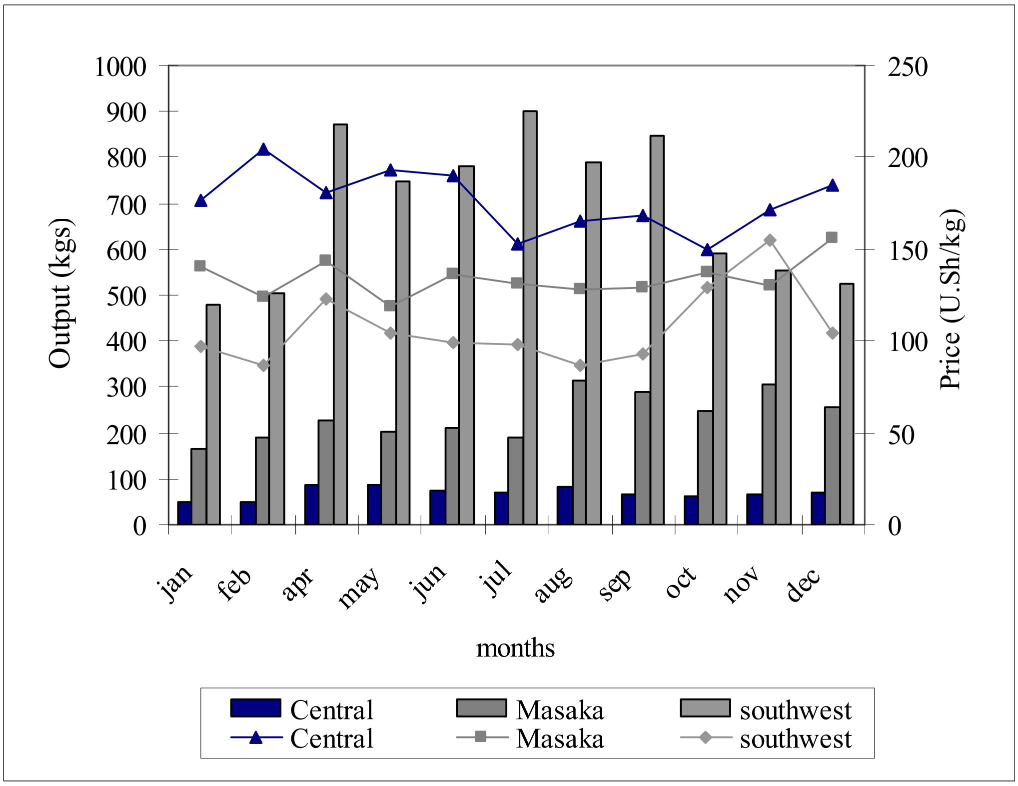
Variable	central		Masaka		southwest		Overall	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Cattle								
Value of stock (k)	374.3	67.8	178.4	51.7	260.1	61.0	297.7	42.8
Proportion of farmers	0.42	0.04	0.30	0.05	0.25	0.04	0.36	0.03
All animals								
Value of stock (k)	458.4	72.0	228.8	56.0	324.2	65.0	368.6	45.7
Proportion of farmers	0.85	0.03	0.78	0.05	0.65	0.05	0.80	0.02
N	340		180		140		660	

SE = standard error

Banana prices

Banana prices were highest in the Central region, followed by Masaka and lowest in the southwest (Figure 2.6). Prices vary during the course of the year responding to supply and demand conditions. There were less variation in prices within Masaka but variation was high for the other two regions. In the southwest, prices were lowest during the peak production period of July to September. Prices were highest in November in response to a decline in output supply. Prices were again low in December to February, even when data showed that output had not increased. The decline in prices during this period was most likely a response to changes in production conditions of other food crops (specifically millet). Millet is harvested during the same period and contributes to subsistence needs of the farmers, leading to a drop in general prices. In the Central region, prices were highest during July to October and this is the period when production of bananas in the southwest was at a peak. This is also the period when cereal (maize) and tuber (sweet potato) harvesting is at the peak. Cereal harvesting takes place from July to August. One of the main complaints of farmers was the low prices they received during the peak production periods, and prices were high when they barely have enough for home consumption and no surplus for sale.

Fig 2.6 Household banana output and price variation by month and region



Source: survey data April 2003 – February 2004

2.3.3 Competitiveness of banana production

Summaries of the economic analysis for banana, coffee and annual crops are presented in Tables 2.12 to 2.15. Table 2.12 presents results of the economic analysis of banana production for the three regions. The gross margin for bananas was highest in the southwest and lowest in the central region. Return to family labour was also highest in the southwest but lowest in Masaka. The high return to family labour obtained for Masaka was as a result of a lower cost of production, in terms of amount of labour required, compared to the other regions. The high gross margin for the southwest justifies why farmers in this region allocated more land to bananas than to other crops compared to the other two regions. In Masaka, the low cost of production justifies why more land was allocated to bananas in this area than in the central region.

Table 2.12 Economic analysis of cultivating one hectare of bananas (*Matooke*)

Variable	Central region	Masaka	southwest	Overall
Output (MT/year)	7.33	7.97	18.91	10.6
Price per ton (k)	170.2	133.6	103.0	149.6
Value of output (k)	1,247.3	1,065.3	1,947.8	1,504.4
Hired labour (hours)	120.2	210.8	474.6	232.8
Family labour (hours)	2630.8	1600.1	3059.8	2295.8
Total labour (hours)	2751.0	1810.9	3534.4	2528.6
Wage rate (U.Sh/hour)	476.9	343.5	218.4	400.1
Cost of hired labour (k)	57.3	72.4	103.7	93,2
Gross Margin (k)	1,190.0	992.9	1,844.1	1,411.3
Return to family labour (Shs/hour)	452	620.5	602.7	614.7

Note: benefits and costs valued in Uganda Shillings (1830 Ush≈1 USD); return to fixed resources (e.g. land) not deducted from the gross margin in the computation of return to family labour.

For central Uganda, the gross margin obtained for bananas was much higher than for most crops with the exception of millet (Tables 2.12 and 2.13). The high gross margin for bananas justified the higher proportion of land allocated to bananas compared to other crops. Apart from gross margin and crop yields, the other factor that determined land allocation to crops was the labour requirements for each crop per hectare. Cassava and sweet potatoes, which required less labour than millet, were allocated more land. Returns to labour were lowest for coffee. Low returns in coffee could be attributed partly to the high incidence of coffee wilt disease in the region currently and also to the old coffee trees.

Table 2.13 Economic analysis of cultivating one hectare for selected crops in central Uganda

Variable	Coffee	Maize	Millet	Cassava	Sweet potato	Beans
Output (MT/year)	0.4	2.5	2.7	2.6	5.8	1.5
Price per ton (k)	331.9	186	380.2	166.4	119.8	345.5
Value of output (k)	132.9	462.8	1,033.4	429.4	696	516.4
Hired labour (hours)	90.6	173.9	16.7	137.2	190.2	100.9
Family labour (hours)	1487.6	2742.4	2782.6	2100.1	1956.5	2869.4
Total labour (hours)	1578.2	2916.3	2799.3	2237.3	2146.8	2970.4
Wage rate (U.Sh/hour)	410.9	459.2	404	525.4	552.7	462.8
Cost of hired labour (k)	37.2	79.9	6,8	72.1	105.1	46.7
Gross Margin (k)	95.6	382.9	1026.6	357.3	590.9	469.7
Return to family labour (Shs/hour)	64.3	139.6	369	170.1	302	163.7

In Masaka, cassava had higher benefits than any of the crops (Table 2.14). Sweet potatoes have the lowest gross margin. Land quality was probably one of the reason for differences in gross margin between crops grown in the same region. The most fertile land was allocated to bananas and coffee, leaving the less fertile plots for the production of annual crops, specifically those that are not produced for the market. Returns to labour are highest for cassava and lowest for maize.

Table 2.14 Economic analysis of cultivating one hectare for selected crops in Masaka

Variable	Coffee	Maize	cassava	sweet potato	Beans
Output (MT/year)	2.1	3.2	8.3	3.2	2.3
Price per ton	390.3	162.8	156.4	111.8	277.4
Value of output (k)	821.4	524.4	1,291.9	362.8	641.4
Hired labour (hours)	347	474.8	59	151.5	163.7
Family labour (hours)	1732.4	1835.2	811.1	1263.2	3803.6
Total labour (hours)	2079.4	2310	870.2	1414.6	3967.3
Wage rate (U.Sh/hour)	391	423	362.9	422.8	423.6
Cost of hired labour (k)	135.7	200.8	21.4	64	69.3
Gross Margin (k)	685.7	323.6	1,270.5	298.7	572.1
Return to family labour (Shs/hour)	395.8	176.3	1566.3	236.5	150.4

In the southwest, coffee was second most profitable crop after bananas. Cassava was the least profitable in terms of gross margin (Table 2.15). Gross margin was lowest for millet, cassava and beans. Use of hired labour was limited to production of bananas and sweet potatoes. Like in Masaka, differences in values of gross margin could be attributed to differences in land quality where for example, farmers allocate the best land to bananas and less fertile land to millet. High returns to labour were obtained for maize and cassava because of the low amount of labour used in their production. Farmers allocated less labour, than was optimal, to the production of maize and cassava most probably because of the importance they attach to the two crops. First, the gross margins of maize and cassava were much lower than for coffee and bananas. Secondly, in terms of food, maize and cassava are less preferred than bananas, millet and sweet potatoes.

Table 2.15 Economic analysis of cultivating one hectare for selected crops in the southwest

Variable	Coffee	Maize	Millet	cassava	sweet potato	Beans
Output (MT/year)	3.45	2.05	1.61	3.91	4.38	1.48
Price per ton	364.6	292.8	301.8	117.1	127	328.1
Value of output (k)	1,259	601.7	484.9	457.4	555.7	486.1
Hired labour (hours)	15	0	3.1	0	142.9	74
Family labour (hours)	1358.6	264.5	1344.2	128	883.2	1035.3
Total labour (hours)	1373.6	264.5	1347.3	128	1026.1	1109.4
Wage rate (U.Sh/hour)	228.4	238.3	216.5	217.4	228.7	218.6
Cost of hired labour (k)	3.4	0	0.7	0	32.7	16.2
Gross Margin (k)	1,255.5	601.7	484.2	457.4	523.1	469.9
Return to family labour (Shs/hour)	924.1	2274.8	360.2	3573	592.2	453.9

2.4 Conclusions

Changes in economic conditions appear to have contributed to the shift of banana production from the Central region to the southwest. Specifically, increase in nonfarm income in the Central region reduced farmers' need for cash income generated from farm production. On the other hand, high food prices increased farmers' need to rely on own farm production for household food needs. There was a shift in resource allocation (land and labour) in favor of crops most suited to satisfying household food needs (e.g. sweet potato, cassava and beans) against crops that are more profitable when valued at farm gate prices (e.g. bananas and millet). Moreover, increase in nonfarm opportunities led to an increase in wage rates; hence farmers shifted from labour intensive to labour saving technologies in banana production and adopted more of crops that are less intensive in terms of labour use (e.g. cassava and sweet potato).

In the southwest, the market for unskilled labour was limited and wage rates were low. Farm sizes are also smaller compared to the central region. Hence farmers adopted technologies and crop activities that were relatively more labour demanding, but more rewarding in terms cash benefits. Specifically, bananas were more adopted because they satisfied both the cash needs and food requirements of the farmers. However, a significant part of land area is still committed to millet production despite its being less profitable in terms of gross margin. There are three possible reasons for this behaviour: (1) millet is less perishable and can be stored and consumed in times of food deficit (e.g. in November when prices are high), (2) it is a traditional food crop in the region with cultural attachment, and (3) it is mainly grown on land that is not suited to banana production. Less labour and land are allocated to maize and cassava because they less profitable in terms of gross margin and less competitive in terms of household food requirements.

CHAPTER 3 Determinants of productivity and technical efficiency in banana production

3.1 Introduction

Banana production provides suitable options for subsistence and income generation not only in Uganda but also in the East African mid- and high-elevation areas. In Uganda, production has been on the decline in the central area, which is the traditional growing region, and increasing in the southwest of the country (Gold et al., 1999). Production has been dependent on own supplied inputs (mainly manure and crop residues), a method that recycles nutrients within the farming system, but does not add to the stock of nutrients in the system (Bekunda, 1999; Pender et al., 1999). There is scarcely any use of artificial fertilizer in banana plots. Manure and mulch application has declined because of the increasing pressure on land that has impacted negatively on natural vegetation and pasture; hence the limited access to grass mulch and animal manure (Gold et al., 1999). The low profitability of inorganic fertilizers (cost higher than benefit) explains the low adoption by farmers, which implies that major improvement in the market conditions facing Ugandan farmers is a prerequisite for substantial adoption to occur (Nkonya et al., 2005). Moreover, limitations in the markets for some factors of production (e.g. credit) and output markets limit the productivity in agricultural production (Barret, 1996; Carter, 1984; Heltberg, 1998).

Soil fertility depletion represents a substantial loss in Uganda's natural capital, as well as reducing agricultural productivity and income. Soil nutrient depletion poses a serious concern since it contributes to declining agricultural production system (Bekunda, 1999; Pender et al., 1999), which in turn contributes to food insecurity. On average, 179kg/ha of nitrogen (N), phosphorus (P) and potassium (K) is depleted per year, which is equivalent to about 1.2% of the nutrient stock stored in the top soil (Nkonya et al., 2005). Soil nutrient depletion force farmers to abandon nutrient depleted areas to more marginal areas such as hillsides and forests. The overall impact of these impacts is increased poverty, which poses enormous development challenges. In turn, poverty contributes to land degradation if poor people lack the ability or incentives to conserve and improve their land. There is limited empirical evidence, in Uganda, concerning policy, institutional or technological responses that could effectively address these problems (Nkonya et al., 2005). This study seeks to address this gap for the banana sub-sector in Uganda.

The focus by researchers and policy makers has been on the impact that the adoption of new technologies can have on increasing farm productivity and income (Hayami and

Ruttan, 1985). However, during the last decade, major technological gains seem to have been largely exhausted across the developing world and specifically in Africa because of lack of complementary inputs (e.g. fertilizers, irrigation and pesticides). This suggests that attention to productivity gains arising from efficient use of existing technologies is justified (Bravo-Ureta and Pinheiro, 1997; Squires and Tabor, 1991). Literature on the efficiency of farmers is vast in the developing countries but few studies focus on African agriculture (Nyemeck et al., 2003). Moreover, much of the work done in this area is on efficiency indices and little has been done to analyze the determinants of the inefficiencies. In this study, we examine the productive efficiency of a sample of banana farmers in Uganda by estimating a stochastic production frontier. The sub-sector's potential for increasing production through improved efficiency is discussed. In particular, the economic and farm specific factors limiting productivity and technical efficiency are identified.

The rest of the chapter is organized as follows. Section 2 presents the theoretical background and model specification. Types of data and methods of collection are discussed in section 3. Research results are presented and discussed in section 4 and end with some concluding remarks in section 5.

3.2 The agricultural production model

3.2.1 Stochastic frontier production function

A large body of theoretical and empirical literature has investigated the measurement of efficiency of farm enterprises, using various methods. Ali and Byerlee (1991) have emphasized that the focus in analyzing economic efficiency should address the performance of the whole production system, including farmers and institutional support systems. These results can be used to pinpoint the factors that impede the capacity of farmers to reach their productivity potential.

Technical efficiency (TE) can be estimated using one-step or two-step approaches. In the two-step procedure, the production frontier is estimated first and the technical efficiency of each firm is derived subsequently. In the second step, the derived technical efficiency variable is regressed against a set of variables that are hypothesized to influence the firm's efficiency (Kalirajan, 1981; Pitt and Lee, 1981). However, the two-stage procedure lacks consistency in assumptions about the distribution of the inefficiencies. In step one, it is assumed that inefficiencies are independently and identically distributed in order to estimate their values. In step two, estimated inefficiencies are assumed to be a function of a number of firm-specific factors, violating this assumption (Coelli et al., 1998). To overcome this inconsistency, Kumbhakar et al. (1991) suggest estimating all the parameters in one step. In a one-step procedure, which we adopt for this study, the inefficiency effects are defined as a function of the farm-specific factors and incorporated directly into the maximum likelihood (ML) estimate.

TE is measured as a ratio of actual output to potential output (Aigner et al., 1977; Meeusen and Broeck, 1997). Approaches for measuring technical efficiency generally vary from programming (non-parametric) approaches to statistical estimation (parametric) approaches depending on functional forms and techniques for estimating the potential output (Bauer, 1990; Coelli, 1995; Forsund et al., 1980; Fried et al., 1993; Kalirajan and Shand, 1997). In analyzing farm level data where measurement errors are substantial and weather is likely to have a significant effect, the stochastic frontier method is usually recommended (Coelli, 1995).

Early frontier production functions that followed Farrell (1957) were deterministic in that they assumed a strict one sided error term (Coelli, 1995; Schmidt, 1986). One of the major criticisms against deterministic frontier estimates is that no account is taken of the possible influence of the measurement errors and other data noise upon the shape and the positioning of the estimated frontiers. All the observed deviations from the estimated frontier are assumed to be a result of technical inefficiency (TI) (Coelli, 1995). Aigner et al. (1977) and Meeusen and Van den Broeck (1997) proposed a stochastic frontier production function, where sources of data noise are accounted for by adding a symmetric error term to the non-negative error. The parameters of this model are estimated by maximum likelihood (ML), given suitable distributional assumptions for the error terms (Harville, 1977). The stochastic frontier is not, however, without problems. The major limitation is that one has to make arbitrary assumptions regarding the functional form of the frontier and the distributional form of the error. Moreover, as the model is estimated by maximum likelihood, the solution obtained might not be optimal since the likelihood function is not globally concave and allows for multiple local maxima (Maddala, 1971).

Using the statistical estimation approach, we define a farm specific stochastic production frontier involving outputs and inputs as follows:

$$y_i^* = f(x_i)\exp(v_i) \tag{3.1}$$

where y_i^* is the maximum possible stochastic potential output from the i^{th} farm; x_i is a vector of m inputs and v_i are statistical random errors assumed to be distributed $N(0,\sigma_v^2)$. The production realized on the i^{th} farm can be modeled as follows:

$$y_i = y_i^* \exp(-u_i) \tag{3.2}$$

where $exp(-u_i)$ is defined as a measure of observed TE of the i[th] farm assuming that $u_i \geq 0$. When u_i takes the value zero, the i^{th} farm is technically efficient and realizes its maximum possible potential output. Thus TE can be defined as:

$$TE = \exp(-u_i) = \frac{y_i}{y_i^*} \qquad (3.3)$$

Substituting equation (3.1) into equation (3.2) and taking logs on both sides, we get:

$$\ln y_i = \ln f(x_i;\beta) + v_i - u_i, \qquad (3.4)$$

where y_i denotes the production of the i^{th} farm (i = 1,2,…,n); x_i is a (1 x k) vector of functions of input quantities used by the i^{th} farm; β is a (k x 1) vector of unknown parameters to be estimated; v_i s are assumed to be independently and identically distributed $N(0,\sigma_v^2)$ random errors; independent of the u_is; and u_i is a one-sided error term representing the TI of farm i.

Subtracting v_i from both sides of equation (3.4), the production of the ith farm can be estimated as:

$$\ln y_i' = \ln f(x_i;\beta) - u_i \qquad (3.5)$$

The efficient level of production can be defined as

$$\ln \hat{y}_y = \ln f(x_i;\beta) \qquad (3.6)$$

From equations (3.5) and (3.6), we can compute TE given by:

$$\ln TE_i = \ln y' - \ln \hat{y} = -u_i \qquad (3.7)$$

$TE_i = e^{-u_i}$ and is constrained to be between 0 and 1. When u_i = 0, the TE = 1 and production is said to be technically efficient.

The distribution of u_i could be half normal with zero mean, truncated normal (at mean, μ), or based on conditional expectation of the exponential ($-u_i$). There are no a priori reasons for choosing a specific distributional form because each has advantages and disadvantages (Coelli et al., 1998). The half normal and exponential distributions have a mode of zero, implying that most firms being analyzed are efficient. The truncated normal allows for a wide range of distributional shapes, including non-zero modes, but is computationally more complex (Coelli et al., 1998).

We adapt the model proposed by (Battese and Coelli, 1995), in which the technical inefficiency effects are defined by:

$$u_i = z_i\delta + w_i \tag{3.8}$$

where z_i is a (1 x m) vector of explanatory variables associated with the technical inefficiency effects; δ is an (m x 1) vector of unknown parameters to be estimated; and $w_i s$ are unobservable random variables. The parameters indicate the impacts of variables in z on technical efficiency. A negative value suggests a positive influence on technical efficiency and vice versa. The frontier model may include intercept parameters in both the frontier and the model for the inefficiency effects, provided the inefficiency effects are stochastic and not merely a deterministic function of relevant explanatory variables (Battese and Coelli, 1995).

The null hypothesis that the TI effects are not random is expressed by H_0: $\sigma_v = 0$. Accepting the null hypothesis that $\sigma_v = 0$ would indicate that σ_u^2 is zero and thus the term u_i should be removed from the model, leaving the specification that can be consistently estimated by OLS (Coelli, 1994). Further, the null hypothesis that the impact of the variables included in the inefficiency effects model in equation (3.8) on the TI effects is zero is expressed by H_0: $\delta' = 0$, where δ' denotes the vector, δ, with the constant term, δ_0, omitted (Battese and Broca, 1997).

3.2.2 Factors affecting technical efficiency

In crop production, TE is likely to be affected by a wide range of factors, ranging from farm-specific to village-specific factors. Forsund, Lovell and Schmidt (1980) argue that inefficiency is typically related to factors that are associated with farm management practices. Such factors include education, family size and composition, experience, proximity to markets and access to credit. Education, which is directly related to management skills, has received adequate attention in the efficiency literature (Nyemeck et al., 2003; Tian and Wan, 2000; Weir, 1999; Weir and Knight, 2000). The results of the impact of education on TE are mixed, with some showing positive impact (Belbase and Grabowski, 1985; Bravo-Ureta and Pinheiro, 1997; Kalirajan and Shand, 1997) and others showing a negative impact (Bravo-Ureta and Evenson, 1994; Kalirajan, 1984; Kalirajan, 1991; Phillips and Marble, 1986). Education increases the household’s ability to utilize existing technologies and be able to attain higher efficiency levels (Battese and Coelli, 1995). In our study, we use education of household heads as a proxy for management skills and age of household heads as a proxy for experience (learning by doing).

TE is expected to increase with age as the farmer gains experience, at a decreasing rate as the farmer becomes elderly. Access to resources (specifically labor and purchased inputs) is one of the reasons for this type of behaviour, because it influences the timing of application of the inputs and implementation of agronomic practices. Timely application of inputs and implementation of management is expected to enhance efficiency. Young households are deficient in resources and might not be able to apply inputs or implement certain agronomic practices in time. On the contrary, old households are likely to be more efficient because they have more income and assets, which they use to purchase inputs and apply them in time and to hire labour and be able to implement agronomic practices in time. The other factor that explains the quadratic relationship between age and efficiency reflects access to information. Elderly farmers are less likely to have contacts with extension and training programs, and are therefore less likely to adopt new practices and modern inputs (Hussain, 1989).

Gender of the household head is expected to have significant effects on technical efficiency. Farms managed by men are expected to attain higher technical efficiency than those that are managed by women. Men are more likely to have priority access to labour so that operations are done on time, which increase production efficiency.

The effect of household size on TE has not been widely reported in the literature. Household size is expected to influence TE through its effect on the labor endowments of households (including child labor). Large households are expected to be more technically efficient since they can implement activities on time, attaining higher output with the same or less labor input. The effect of more adults per household on TE is expected to produce mixed results. On the one hand, an increase in the number of adults in the family could increase TE if it results in increased labor devoted to banana production. On the other hand, the effect could be negative if adults have higher chances of obtaining off-farm employment. The effect could be insignificant if labor withdrawn from the farm into off-farm employment is substituted with capital inputs.

Another factor for which the effect on TE has been infrequently reported in the literature is proximity to factor markets. Households located nearer to factor markets are expected to have higher technical efficiency than those located in remote areas. Proximity to good roads increases access to training and extensions programs from which farmers can attain information and skills for better crop management. Proximity to markets also increases farmers' access to credit facilities and income generating activities (e.g. off-farm employment) that enable them to buy and apply inputs on time. However, access to nonfarm labour markets increases the probability of diversifying into nonfarm activities, where farmers reallocate labor from farm to nonfarm activities and not able to implement management practices in time. Farmers who diversify in off-farm activities are also less likely to be committed to farming and hence spend less time in the management of farm enterprises, which makes them to be technically inefficient.

3.2.3 Agricultural production function

The agricultural production function describes the rate at which resources (land, labour and capital) are transformed into agricultural products and summarizes the technological relationships between output and inputs. The convention production function comprises of two inputs, x1 and x2, combined to produce a unique maximum output y:

$$y = f(x_1, x_2) \quad (3.9)$$

The function f is assumed to be continuous and at least twice differentiable. The elasticity of production is given as:

$$\varepsilon_i = (\partial y / \partial x_i)(x_i / y),\ (i = 1,2) \quad (3.10)$$

ε_i is also computed as:

$$\varepsilon_i = \frac{\partial \ln y}{\partial \ln x_i} \quad (3.11)$$

Total scale elasticity, ε, is given by the sum of the output elasticities, ε_i:

$$\varepsilon = \sum \varepsilon_i = \sum [(\partial y / \partial x_i)(x_i / y)] \quad (3.12)$$

ε is the sum of the ratios of marginal to average products. For a production function to exhibit decreasing (constant) returns to scale, all marginal products have to be less (no greater) than the corresponding average products. Hence, for production functions characterized by decreasing returns to scale, the marginal contribution of an input, over the entire input space, is always less than its average contribution.

A number of functional forms have been used in the empirical estimation of frontier models. The simplest, the Cobb-Douglas, is specified in logarithmic form as

$$\ln y = \ln A + b_1 \ln x_1 + b_2 \ln x_2 \quad (3.13)$$

where y is output, A, b_1 and b_2 are parameter estimates, and x_1 and x_2 are inputs. The total scale elasticity for a Cobb-Douglas production function is computed as:

$$\varepsilon = \sum \varepsilon_i = b_1 + b_2 \quad (3.14)$$

The transcendental production function, which is a generalized Cobb-Douglas function (Halter et al., 1957; Mundlak, 1964), is specified as

$$\ln y = \ln A + b_1 \ln x_1 + b_2 \ln x_2 + c\, x_1/x_2 \tag{3.15}$$

where A, b_1, b_2 and c are parameter estimates.

The elasticity of production for input 1 is computed as:

$$\varepsilon_1 = \frac{\partial \ln y}{\partial \ln x_1} = b_1 \tag{3.16}$$

For input 2,

$$\varepsilon_2 = \frac{\partial \ln y}{\partial \ln x_2} = b_2 \tag{3.17}$$

Total scale elasticity is computed as:

$$\varepsilon = b_1 + b_2$$

A more complex form, the transcendental logarithmic (Translog) form for a single output two input function is specified as

$$\ln y = \ln \alpha + \beta_1 \ln x_1 + \beta_2 \ln x_2 + \theta_1 (\ln x_1)^2 + \theta_2 (\ln x_2)^2 + \gamma \ln x_1 \ln x_2 \tag{3.18}$$

where α, β, θ_1, θ_2 and γ are parameters estimated. Output elasticity for input 1 is given by:

$$\varepsilon_1 = \frac{\partial \ln y}{\partial \ln x_1} = \beta_1 + 2\theta_1 \ln x_1 + \gamma \ln x_2 \tag{3.19}$$

Output elasticity for input 2 is given by:

$$\varepsilon_2 = \frac{\partial \ln y}{\partial \ln x_1} = \beta_2 + 2\theta_2 \ln x_2 + \gamma \ln x_1 \tag{3.20}$$

Total scale elasticity is computed as:

$$\varepsilon = \beta_1 + 2\theta_1 \ln x_1 + \gamma \ln x_2 + \beta_2 + 2\theta_2 \ln x_2 + \gamma \ln x_1 \qquad (3.21)$$

The most commonly used function forms are the translog and Cobb-Douglas function. Often preferred for its simplicity, the Cobb-Douglas imposes restrictions on elasticities. The translog is a more flexible form, but suffers from multicollinearity and degrees of freedom problems. In any case, the impact of functional form on estimated efficiency has been reported to be very limited (Kopp and Smith, 1980). Battese and Broca (1997) recommend approaches in which more general model specifications and assumptions are made and simpler formulations are formally tested. In our estimations of the frontier production functions we use each of the three functional forms to estimate the production of cooking bananas. We then compare the results of the inefficiency effects across the three forms. We include, in the production function, selected farm characteristics (e.g. farm size and access to extension) and plot characteristics (e.g. plot age, disease and pest severity[1]) to account for their effect on banana productivity.

Accounting for soil organic matter

Agricultural production in Uganda, as in many other developing agricultural economies, depends largely on land and labor input with little or no external inputs used. The soils are poor in nutrients and rely on recycling of nutrients from soil organic matter (SOM) to maintain crop productivity. The soil's ability to retain and supply nutrients to a crop depends on the cation exchange capacity (CEC) – soils with high CEC are able to bind more cations such as $K+$ to the exchange sites of clay and SOM particle surfaces. Soils with high CEC also have a greater battering capacity and thus the ability to resist changes in pH. Thus soils with high amounts of clay and/or SOM typically have higher CEC and buffering capacities than more silty or sandy soils. Soil pH also affects nutrient retention and availability to crops. Soils with high pH have low concentration of $H+$, which enables more base cations to be on the particle exchange sites and thus be less susceptible to leaching. With the exception of P,

[1] Farmers were asked to score the presence of the disease/pest on a particular plot and the number of years the disease/pest had been observed on the plot. Presence of disease/pest was scored as 1 and not present as 0. The final score of the disease/pest was computed taking into consideration the number of years the disease/pest had been observed on the plot and the size of the plot. For example if the household has three plots with disease scores 0 for all the years, 1 for 3 years out of 5 years and 1 for 7 out of 10 years and the corresponding area of each plot is 0.5, 0.9 and 1.5 acres. The final disease/pest score is (0*0.5 + 0.6*0.9 + 0.7*1.5)/0.5 + 0.9 + 1.5) = 0.548. The lowest score is 0 and the maximum is 1.

which is most available within a pH range of 6 to 7, other macronutrients (N, K, Ca, Mg and S) are more available within a pH range of 6.5 to 8. High rainfall can result in soil acidity (Tisdale et al., 1993). Rufino (2003) found that unfavorable soil pH conditions limit maximum yield in 42% of the banana plots in Bamunanika, Kisekka and Ntungamo, which is indicative of other soil fertility problems. In the same sites, soil-K was a limiting factor for 19% of the banana plots, N was limiting in 12%, while P was not a limiting factor. Exchangeable K is determined by the neutral ammonium acetate method (Thomas, 1982). Available P is determined by the Olsen method (Olsen et al., 1954).

There is need to take into considerations the interrelations between N, K, SOM, soil texture and chemical characteristics in modeling production behaviour. First, SOM is affected by the soil texture and drainage (sand content), C:N ratios of organic materials, climate and cropping practices. The SOM content can be estimated as follows:

$$\ln SOM = \alpha_0 + \alpha_1 sand + \alpha_2 D1 + \alpha_3 D2 \qquad (3.22)$$

where *lnSOM* is natural log of soil organic matter content (%), $\alpha_0, \alpha_1, \alpha_2, \alpha_3$ are parameters to be estimated, sand is the ratio of sand to clay + silt (%), and D1 and D2 are regional dummies, representing Masaka and southwest respectively, for measuring the impact of differences in climate and cropping practices. Equation (3.22) can be estimated by OLS to obtain the estimates of $\alpha_0, \alpha_1, \alpha_2, \alpha_3$.

Soil N is highly correlated to SOM, organic amendment (mainly animal manure) and regional characteristics and can be estimated as follows:

$$\ln N = \theta_0 + \theta_2 \ln SOM + \theta_2 M + \theta_3 D1 + \theta_4 D2 \qquad (3.23)$$

where *lnN* is natural log of soil nitrogen content (%), $\theta_0, \theta_1, \theta_2, \theta_3, \theta_4$ are parameters to estimate, and M is animal manure input (kg/year). The rest of the variables are as already defined. Equation (3.23) can be estimated using a two stage least squares (2SLS) where lnSOM is instrumented by sand.

Availability of soil K is affected by soil pH, SOM content in the soil and additions of crop residues and can be estimated as follows:

$$\ln K = \delta_0 + \delta_1 pH + \delta_2 \ln SOM + \delta_3 C + \delta_4 D1 + \delta_5 D2 \qquad (3.24)$$

where *lnK* is natural log of available soil potassium (meq/100g soil), $\delta_0, \delta_1, \delta_2, \delta_3, \delta_4, \delta_5$ are parameters to be estimated, pH is soil pH and C is crop residue input (kg/year). Equation (3.24) is estimated using 2SLS again instrumenting lnSOM with the sand variable.

Crop output is determined by labour input, area allocated to the crop and nutrient availability (mainly N and K for bananas). Organic amendment (animal manure, grass mulch and crop residues) contribute to soil nutrients but also to the physical and chemical properties soil, enabling a given land area to produce higher output. Crop output can be modelled as follows:

$$\ln Y = \beta_0 + \beta_1 \ln A + \beta_2 \ln L + \beta_3 M + \beta_4 C + \beta_5 \ln SOM + \beta_6 \ln K + \beta_7 D1 + \beta_8 D2 \qquad (3.25)$$

where *LnY* is natural log of crop output (kg/year), $\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7, \beta_8$ are parameters to estimate, *lnA* is natural log of area allocated to crop (cooking bananas) (acres), and *lnL* is natural log of labor input (hours/year). Equation (3.25) is estimated using 2SLS and with instruments sand (for SOM) and pH (instrument for K).

To obtain efficient estimates, equations (3.22), (3.24) and (3.25) are estimated simultaneously using a three stage least squares (3SLS). The 3SLS is the most appropriate technique to use to estimate a system of equations with endogenous variables included on the right hand side.

The three equations (3.22), (3.24) and (3.25) can be collapsed into a reduced form equation:

$$\ln Y = \beta_0 + \beta_1 \ln A + \beta_2 \ln L + \beta_3 M + \beta_4 C + \beta_5 sand + \beta_6 pH + \beta_7 D1 + \beta_8 D2 \qquad (3.26)$$

Endogeneity

Equation (3.26) is estimated using OLS. A problem could arise if labor input were endogenously determined. We test for endogeneity by first estimating the labor equation with wage rate, output price, household characteristics and opportunities included on the right hand side. The residual obtained from the estimated labor equation is then included on the right hand side in the production function estimation. If the effect of the residual turns out to be significant (5%), then labor input is confirmed as endogenously determined. The instrumental variable (IV) or the 2SLS would be the valid approaches to obtain efficient and consistent estimates if valid instruments are available. If the soil quality variables are included in equation (3.26), OLS is valid for obtaining consistent and efficient estimates of manure and other organic amendments. When soil quality variables (sand and pH) are missing in equation (3.26), the manure and crop residue variables can be treated as endogenous since farmers would tend to apply these inputs where soils are poor and no application is carried out if the soil is fertile. We lack sufficient and valid instruments for manure and crop residues. Therefore the estimates for manure and crop residue should be interpreted with care. In absence of endogenous variables on the right hand side, equation (3.26) can be consistently estimated using a stochastic frontier approach.

3.3 Data

The data design is described in Chapter 2 and Annex 4. Of the total sample of 660 farmers surveyed in Uganda, data for 512 were usable in the analysis. The production function is estimated for cooking bananas while the whole sample was selected for farmers that grow bananas. Some farmers, especially in the lower elevation areas, had banana plots that were less than 2 years old and harvested no output. Others had abandoned plots and did not allocate labor to them. These farms were not included in the estimation. Some households had missing cases in some of the variables, and therefore were excluded from the sample. Definitions of variables and summary statistics are shown in Table 3.1. In the next section, econometric results are presented and discussed.

Table 3.1 Variable definitions and summary statistics for cooking bananas productivity and technical efficiency analysis

Variable	Definition	Overall sample		central region		Masaka		Southwest		Case study	
N		512		248		126		138		157	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Y	Cooking bananas output (kg/year)	3109.7	4919	939.9	1226	2843	2460	7252	7494	4145.4	5943
A	Area (acres) under cooking bananas	0.584	0.76	0.375	0.433	0.756	1.142	0.801	0.688	0.625	0.574
L	Labor input (hours/year)	636.3	650.3	347.3	354	710.9	660.5	1088	769	517.3	523.6
M	Manure input (kg/year)	495	2707	229.4	1036	415.6	1575	1045	4765	541.6	2642
G	Grass mulch input (kg/year)	194	1461	64.4	407.6	155.6	1006	1045	4765		
C	Crop residue input (kg/year)	331	1660	194.9	779.7	448	1569	469	2620	210.5	1021
N	Soil nitrogen (%)									0.123	0.066
K	Available soil potassium (meq/100g soil)									1.077	0.846
SOM	Soil organic matter (%)									5.959	0.609
pH	Soil pH									5.96	0.609
sand	Ratio of sand to (clay + sand + silt) (%)									59.5	10.04
Farm size	household farm size (acres)	4.023	8.567	4.479	5.148	4.392	14.521	2.866	5.635		
Ext	Extension visits in six months	0.702	1.912	0.631	2.176	0.81	1.774	0.732	1.487		
plotage	years of banana plot	20	23	7	6.3	21.25	18.72	41.8	28.3	23.51	26.3
$plotage^2$	plotage squared	926	1996	91	196.8	799	1417	2544	3006	1240.3	2546
sigatoka	sigatoka score	0.163	0.272	0.258	0.318	0.137	0.237	0.018	0.066	0.091	0.184
weevils	weevils score	0.394	0.333	0.375	0.335	0.505	0.321	0.326	0.317	0.408	0.342
Age	Age of household head (years)	45.2	16	46.7	16.6	43.7	16	43.7	14.6	45.9	15.6
Age2	Age squared	2295	1610	2458	1711.5	2168.4	1582	2118	1417	2353	1633
edhh	Education household head (years)	5.39	4.09	5.847	4.5	4.976	3.176	4.93	3.99	6.04	4.08
D	Distance to tarmac road (km)	13.46	18.7	11.68	8.64	20.45	32.11	10.28	12.97		
hhsz	Number persons in household	5.89	2.65	6.069	2.725	5.397	2.608	6.02	2.518	6.59	2.68
depr	(>64+<14 years)/family size	0.497	0.239	0.499	0.247	0.497	0.263	0.494	0.201	0.54	0.22
hplot	Plot managed by husband	0.764	0.425	0.645	0.479	0.896	0.305	0.855	0.353	0.847	0.361
kk	Amount credit obtained (‘000)	14	92.3	25.1	130.2	3.516	22.71	3.659	17.15		
sk	Remittances + rent (‘000)	90	368	114.3	370.9	14.44	29.9	115.3	500		
wp	real village wage	2.667	1.076	2.903	1.3	2.353	0.894	2.53	0.578		

3.4 Results and discussion

3.4.1 Production functions

The hypothesis that labor is endogenously determined in the production of cooking bananas is rejected in all the cases except for the central region where the error term is found to have a significant effect on output (Table 3.2). The endogeneity hypothesis assumes a two way causal relationship where farmers are expected to rely on the expected output to determine the amount of labor to allocate to production of cooking bananas, while at the same time the amount of labor allocated would determine the output obtained from the production process. The residues used in the production function were estimated from the labour use functions (first stage of the production function estimation) (Appendix 3.1). Rejection of the endogeneity hypothesis implies that labor used in cooking bananas production is exogenously determined independent of the realized output. This is most likely true for cooking bananas, where most of the labor is used before the harvest and by the time the farmer applies the labor he is not sure how much output to expect. Traders often do the harvesting of cooking bananas, while harvesting for home consumption is piecemeal and the farmer is often unaware of the total amount of labor used. Thus we excluded harvesting labor from the amount of labor used in the production function estimation. Since the endogeneity hypothesis is rejected, we proceed to estimate the production frontier function for cooking bananas, which is expected to yield efficient and consistent estimates.

Results of the frontier function are shown in Table 3.3. Results from the Cobb-Douglas function show that output responds positively to area and labor, in all the regions, consistent with expectations. However, the results for central and southwest show higher labor contribution to productivity compared to Masaka where higher contribution to productivity is from crop area. The labor/crop area (L/A) variable has a significant effect in the transcendental function for central region (1%) but not for Masaka and the southwest. Manure has a positive and significant effect (1%) on productivity in most of the cases except in Masaka where the effect is not significant. The effect of grass mulch is positive but not significant except for the southwest where the effect is significant at 10% in the Cobb-Douglas and transcendental production functions and at 5% in the translog production function. The effect of crop residues is only significant in the southwest, where it has a positive effect and significant at at 5% (Cobb-Douglas) and 1% (transcendental and translog).

Total farm size has a positive effect on output, which is significant in all the cases, implying that farmers with larger farm sizes produce more output per unit land and labour. Farmers with large farms have a higher probability of having land allocated to bananas that is of higher quality. Also they are likely to be more committed to farming than small farmers who are more likely to diversify into off-farm wage employment.

Table 3.2 Production function estimates for cooking bananas (endogeneity test)

variable	central		Masaka		southwest		Overall	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
Constant	3.729**	2.755**	7.064**	6.7**	6.304**	5.426**	4.385**	5.489**
	(8.94)	(3.87)	(15.32)	(7.99)	(11.73)	(3.37)	(15.97)	(6.76)
Ln(A)	0.243**	0.168*	0.308**	0.278**	0.306**	0.256*	0.296**	0.39**
	(3.45)	(2.02)	(4.35)	(3.05)	(5.59)	(2.48)	(6.97)	(5.01)
Ln(L)	0.459**	0.634**	0.122^	0.177	0.297**	0.427^	0.39**	0.213
	(7.35)	(5.24)	(1.75)	(1.39)	(3.8)	(1.8)	(9.19)	(1.64)
M	0.0002**	0.002**			0.00002*	0.00002*	0.00003*	0.00003*
	(2.82)	(2.67)			(2.32)	(2.32)	(2.13)	(2.08)
G	0.0001	0.0001	0.00002	0.00002	0.00001	.000001	0.00002	0.00002
	(0.79)	(0.82)	(0.47)	(0.37)	(0.56)	(0.48)	(0.65)	(0.71)
C	0.00005	0.00005	0.00003	0.00003	0.00003^	0.00003^	0.00002	0.00002
	(0.61)	(0.61)	(0.92)	(0.96)	(1.92)	(1.83)	(0.92)	(1.06)
Farm size	0.031*	0.029*	0.009*	0.009*	0.019**	0.018**	0.013**	0.013**
	(2.17)	(2.02)	(2.38)	(2.42)	(2.72)	(2.6)	(2.83)	(2.78)
Ext	-0.011	-0.008	0.039	0.039	0.123**	0.124**	0.024	0.022
	(-0.38)	(-0.27)	(1.29)	(1.27)	(4.77)	(4.78)	(1.24)	(1.15)
plotage	0.022	0.007			0.007	0.005	0.006	0.012^
	(0.8)	(0.25)			(1.55)	(0.92)	(1.00)	(1.68)
$plotage^2$	-0.0001	0.0004			0.000	0.00002	0.00001	-0.00003
	(-0.12)	(0.42)			(0.01)	(0.31)	(0.19)	(-0.5)
sigatoka	0.593**	0.599**			-0.617	-0.542	0.247	0.178
	(2.7)	(2.75)			(-1.15)	(-0.98)	(1.64)	(1.113)
weevils	-0.468*	-0.467*			-0.141	-0.114	-0.218	-0.238*
	(-2.24)	(-2.25)			(-1.13)	(-0.86)	(-1.84)	(-2)
Masaka							0.943**	0.92**
							(8.88)	(8.57)
southwest							1.403**	1.355**
							(10.78)	(10.1)
Residual[+]		-0.237^		-0.08		-0.145		0.202
		(-1.68)		(-0.52)		(-0.58)		(1.44)
Adj. R^2	0.43	0.435	0.299	0.294	0.689	0.687	0.704	0.705

**, *, ^ imply significant and 1%, 5% and 10% respectively. [+] Residual from the first stage estimation (i.e. labour equation); variables included in the labour equation are area under cooking bananas, wage price ratio, distance to tarmac, household characteristics (size, composition, age education and gender)

Extension visits have a positive effect on cooking bananas output, but are significant (1%) only in the southwest. Interaction with extension agents could enable farmers to adopt new farming techniques and be able to raise their production frontier. However, it is possible that the extension agents visit the most productive farmers and not necessarily that they improve farmers' adoption of new technologies.

The effect of life (age) of a banana plot was not significant for Masaka and the central region. The effect for the southwest is positive and significant (1%) while the effect of the quadratic term is negative and significant at 10% level. Age of the banana plot was included in the estimation to account for the low yields observed in young plantations and old ones. Results for Sigatoka (disease) are ambiguous and insignificant for the southwest. The disease has negative and significant effect (1%) on output for Masaka. However, for this region, the variable was excluded from the estimation since it is highly correlated with labour input and leads to an estimate of labour that is negative. The insignificant results obtained for Sigatoka for the overall sample might be due to correlation between the disease and location dummies. The location dummies capture the effect of climate and ecological conditions, which are highly associated with severity of disease (Speijer et al., 1994). Excluding the dummy variables from the estimation makes the coefficient of Sigatoka negative and significant at 5% while significance of the effect of weevils reduces from 1% to 10% (Tables 3.4 and 3.5). The effect of weevils is severe in the central region and least or not significant in Masaka. The dummy variables (Masaka and southwest) have positive and significant effects on output. Southwest has a higher impact on production, almost one and half times the effect of Masaka. The significant result obtained for the location dummies implies that there are other factors not included in the regressions that are correlated with location and impact positively on output for Masaka and the southwest.

Table 3.3 Results of the frontier function

Variable	central region			Masaka			southwest			overall sample		
	Eq1	Eq2	Eq3	Eq1	Eq2	Eq3	Eq1	Eq2	Eq3	Eq1	Eq2	Eq3
N	248	248	248	126	126	126	138	138	138	512	512	512
Constant	5.345**	4.45**	4.43**	7.629**	7.963**	7.682**	6.637**	6.259**	3.526	5.593**	4.908**	4.328**
	(15.37)	(10.67)	(4.35)	(17.41)	(13.65)	(3.6)	(14.52)	(9.68)	(0.78)	(21.26)	(15.4)	(5.71)
Ln(A)	0.262**	0.044	-1.028**	0.312**	0.375	0.328	0.264**	0.199*	0.065	0.277**	0.126*	-0.353
	(3.95)	(0.53)	(-2.76)	(5.07)	(3.94)	(0.54)	(5.79)	(2.19)	(0.10)	(6.76)	(2.21)	(-1.33)
Ln(L)	0.414**	0.569**	0.347	0.108	0.051	0.021	0.282**	0.343**	1.189	0.368**	0.484**	0.717**
	(8.31)	(9.45)	(1.06)	(1.58)	(0.54)	(0.003)	(4.24)	(3.43)	(0.93)	(9.53)	(9.91)	(3.05)
$Ln(A)^2$			-0.159**			0.104*			-0.096*			-0.074**
			(-4.07)			(2.2)			(-2.06)			(-2.97)
$Ln(L)^2$			0.03			0.008			-0.065			-0.024
			(1.00)			(0.16)			(-0.72)			(-1.21)
Ln(L)*Ln(A)			0.141**			0.019			0.013			0.076*
			(2.69)			(0.22)			(0.13)			(2.05)
L/A		-0.0001**			0.00003			-0.00003			-0.0001**	
		(-4.16)			(0.84)			(-0.82)			(-3.71)	
M	0.001*	0.0001**	0.0002**	-0.00003	-0.00003	-0.00002	0.00002	.00002**	0.00002**	0.00003*	0.00003*	0.00003*
	(2.45)	(2.63)	(3.16)	(-0.8)	(-0.83)	(-0.51)	(2.77)	(2.82)	(3.18)	(2.18)	(2.21)	(2.27)
G	0.0001	0.0001	0.0001	0.00001	0.00002	.000001	.000002^	.00002^	0.00003*	0.00002	0.00002	0.00002
	(0.78)	(0.7)	(0.67)	(0.29)	(0.36)	(0.3)	(1.66)	(1.74)	(2.26)	(0.92)	(1.02)	(1.15)
C	0.0001	0.0006	0.00006	0.00001	0.00001	3e-06	0.00003*	.00003**	0.00003**	0.00002	0.00002	0.00002
	(0.85)	(0.76)	(0.67)	(0.37)	(0.42)	(0.11)	(2.58)	(2.6)	(3.00)	(1.25)	(1.28)	(1.37)
Farm size	0.02^	0.022^	0.022^	0.008^	0.008^	0.007	0.014*	0.014*	0.016**	0.012*	0.013*	0.015*
	1.72	(1.9)	(1.78)	(1.87)	(1.91)	(1.66)	(2.21)	(2.22)	(2.61)	(2.22)	(2.34)	(2.5)
Ext	-0.042	-0.045^	-0.031	0.037	0.037	0.046	0.134**	0.135**	0.134**	0.022	0.02	0.019
	(-1.63)	(-1.9)	(-1.08)	(1.3)	(1.33)	(1.64)	(4.83)	(4.82)	(4.68)	(1.08)	(0.99)	(0.95)
plotage	0.015	0.012	0.003	0.005	0.004	0.005	0.0153**	0.0148**	0.016**	0.006	0.006	0.007
	(0.64)	(0.53)	(0.15)	(0.45)	(0.41)	(0.53)	(3.68)	(3.55)	(3.79)	(1.17)	(1.2)	(1.28)
$plotage^2$	0.0003	0.0003	0.0005	0.00001	0.00001	-0.00002	-.00007*	-.00007^	-0.0001^	5.9e-06	5.8e-06	3.1e-06

	(0.43)	(0.45)	(0.64)	(0.1)	(0.1)	(-0.16)	(-1.77)	(-1.72)	(-1.86)	(0.1)	(0.1)	(0.05)
sigatoka	0.333^	0.378*	0.459*				-0.737	-0.742	-0.744	0.061	0.066	0.068
	(1.84)	(2.36)	(2.52)				(-1.59)	(1.6)	(-1.61)	(0.47)	(0.53)	(0.53)
weevils	-0.482**	-0.584**	-0.7**	-0.11	-0.101	.034	-0.161	-0.153	-0.172^	-0.244*	-0.282**	-0.303**
	(2.7)	(-3.54)	(-3.72)	(-0.74)	-0.67)	(0.22)	(-1.53)	(1.46)	(-1.68)	(-2.39)	(-2.82)	(-2.93)
Masaka										0.731**	0.745**	0.73**
										(7.44	(7.8)	(5.71)
southwest										1.035**	1.01**	0.999**
										(7.72)	(7.81)	(7.54)
Log likelihood	-325.6	-318.5	-316	-95.5	-95.1	-90.6	-51.4	-51.1	-48.2	-595.8	-5.89.9	-591.5
Wald X^2	250.8	288.4	199.8	84.8	84.6	77.2	321.5	329.6	373.8	885.5	939.2	941.3

**, *, ^ imply significant and 1%, 5% and 10% respectively. Eq1=Cobb-Douglas technology, Eq2=Transcendental production function, Eq2 = Transcendental logarithmic function (translog)

Table 3.4 Cobb-Douglas production estimates for the overall sample (location dummies excluded)

Variable	Coefficient	t-value
Production function estimates		
Constant	5.773**	18.55
Ln(A)	0.34**	8.17
Ln(L)	0.422**	9.66
M	0.00003^	1.65
G	0.00002	0.88
C	0.00002	1.28
Farm size	0.006	1.32
Ext	0.017	0.74
plotage	0.024**	4.62
plotage^2	-0.0001*	-2.10
sigatoka	-0.304*	-2.36
weevils	-0.167^	-1.65
Log likelihood	-639.1	
Wald X^2	726.7	
TE	0.449	
Technical inefficiency estimates		
Constant	0.511	0.71
Age	0.024	0.82
Age_2	-0.0002	-0.76
Hplot	-0.533**	-3.13
Edhh	0.018	1.02
Hhsz	-0.053^	-1.83
depr	0.368	1.26
Kk	-0.001	-1.00
D	-0.005	-0.84
σ_v (se)	0.38	0.048

Figure 3.1 shows output response to labour when land is fixed and Figure 3.2 shows the corresponding marginal and average products of labour for the three regions. The marginal products are all less the corresponding average products, which imply that the production function for all the three regions exhibit decreasing returns to scale.

It is clear from figure 1 that the technology used in Masaka favors lower labour use intensity (lower marginal product at mean) compared to the other two regions. As more labour per unit area is used, the curves for Masaka and central region get closer while the gap between Masaka and southwest increases. This implies that farmers in Masaka cannot achieve output levels attained in the southwest through just increasing labour use intensity, while farmers in the central region can attain the Masaka output level by increasing labour use intensity. However, farmers in the central region are limited in their labour use by the high cost of labour. Real wage rate, on average, is high for central (2.9) compared to that of Masaka (2.35) and southwest (2.53). The marginal products of labour, for all the regions, are lower than the going real wage rates, implying that either farmers are using more labour than optimal or there are imperfections in either the labour market or food market, or both.

Figure 3.1 Output labour response bananas (land fixed at 0.8 acres)

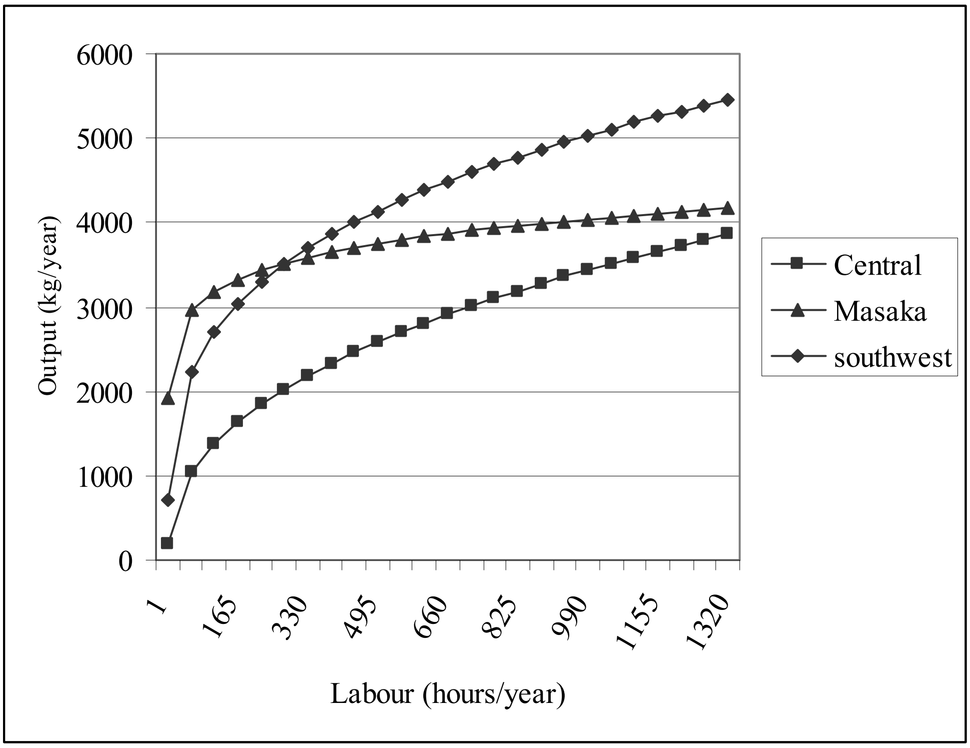


Figure 3.2 Marginal productivity of labour for bananas

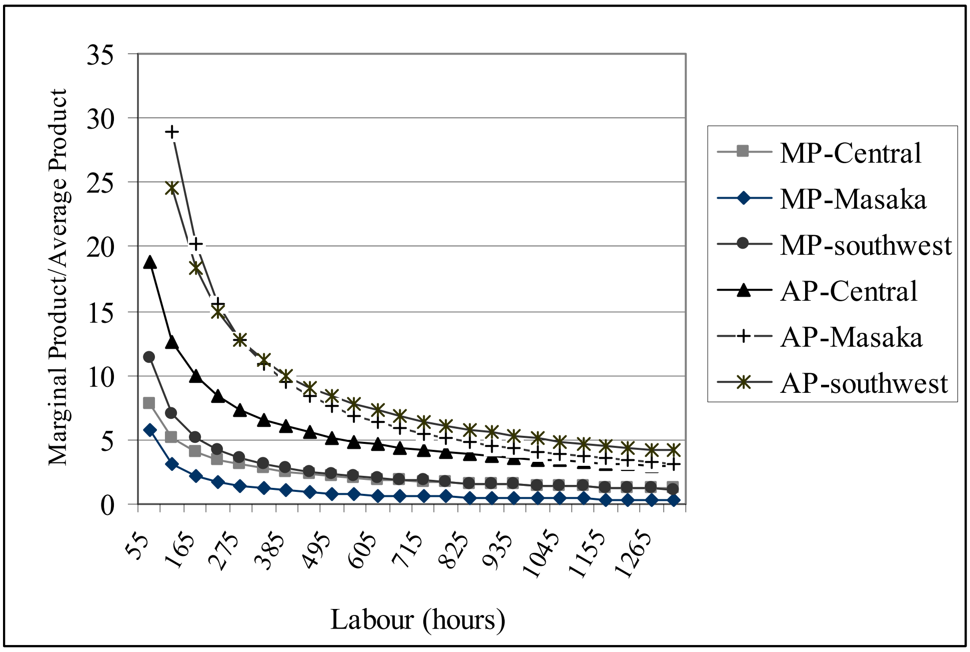


Table 3.5 shows elasticities of production, with respect to labor and land, and the returns to scale for cooking bananas production in the three regions. The output share of labor (in comparison with crop area) is highest for the central region, followed by the southwest and least for Masaka. This implies that farmers in the central region would benefit most from increasing labour use intensity if the labour market were the same as in the other two regions. This is further illustrated in Figure 3.1, in which the slope of the production function for Masaka becomes less steep only after 165 hours of labour input, an indication that the technology in the region is less labour intensive. The sum of the elasticities of labor and land are all below one in all the cases, which confirms decreasing returns to scale in contrast to the perception that returns to scale in agriculture tend to be constant (Ellis, 1993). The implication of this result is that farmers would lose efficiency if they increase the scale of production. This appears to contradict the result that farmers with large farms are more efficient than those with small farms. The implication of scale of production is that farmers should not increase resources committed to bananas (area and labour). On the other hand, keeping all other factors fixed (labour and area allocated to bananas), larger farm sizes are associated with higher productivity/efficiency. The decrease in efficiency as a result of the increase in scale of production is most likely due to differences in soil quality between small and large plots. Plant density also tends to be lower in larger plots.

The three functional forms (Cobb-Douglas, transcendental and translog) yield almost similar results in terms of returns to scale. Elasticities of production with respect to land and labour obtained from the Cobb-Douglas function are almost similar to those obtained from the translog. The Cobb-Douglas seems to be a consistent and an appropriate function for assessing production technology across the different regions.

Table 3.5 Elasticities of Production

Region	Elasticities of production		Returns to scale
	Land	Labour	
central			
Cobb-Douglas	0.262	0.414	0.676
Transcendental	0.044	0.569	0.613
Translog	0.212	0.447	0.659
Masaka			
Cobb-Douglas	0.312	0.108	0.42
Transcendental	0.375	0.051	0.426
Translog	0.297	0.106	0.403
southwest			
Cobb-Douglas	0.264	0.282	0.546
Transcendental	0.199	0.343	0.542
Translog	0.261	0.296	0.557
Overall sample			
Cobb-Douglas	0.277	0.368	0.645
Transcendental	0.126	0.484	0.61
Translog	0.257	0.351	0.608

The TE scores reveal presence of inefficiency especially for central Uganda (Table 3.6). This implies that there is a potential of increasing banana production through improved efficiency. The TE scores obtained are highest for southwestern Uganda and lowest for central Uganda. The TE scores obtained by using different function forms were very close, implying that model specifications for the frontier function have no impact on the predicted technical efficiencies for the farmers, consistent with what is reported in literature (Kopp and Smith, 1980). Kernel density estimates of technical efficiency scores show two distinct groups of farmers for the central region: one group is less efficient (TE < 0.5) and the other efficient (TE > 0.5) (Figure 3.3). For Masaka region and the southwest, the Kernel density distribution shows that most farmers are efficient, with TE > 0.8. The bimodal shape in Figure 3.3 (a) indicates two distinct groups of farmers in the central region in terms technical efficiency. The more efficient group is characterized by relatively larger farm sizes, smaller banana plot sizes, more labour input to banana production, nearer to tarmac road, lower education, more access to credit and more extension visits (Table 3.7).

Table 3.6 Technical efficiency scores

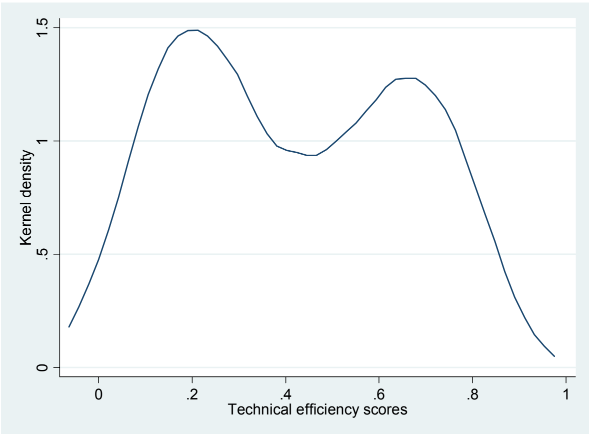
Equation	central	Masaka	southwest	overall sample
Cobb-Douglas	0.42	0.661	0.705	0.49
Transcendental	0.426	0.668	0.703	0.49
Translog	0.462	0.688	0.706	0.49

Table 3.7 Characterization of farm households in central region by level of efficiency

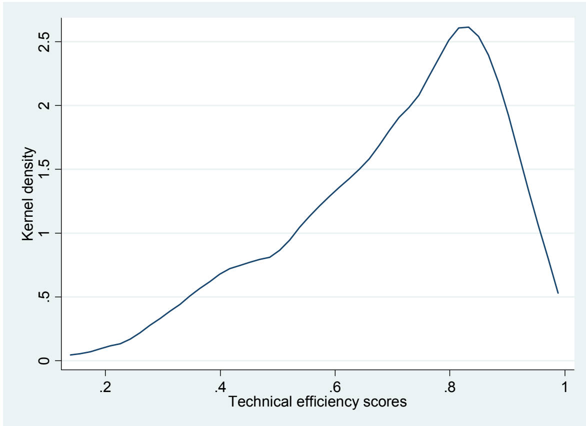
Characteristic	Inefficient (<= 50%) (n=146)		Relatively efficient (> 50%) (n=102)	
	Mean	SD	Mean	SD
Farm size (acres)	4.234	5.467	4.773	4.664
Cultivated area (acres)	2.398	3.863	2.913	3.725
Banana area (acres)	0.389	0.47	0.356	0.73
Labour in banana (hours/year)	317.8	320.6	389.6	395
Income from animals (1000 U.Sh)	419	913.4	343.3	521.4
Distance to tarmac road (km)	12.63	9.888	10.3	6.26
Family size	6.027	2.848	6.127	2.55
Age of farmer (years)	46.99	16.56	46.34	16.78
Education (years)	6.123	4.6	5.451	4.32
Gender of household (1=male, 0=female)	0.788	0.41	0.824	0.383
Credit obtained in 6 months (1000 U.sh)	14.28	57.91	40.59	190.4
Number of extension visits in six months	0.473	1.678	0.858	2.729

SD = standard deviation

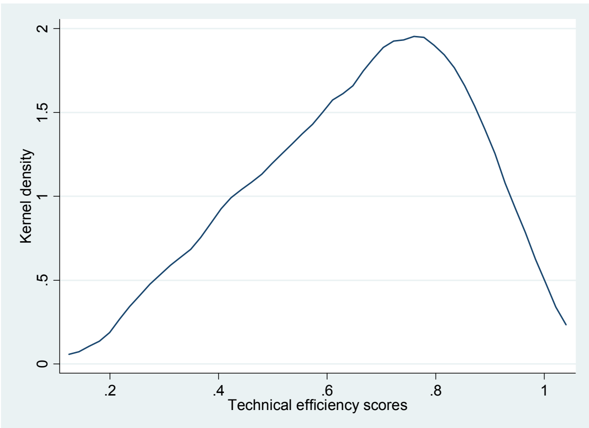
Figure 3.3 Kernel density estimates of technical efficiencies by region: (a) central region (b) Masaka and (c) southwest



(a)



(c)



(b)

The null hypothesis, H0: $\sigma_u = 0$, which specifies that cooking bananas farmers are technically efficient, is rejected by the data for central and the southwest but not for the Masaka sample (Table 3.8). This hypothesis is also rejected when tested on the whole sample.

Table 3.8 Test for the null hypothesis that $\sigma_u = 0$

Region	Chi_2	P	Outcome
Overall sample	35.01	0.000	Reject null
central	20.93	0.000	Reject null
Masaka	1.12	0.145	Accept null
southwest	8.9	0.001	Reject null

3.4.2 Technical efficiency effects

The results for factors influencing TE are shown in Table 3.9. The effect of age of farmer on TE is not significant. Multicollinearity is a possible cause of the insignificant results obtained. TE decreases as age increases in the early years, but later starts to increase as shown by the negative effect of the quadratic term on technical inefficiency. This result implies that young household and old households are more efficient than middle aged households contrary to what was expected. The possible reason for this behaviour could be associated with the reproduction process and family composition of the household where middle aged households have more dependants than workers and therefore are less likely to implement management decisions on time. Young farmers have more education and are more able to gather and interpret information about new farming practices. On the other hand, old households have access to more resources (land and labour) are able to implement recommended agronomic practiced in time. The children in old households are old enough to contribute significantly to household farming activities.

The husband being the manager of the banana plot has a positive impact on TE except in the southwest where the relationship is negative but not significant. The effect is positive and significant for the whole sample implying that production on plots managed by husbands is more efficient. Higher efficiency in plots managed by husbands can be explained by differential access to labour and thus are able implement farm activities in time.

The education variable gives mixed results as expected. In the central region, the impact of education on TE is negative, which is consistent with our hypothesis that educated households are less efficient if education increases farmers' returns from nonfarm activities, thereby reallocating attention or management from farm to nonfarm activities. The impact of education on TE in Masaka is positive, implying that education increases farmers' management capabilities and ability to utilize existing technologies in the region.

The family size variable is positively related to TE and significant at 5% for the whole sample and in the central region. Households with big families are more technically efficient, most likely because they strive to achieve higher output to meet the subsistence requirements. Moreover, large families have more labor endowment (including children) needed to implement management decisions. The effect of dependency ratio on TE is negative in all the cases except for Masaka where it is positive but not significant. A higher ratio of dependants in the family implies that there is less labour available for work, which affects timely application of farm activities.

The results on credit show that higher access improves efficiency in banana production in the central region, but the effect is not significant for Masaka and the southwest. This confirms that liquidity constraints affect farmers' efficiency by affecting their ability to apply inputs and implement farm management decisions on time.

The results for the relationship between the distance variable and TE are also mixed. In central Uganda, the impact of distance on TE is negative implying that farmers who are in close proximity to the tarmac road are more efficient than remote farmers. Market access is considered to influence farmers' technical efficiency because it affects availability of inputs and thus the timeliness of application of inputs and farm management decisions. In Masaka and southwest, however, distance to tarmac is positively correlated with TE implying that distant farmers are more efficient. The distant farms are more technically efficient mostly likely because of access to cheap labor, which enables them to implement management decisions on time.

Table 3.9 Factors influencing technical inefficiency

Variable	central region			Masaka			southwest			Overall sample		
	Eq1	Eq2	Eq3	Eq1	Eq2	Eq3	Eq1	Eq2	Eq3	Eq1	Eq2	Eq3
Constant	-0.062	-0.382	-0.377	2.181	2.31	2.015	-2.375^	-2.312	-2.358	0.535	0.426	0.43
	(-0.06)	(-0.34)	(-0.29)	(1.22)	(1.25)	(1.02)	(1.3)	(-1.28)	(-1.33)	(0.72	(0.58)	(0.59)
Age	0.029	0.044	0.032	0.002	-0.0004	0.01	0.039	0.04	0.042	0.014	0.02	.002
	(0.66)	(1.01)	(0.66)	(0.03)	(-0.00)	(0.11)	(0.51)	(0.53)	(0.59)	(0.47)	(0.68)	(0.57)
Age_2	-0.0003	-0.0005	-0.0004	-0.0001	-0.0001	-0.0002	-0.0003	-0.0003	-0.0004	-0.0002	-0.0002	-0.0002
	(-0.8)	(-1.2)	(-0.82)	(-0.13)	(-0.12)	(-0.26)	(0.43)	(-0.46)	(-0.5)	(-0.58)	(-0.78)	(-0.65)
Hplot	-0.184	-0.189	-0.23	-0.871	-0.868	-0.938	0.293	0.288	0.184	-0.442*	-0.447*	-0.448*
	(-0.8)	(-0.83)	(-0.94)	(-1.3)	(-1.26)	(-1.26)	(0.63)	(0.63)	(0.41)	(-2.44)	(2.51)	(-2.51)
Edhh	0.044^	0.041^	0.055^	-0.185*	-0.19*	-0.202^	-0.037	-0.043	-0.044	0.012	0.01	0.012
	(1.81)	(1.73)	(1.68)	(-2.1)	(-2.1)	(-1.89)	(-0.86)	(-0.99)	(-1.00)	(0.63)	(0.53)	(0.66)
Hhsz	-0.097*	-0.1*	-0.108^	-0.15	-0.158	-0.158	-0.049	-0.047	-0.032	-0.065*	-0.067*	-0.063*
	(-2.32)	(-2.41)	(-1.97)	(-1.2)	(-1.24)	(-1.13)	(-0.57)	(0.55)	(-0.39)	(2.08)	(-2.17)	(2.03)
depr	0.585	0.62	0.496	-0.193	-0.165	-0.122	1.505^	1.513^	1.378^	0.312	0.299	0.277
	(1.35)	(1.46)	(1.08)	(-0.23)	(-0.2)	(-0.14)	(1.73)	(1.78)	(1.66)	(1.02)	(1.00)	(0.92)
Kk	-0.003*	-0.003*	-0.003	-0.0004	-0.001	0.004	-0.015	-0.018	-0.022	-0.002	-0.002^	-0.002^
	(-2.11)	(-2.26)	(-1.52)	(-0.05)	(-0.07)	(0.43)	(-1.04)	(1.06)	(-0.74)	(-1.62)	(1.69)	(-1.65)
D	0.04**	0.041**	0.049**	-0.041*	-0.042*	-0.041*	-0.064**	-0.065**	-0.061**	0.002	0.002	0.004
	(3.3)	(3.54)	(2.76)	(-2.51)	(-2.53)	(-2.34)	(-2.88)	(-2.98)	(-2.79)	(0.25)	(0.35)	(0.6)
σ_v (se)	0.394	0.375	0.472	0.383	0.389	0.39	0.205	0.201	0.192	0.411	0.391	0.394
	(0.107)	(0.086)	(0.175)	(0.059)	(0.056)	(0.061)	(0.032)	(0.032)	(0.035)	(0.052)	(0.051)	(0.053)

**, *, ^ imply significant and 1%, 5% and 10% respectively. Eq1=Cobb-Douglas technology, Eq2=Transcendental production function, Eq2 = Transcendental logarithmic production function (translog)

3.4.3 Soil quality

The results on the interaction between SOM and K, and physical (sand) and chemical (pH) characteristics and the effect on productivity are presented in Tables 3.10 and 3.11. The estimates from 3SLS show that the proportion of sand in the soil negatively affects SOM content (Table 3.10). The results also show that the SOM content is higher in Masaka, implying that differences in regional characteristics affect SOM accumulation and decomposition. It should be noted that SOM is highly correlated with N content in the soil (appendix 3.2). Availability of K is positively influenced by the SOM content in the soil, pH and additions of crop residues. In turn, K availability positively affects cooking bananas output as expected but the effect is not significant. However, the effect of SOM on cooking bananas output is negative, but only significant at 10%. This could be explained by the conditions that favor accumulation of SOM, but are not favourable for cooking bananas production. SOM tends to accumulate faster in clay soils, which are not good for cooking bananas production because of physical impediment of banana root growth. Another reason could be related to the C:N ratio of materials used in the formation of the SOM. SOM with high C:N ratio can affect availability of nutrients through immobilization of the nutrients during the SOM decomposition. Animal manure has a positive and significant (10%) effect on cooking bananas output.

The effect of plot age is significant at 1% (positive for young plots and negative for older plots). Effect of sigatoka is negative and significant at 5%. We finally estimate a reduced form of the production function using OLS (Appendix 2). Both pH and sand content have a positive impact on cooking bananas output but the effect of pH is not statistically significant.

Table 3.10: Production function estimates, 3SLS

Variable	Ln(SOM) Coefficient	t-value	Ln(K) Coefficient	t-value	Ln(Y) Coefficient	t-value
Constant	2.192**	14.97	-4.43**	-13.53	5.693**	3.51
Ln(A)					0.297*	2.38
Ln(L)					0.712**	6.64
M					8.2e-05*	2.33
C			6.7e-05*	2.05		
Ln(SOM)			0.834*	2.56	-1.663^	-1.68
Ln(K)					0.624	1.52
Sand	-0.012**	-5.3				
pH			0.506**	5.15		
plotage					0.037**	3.39
$plotage^2$					-0.0003**	-2.77
sigatoka					-1.107*	-2.3
Masaka	0.139**	2.64				
Southwest	0.005	0.097				
Adjusted R-squared	0.266		0.585		0.555	

**, *, ^ imply significant and 1%, 5% and 10% respectively. Sand instruments SOM and pH instruments K in the output equation

We also estimate the reduced form using the frontier function approach (Table 3.10). The elasticities of labor and crop area are positive as expected. The sum of the elasticities, with respect to land and labour, from the Cobb-Douglas function indicates constant returns to scale (returns to scale = 0.995). This result contrasts with the result obtained from the main sample, which displays decreasing returns to scale. The sum of elasticities remains close to 1 even after removing the soil texture and pH variables from the estimation (Table 3.12). Most likely the case study sites are not representative of the whole sample; hence the difference in the results obtained for returns to scale. All the three case study sites are within 10km from the tarmac road, unlike some of the sites in the whole sample which are located well beyond 10 km from the tarmac road. However, the results of the cases study still shade some light on the contribution of biophysical characteristics (soil texture and disease pressure) to the shift of banana production from the central region to the southwest. For example, when the regional dummy variable (southwest = 1 and 0 otherwise) is included in the estimation, the effects of soil texture (sand content) and Sigatoka on banana output become insignificant implying that the dummy variable captures the effects of these variables (Table 3.12 second column). Therefore, the high banana production in the southwest is favored by better soil texture conditions and lower disease pressure. Soils in the southwest are also younger and may have more weatherable minerals (i.e. better plant nutrition not necessarily shown by standard soil analysis.

Animal manure has a positive effect on productivity, being significant at 1%. The effect of sand on cooking bananas productivity is positive and significant at 1%. The effect of pH is positive and significant at 5% for all the model specifications. The effect of plot age on output is significant (positive for young plantations and negative for older plantations. Sigatoka has a negative effect on output, which is statistically significant at 1% level. The average TE obtained (44.9% to 45.6% depending on function form) from the case study is close to those obtained for the main sample.

Table 3.11 Frontier production function and technical inefficiency estimates (case study sample, n=157)

Variable	Cobb-Douglas		Transcendental		Translog	
	Coefficient	z-value	Coefficient	z-value	Coefficient	z-value
Stochastic frontier function						
constant	2.612**	2.75	2.533*	2.35	4.509	1.56
Ln(A)	0.446**	4.52	0.426*	2.56	0.624	0.84
Ln(L)	0.549**	6.79	0.568**	3.88	-0.18	-0.17
$Ln(A)^2$					-0.048	-0.59
$Ln(L)^2$					0.062	0.71
Ln(L)*Ln(A)					-0.049	-0.4
L/A			-0.00002	-0.15		
M	0.0001**	3.8	0.0001**	3.69	0.0001**	3.27
C	0.00004	0.44	0.00004	0.45	0.00001	0.13
sand	0.02**	3.42	0.245**	3.39	0.264**	3.38
pH	0.245*	2.43	0.02*	2.44	0.021*	2.46
plotage	0.033**	3.89	0.033**	3.78	0.034**	3.86
$plotage^2$	-0.0003**	-3.27	-0.0003**	-3.21	-0.0003**	-3.28
sigatoka	-1.5**	-3.83	-1.511**	-3.8	-1.517**	-3.79
Log likelihood	-193.8		-193.7		-193.2	
Wald X^2	301.8		303.9		297.8	
TE	0.451		0.449		0.456	
Factors influencing technical inefficiency						
constant	0.453	0.34	0.456	0.34	0.304	0.22
Age	-0.001	-0.02	-0.001	-0.02	0.007	0.12
Age_2	0.0001	0.23	0.0001	0.22	0.00005	0.09
Hplot	-0.355	-0.94	-0.35	-0.92	-0.399	-1.03
Edhh	-0.017	-0.45	-0.017	-0.45	-0.018	-0.48
Hhsz	0.044	0.89	0.045	0.9	0.035	0.68
depr	-0.096	-0.17	-0.094	-0.17	-0.051	-0.09
σ_v (se)	0.383	0.1	0.378	0.105	0.395	0.22

**, *, ^ imply significant and 1%, 5% and 10% respectively

Table 3.12 Cobb-Douglas frontier production function estimates when soil characteristics are excluded (case study sample)

Variable	Soil characteristics excluded		Regional dummy included	
	Coefficient	z-value	Coefficient	z-value
Stochastic frontier function				
constant	5.18**	8.38	0.349	0.32
Ln(A)	0.449**	4.21	0.435**	3.88
Ln(L)	0.553**	6.11	0.548**	5.79
M	0.00009**	2.91	0.00006^	1.84
C	0.00005	0.5	0.00004	0.57
sand			0.006	0.67
pH			0.571**	4.09
plotage	0.037**	4.03	0.012	1.21
$plotage^2$	-0.0003**	-3.29	-0.0001	-1.41
sigatoka	-1.454**	-3.54	-0.318	-0.73
Southwest			1.22**	5.05
Log likelihood	-198.9		-191.5	
Wald X^2	249.7		326.5	
Factors influencing technical inefficiency				
constant	-0.852	-0.57	-27.19	-0.01
Age	0.05	0.84	0.215	0.37
Age_2	-0.0003	-0.58	-0.004	-0.56
Hplot	-0.294	-0.75	26.816	0.01
Edhh	-0.023	-0.56	-0.523	-0.97
Hhsz	0.051	0.98	-1.014	-1.06
depr	-0.274	-0.44	1.82	0.33
σ_v (se)	0.46	0.097	0.817	0.046

**, *, ^ imply significant and 1%, 5% and 10% respectively

3.5 Conclusions

This chapter uses the stochastic production functions to analyze productivity and efficiency of smallholder banana farmers in Uganda. Three regions are considered: central region, which has low production, Masaka with medium production and the southwest, which has high production levels. The three regions exhibit different technologies, which influence the level of labour use intensity in banana production. The technology used in Masaka is such that farmers cannot obtain output levels prevailing in the southwest just by increasing labour use. In the central region, labour use intensity is limited by the high cost of labour and thus less labour is used per unit area than is used in the southwest but close to that used in Masaka. It is possible for farmers in the central region to obtain output levels similar to that obtained in Masaka, but at higher intensity of labour use, which is not profitable given the high wage rates.

Production of bananas exhibits decreasing returns to scale contrary to the perceived constant returns to scale for agriculture. Constant returns to scale can hold if the quality of land and other resources (e.g. labour) is constant. The labour input by different types of labour (men, women and children) was transformed by adult male equivalent ratios to make it uniform. However, it was not possible to observe plot characteristics, for the whole sample, which would used to standardize the land quality for all plots and farms. Results from the case study confirm that differences in plot characteristics explain the differences in banana productivity, specifically the low productivity in the central region and high production in the southwest. In particular, lower land quality is responsible for the observed reduced efficiency when the scale of production increases. However, fixing labour and crop area constant, large farm sizes are associated with high productivity contrary to what is reported in literature. Households with large farms are more likely to be committed to farming than households with small farms. Moreover, households with large farms are more likely to maintain higher soil fertility through crop rotation and keeping a significant proportion of their land under fallow.

Masaka exhibited a higher intercept in the labour production function, which can be attributed to better soil quality conditions (pH and soil texture). Overall, the effect of soil nutrients (N and K) on output is not significant, contradicting the view that decline in soil fertility contributed to banana production decline in central Uganda. However, soil chemical and texture characteristics significantly affect banana production. Pests (weevils) and diseases (Sigatoka) contribute to differences in banana production: low production in the central region because of high incidence of sigatoka and weevil infestation and high production in the southwest due to low weevil and Sigatoka infestation. The regional dummies (Masaka and southwest) included in the equation for the overall sample significantly increase the levels output. This implies that there are other factors that contributed to the decline of banana production in the central region that are not accounted for.

Factors that affect production efficiency are region-specific. In the central region, providing farmers with greater access to credit and improved road access reduces inefficiency in banana production. In Masaka, improving education reduces inefficiency. In the southwest, farmers benefit from improved access to extension services.

CHAPTER 4 Market access and allocative efficiency

4.1 Introduction

Earlier studies on farmer behavior and resource allocation efficiency in traditional agricultural systems were sparked off by Schultz's (1964) assertion that farmer operators in less developed areas cannot significantly increase their farm production either by reallocating their farm resources or by making further traditional investments. He defined traditional agriculture as one in economic equilibrium, this state having been achieved after a considerable period of time during which technology, preferences and motives remain constant. The rate of return to increased investment under existing technology was thus considered too low to induce further investment. Agricultural development at this stage therefore would depend more on breaking the existing equilibrium and adopting new technology involving the introduction of new modern inputs. Hence the view that only dramatic shifts in farm technology (seed, fertilizers, insecticides coupled with provision of credit) manifested itself in many rural development programmes of the 1960s and 1970s (Ellis, 1993).

On the other hand, because farmers were deemed allocatively efficient, engineering price changes were believed to cause them to change their production methods and to innovate. Thus the policies such as fertilizer price subsidization and credit schemes were promoted in the 1980s to stimulate adoption of improved technologies. Farmer education and extension work are considered low-cost methods of achieving increases in productive efficiency under the hypothesis of allocatively efficient but technically inefficient practices. However, if the strict hypothesis of peasant efficiency under competitive markets is relaxed to the notion of partial or conditional profit maximization, then emphasis switches to identification and removal of the constraints to the achievement of higher productivity (Ellis, 1993).

Studies on resource allocation efficiency in agriculture in developing countries support the hypothesis that farmers are allocatively efficient (Chennareddy, 1967; Hopper, 1965; Sahota, 1968). The studies describe farmers as involved in a technologically stagnant agriculture but to be aware of resource substitution possibilities. Some of these resources, such as fertilizers, which are not within easy reach of individual farmers, show high marginal returns, in which case fertilizer use would be less than optimal.

A number of criticisms, however, were voiced against Schultz' propositions on agricultural transformation: The model was criticized for being based only on the farm firm and profit maximization criteria, disregarding other economic factors such as risk, uncertainty and the associated differences in marginal utilities that farm operators attach to prospective gains and losses (Adams, 1967). Adams noted that acceptance of the claim that farm operators are economically rational and efficiently allocate resources at their disposal does not necessarily entail belief in efficient resource allocation at the sector level. Feder (1967) shared that view of economic inefficiency at sectoral level, which he attributed to estate owners (absentee landlords) whose incomes are supplemented and often exceeded by non-farm incomes, a factor that forms a disincentive to farm their land well.

Results by Randhawa and Heady (1964) were in agreement with the above view where additional production was realized from re-planning available resources without improvement in technology. Results by Mubarik and Flinn (1989) also show substantial improvement in the profitability of Basmati rice in Gujaranwala district, India through better use of existing technology. A number of studies provide evidence of agricultural inefficiency in Africa, and show heterogeneity across households in terms of their access to the best available technology (Adesina and Djato, 1996; Aguilar and Bigsten, 1993; Croppenstedt and Demeke, 1997; Heshmati and Mulugetya, 1996; Mbowa et al., 1999; Olowofeso, 1999; Seyoum et al., 1998).

Nevertheless, food production per capita has declined by 17% in the sub-Saharan region since the 1970s (FAOSTAT, 2004). The decline has been attributed to rapid population growth, low agricultural productivity and resource degradation (Bruntland, 1987), market failures (Holden and Binswanger, 1998), poor input use and government policies including research and infrastructure (Craig et al., 1997). The low food productivity has been attributed to an unfavorable socioeconomic environment, unfavorable policies, biophysical constraints, and unsustainable land management practices. It has been argued that abundant land availability and low population densities have persistently caused high transport and transaction costs, limiting the emergence of competitive markets that would boost growth in agricultural productivity (Binswanger and Townsend, 2000). Agricultural intensification has been associated with increasing population pressure, where land gets more intensively cultivated through the use of abundant labour in production (Boserup, 1965; Brush and Turner, 1987; Pingali et al., 1987; Ruttan, 1984). High population density permits the development of specialization and markets (Tiffen, 1988). Poor price policies, specifically those taxing agriculture heavily, have been identified as causes of negative rates of productivity change in agriculture observed in most developing countries (Fulginiti and Perrin, 1997).

There has been considerable diversification of income in Africa, between farm and nonfarm activities (Haggblade et al., 1989), which can be considered a response to poorly functioning and/or missing financial and insurance markets. Inefficiencies in agricultural production have been attributed to imperfections in credit and capital markets (Adesina and Djato, 1996; Aguilar and Bigsten, 1993; Ray and Bhadra, 1993). Earnings from nonfarm activities can stimulate farm investments and improve agricultural productivity and efficiency (Haggblade et al., 1989; Hazell and Hojjati, 1994). However, limited access to nonfarm income opportunities and imperfections in the labour market can contribute both to inefficient labour allocation in rural households and to a more unequal distribution of income (Reardon et al., 1994). Nonfarm income-generating activities are likely to have a positive impact on farm productivity in cases where the credit market is not functioning, while imperfect labour markets are likely to cause negative growth linkages between nonfarm and farm activities as prohibitive wages (resulting from higher transaction costs) discourage investment in farm labour.

Options for rural employment are often limited to informal labour exchange amongst households during periods of peak labour demand. Lack of complementary inputs that are required to improve labour productivity has contributed to the stagnation in the development of the local labour market. As a result, migration and engagement in nonfarm activities offer attractive alternatives to rural agricultural employment (Barrett et al., 2001; Reardon et al., 2001). Although studies on household income composition have reported substantial contributions of income from off-farm and nonfarm activities in sub-Saharan Africa (Barrett et al., 2001; Bryceson and Jamal, 1997; Little et al., 2001; Reardon, 1997), most households are still constrained in accessing the highly remunerative segments of the labour market due to lack of appropriate training, high relocation costs and lack of possibilities for making lumpy investments (e.g. in equipment and machinery) (Ruben and Pender, 2004). In their analysis of nonfarm income activities for Ghana and Uganda, Canagrajah et al. (2001) found that education, age of the individual, location and regional characteristics were significant determinants of involvement in nonfarm income activities.

Transaction costs in different markets in developing countries determine whether a particular household participates or does not participate in a market. Households facing different market opportunities may make different decisions related to production, which affects efficiency. In the absence of credit and insurance markets, liquidity-constrained farmers might limit their investments in purchased inputs and hired labour. Imperfections in output markets could force farmers into subsistence production, leaving no or limited surplus for market sales.

In a survey to document production dynamics in Uganda's highland cooking bananas, farmers attributed the decline of banana production in Central Uganda to soil exhaustion, pest and disease pressure, socioeconomic constraints and changing opportunities (Gold et al., 1999). Results in chapter 3 confirm that pests (banana weevil) and diseases (Sigatoka) contribute to differences in banana production, but the effect of soil nutrients is insignificant. High cost of labour is found to be one of the major factors limiting labour use in banana production in the Central region. However, it is not clear why farmers invest more labour in annual crops than in bananas, despite the fact that farmers obtain a higher gross margin from bananas (at market prices) as seen in Chapter 2. Most probably imperfections in the food and labour markets play a big role in the allocation decisions made by farmers. This study was carried out to analyze allocative efficiency among smallholder farmers in Uganda. Specifically, we test the null hypothesis that production and consumption decisions are separable and use of labour is determined purely by profit. The alternative hypothesis is that food and labour markets are imperfect and production decisions are influenced by the consumption side variables, in particular household size and composition. Understanding the interactions between labour markets, product markets and farm production is essential for formulating appropriate policies for improving the banana sub-sector and the overall agricultural sector. The remainder of this paper is organized as follows: the theory is discussed in section 4.2 while section 4.3 covers the empirical specification of the model and a brief description of the data used in the study. Results are presented and discussed in section 4.4 while section 4.5 provides concluding remarks.

4.2 Agricultural household model

In chapter 3 we analyze the factors that influence banana productivity and technical efficiency of banana farmers in central and southwestern Uganda. However, in the chapter, we do not capture the factors that influence production decisions made by farm households. The analysis in chapter 3 puts emphasis on the response of farm output to changes in input application, without giving attention to the factors that determine the levels of input use. In this chapter, we extend the production model to a household model to be able to analyze the factors that influence smallholder farmer resource allocation decisions. Smallholder farmers in developing countries are both producers and consumers and make decisions that affect production, work and consumption simultaneously. Hence the need to employ the household model in the analysis of smallholder farmer behaviour as it integrates production, consumption and work decisions.

Traditionally, economists have used a profit function approach to explain firm behavior. This is possible when markets are functioning well and there are no missing or incomplete markets, with farmers facing low transaction costs, thus rendering consumption and production decisions to be separable; a recursive property where farmers maximize profit from production and use the profit income for consumption decisions (Benjamin, 1992). Inclusion of the profit effect in analysis of household consumption behavior led to what is termed the farm household model, in its neoclassical form. The major difference between the farm household model and the pure consumption model is the assumption that the household budget is fixed in the pure consumption model, whereas in the farm household model it is endogenous and depends on production decisions that contribute to income through farm profits (Taylor and Adelman, 2003). The theory of farm household is consistent with the analysis of the farm household behaviour first advanced by A.V. Chayanov (Thorner et al., 1966), who considered the farm household as one that makes decisions on family labour use in order to satisfy its consumption needs.

When farmers face missing or incomplete markets (e.g. labour, credit and insurance markets), production decisions cannot be separated from consumption decisions and the proposition that profit is the principle driving factor for production decisions is not plausible. Where development of reliable markets for consumer goods (crop inputs and food stuffs) is lacking, households allocate their time preferably to essential non-market household activities, including the provision of secure food supply (Low, 1986). Analysis of farm household behavior in a situation where markets are not functioning well requires a household approach, which involves simultaneous estimation of production and consumption. Estimation of the complete structural system of equations for consumption and production behavior and reduced form approaches are often used. One of the approaches focuses on the time allocation of farm households under labour market imperfections, in which one estimates households' shadow wages and incomes, based on first-order conditions for utility maximization in the context of a non-separable household model, which are then used as regressors in subsequent labour supply estimations (Abdulai and Regmi, 2000; Barrett et al., 2005; Jacoby, 1993; Mishra and Goodwin, 1997; Newman and Gertler, 1994; Skoufias, 1994). The separability condition is rejected if the shadow wage rates are significantly different from the market wage rate.

4.2.1 Household behavior under functioning labour markets

The basic household model postulates the existence of perfect markets for goods produced and consumed by farm households, which enables the households to separate production and consumption decisions by first maximizing profit from food production, and use income from profit to maximize utility from consumption.

Following a household economics framework, the farm household's utility function *u*, is

$$u=u(c, l; z) \qquad (4.1)$$

where c is a vector of home produced goods and l is time spent in leisure and social activities. The vector *z* parameterizes the utility function and summarizes household characteristics, such as number of people in each age and sex category, education level and distance to market. The c are produced using a vector of purchased goods, x, and a vector of quantities of own time. A significant part of c is also obtained from own production, the rest being sold to the market at competitive prices. Limiting the consumption of goods, c, to a staple crop (e.g. bananas), the farmer's problem is:

$Max\ u(c, l; z)$ with respect to c, l, l_o, l_f *and* l_h (4.2)

∍

$$c = pf(l_F; x) - wl_h + wl_o + y \text{ (cash constraint),} \qquad (4.3)$$

$l + l_f + l_o = E$ (labour constraint) (4.4)

$l_f + l_h = l_F$ (4.5)

and $l \geq 0, l_o \geq 0, l_f \geq 0, l_h \geq 0$ (nonnegativity constraints)

where $q = f(l; x)$ is a twice differentiable, concave production function and p is price of farm output. Land area, x, is allocated to production of q and is assumed to be fixed and exogenous. Labour l_F is the sum of family and hired labour, $l_f + l_h$, and w is the price for hired labour and off-farm labour l_o. The household is endowed with resources: time E and exogenous income y. Hired labour and family labour are perfect substitutes and have the same wage rate w.

From (4.4), we have;

$$l_o = E - l - l_f \tag{4.6}$$

Substituting (4.6) for l_o in (4.3), we obtain,

$$c = pf(l_F; x) - wl_h + w(E - l - lf) + y \tag{4.7}$$

From (4.7), we obtain the full income constraint:

$$c + wl = y + pf(l_F; x) - wl_h - wl_f + wE = M \tag{4.8}$$

where $y + pf(l_F; x) - wl_h - wl_f = \pi$, the profit.

Maximizing M leads to an indirect utility function: $u = \phi(y + \pi(w; x) + wE(\beta), w; \beta)$. Utility is maximized through maximizing full income M, which itself is maximized by maximizing profits: $\pi = \pi(w; x)$. This is the recursive property, where the household first maximizes profits and then maximizes utility from the income obtained from the profits.

The first order condition with respect to l_F from profit maximization is:

$$f_{l_F}(l_F; x) = w^* \tag{4.9}$$

where $w^* = w/p$. $f_{l_F}(l_F; x)$ is the marginal product of labour and w is the market farm wage rate for labour. We can derive the reduced form for farm labour demand as

$$l_F = l_F(w^*, x) \tag{4.10}$$

Equation (4.10) shows that farm labour demand (family or/and hired labour) is determined by the real farm wage rate and the fixed land resource (in the short-run). Demand for labour is independent of consumption decisions and therefore not influenced by household characteristics. The first order condition for profit maximization in (4.9) implies that an increase in wage rate reduces labour demand while an increase in output price would result in an increase in labour use.

The Lagrange for utility maximization is

$$z = u(c, l; z) + \lambda(M - pf(l_F; x) + wl_h + wl_f - wE - y) \tag{4.11}$$

This leads to the following first order conditions:

$$\frac{\partial z}{\partial c} = u_c - \lambda p = 0 \tag{4.12}$$

$$\frac{\partial z}{\partial l} = u_l - \lambda w = 0 \tag{4.13}$$

From (4.12) and (4.13), we have the following first order condition for utility maximization:

$$\frac{u_c}{u_l} = \frac{p}{w} \tag{4.14}$$

From (4.14), we can derive the reduced form for family labour supply as

$$l_f = l_f(w, p, M, z) \tag{4.15}$$

The separation property provides a representation of the dual nature of the farm household both as a producer and worker. The household is able to attain maximum utility through the market either through hiring more labour, in case of labour deficit, or by selling labour to the market, in case of labour surplus. The condition in (4.14) shows that consumption decisions include the choice of home time, *l*, which is traded off with the consumption of goods, c, that would need more income and hence more work. Unless commodity c is a Giffen good (in which case its consumption increases when the price rises), the relationship between the consumption of c and price, p, should be negative. Likewise, leisure, l, is a normal good and the household should reduce its consumption when there is a rise in wage rate. A rise in price of the farm product, c, raises its output and full income, reduces family time committed to its production, increases use of hired labour, increases market surplus, and reduces consumption of the farm output by the household. A rise in market wage results in reduction in use of hired labour, an increase in consumption of home produced goods and a reduction in consumption of purchased goods.

However, they are several substitution and income effects involved that affect the net outcome of the price and market wage rate changes (Ellis, 1993). The outcomes depend on household consumption preferences between the three consumption choices: own farm produce, nonfarm time and the consumer good, which cannot be anticipated by theory but by empirical estimations. The general impact of the income (profit) effect is to give the household greater scope to pursue its preferences. Ellis (1993) observes that peasant farmers strive to obtain economic efficiency although this might not be attained in the strict neoclassical sense due to the nature of the peasant economy in which they operate. Profit maximization conditional on multiple goals pursued, resource constraints and markets confronted by the farmers may exist even if the strict efficiency is not observed. Farmers take into account risk and uncertainty, have household goals other than profit maximization (e.g. food security, social status and income sustainability), and face imperfections in different factor markets (land, labour and capital).

4.2.2 Imperfections in the hired labour market

Small farmers confront wage rates that are different from those faced by large farmers due to imperfections in the labour market. Specifically, small farmers confront a low opportunity cost of labour, which is lower than the social wage, while by contrast lager farmers confront a higher price for labour that is above the social wage (the opportunity cost of labour in the economy at large) (Ellis, 1993). Transaction costs have the effect of raising the wage rate for the employer (larger farmer) above the level that would occur in the absence of the transaction costs. Such costs include monitoring and supervision costs for hired labour, incentive costs, labour retaining costs, efficiency costs and moral hazard. On the other hand, small farmers confront a wage rate that is lower than the social wage, which makes them retain surplus labour on their farms. Hence larger farmers tend to substitute labour with capital and land and adopt socially inefficient techniques of production, while small farmers employ labour intensive techniques.

The full income for a household facing transaction costs in the hired labour market is expressed as follows:

$$M = pf(l_F; x) - (w + T_w)l_h - w_f l_f + w_f E + y \qquad (4.16)$$

where w = social cost of labour, w_f is the opportunity cost of labour for the household and T_w is cost incurred by the household above the social cost as a result of transaction costs.

The household maximizes utility by maximizing the full income and first order condition for profit maximization is:

$$pf'(l_F;x) = w + T_w \tag{4.17}$$

From (4.17), we get:

$$f'(.) = w/p + T_w/p = w^* \tag{4.18}$$

Labour will be hired in by the household if $f(.) > w^*$ and hired out if $f'(.) < w_f$. Households are self sufficient in labour if $w_f \le f'(.) \le w^*$. Farm labour demand is derived from equation (4.18) as follows

$$L_F = f(w^*, x) \tag{4.19}$$

w^* itself is a function of the market wages (w and p) and household specific characteristics that are correlated with the transaction costs (e.g. household size and composition).

4.2.3 Imperfections in the off-farm labour market

Consider the case of imperfections in the nonfarm sector in which some household members are segregated in the labor market, while others cannot be fully absorbed by the labour market. This is the situation that prevails in most developing countries, where individual workers can only find work in certain periods of the year (peak season) and work the rest of the year on their farms.

$$l_0 = l_{\max} \tag{4.20}$$

The full income, M, can no longer be determined by the profits from production alone but also by the conditions in the nonfarm labour market. The farmers' utility problem is solved through maximizing income and leisure concurrently. The farmer's utility maximization problem is:

Max $u(c, E - l_f - l_0; z)$ (4.21)

∍

$c = pf(l_F; x) - w_h l_h + w_f l_o + y$ (Budget constraint) (4.22)

$l = E - l_f - l_0$ (Time constraint) (4.23)

$l_o = l_{\max} = E - l - l_f$ (Off-farm labour constraint) (4.24)

Utility is maximized through maximization of full income subject to the off-farm labour constraint. The Lagrange function for the problem is:

$$z = \lambda(pf(l_F; x) - w_h l_h - w_f l_f + w_f E + y) + \psi(l_{\max} - l_o) \quad (4.25)$$

The first order condition with respect to family labour working on farm is

$$\frac{\partial z}{\partial l_f} = \lambda pf(l_F; x) - \lambda w_f + \psi = 0 \quad (4.26)$$

From (4.26), we get:

$$pf'(l_F; x) = w_f - \frac{\psi}{\lambda} \quad (4.27)$$

$$f'(.) = 1/p(w_f - \frac{\psi}{\lambda}) = w^* \quad (4.28)$$

where $\lambda > 0$ is the Lagrange multiplier associated with the budget constraint, $\psi \geq 0$ is the Lagrange multiplier associated with the time constraint, p is farm gate price of farm output while w_h and w_f are wage rates for hired and off-farm labour respectively. From equation (4.28), it is shown that the impact of ψ is to reduce the opportunity cost of labour; hence limiting household members on the amount of labour they can supply to the off-farm sector. Labour will be hired out if $f'(.) < w^*$ and hired in if $f'(.) > w_h$. Households are self-sufficient in labour if $w^* \leq f'(.) \leq w_h$.

The first-order condition in (4.28) shows that the shadow wage rate for the household facing market imperfections is not the market wage rate but is a function of exogenous prices and other factors, *z*, which affect household consumption decisions. In particular, factors that influence access to off-farm opportunities (e.g. road infrastructure, proximity to urban centers and characteristics of individual household members) would influence farm production and consumption decisions.

Apart from transaction costs, different wage rates exist because of differences in labour input choices between two different categories of farmers. Whereas big (commercial) farmers maximize profit in the orthodox way by equalizing the marginal product of labour to the wage rate, smaller farmers equalize the average product of labour to the market wage. This is demonstrated in Figure 4.1 where the commercial farmer operates at point A corresponding to labour use L_1 and pay a market wage w_h, while the small farmer operates at point B with higher labour use intensity at L_2. The marginal product of labour for the small farmer is below the market wage (point D) and may even tend towards zero (Sen, 1966). Households facing transaction costs within the category of small farmers will even use more labour up to point L_3 where the average product of labour is equal to w^*, the discounted wage rate equivalent to the marginal product at the point where the farmer equalizes the average product of labour (APL) to the market wage. The small farmer (particularly in the remote area where transaction costs are high) equates the subsistence wage, APL, to the discounted market wage, w^*, when choosing how much labour to apply to own production.

4.2.4 Imperfections in the food market

The principle of equal marginal returns from crops grown in a given locality may not hold if the households within that locality pursue different objectives other than profit maximization (i.e. if there are imperfections in the labour market and/or food market). Take for example two households, both representing a case of net food buying. One of the two households faces constraints in the food market and the other has no constraints in the food market. The households face a trade-off between consuming food and leisure. The food can be produced on the farm or bought from the market using income earned from off-farm work. The choice between food production on own farm, off-farm employment and leisure as made by the two different households is illustrated in Figure 4.2. The line ww^* is the wage line representing the price ratio w/p, and describes the rise in the total cost of labour as its use increases. The optimal production level for the household with perfect food market is at point A where the slope of the production function is equal to the slope of ww^*. Optimal consumption for the household facing a perfect food market is at point B where the marginal rate of substitution between food and leisure equals the price ratio (where the highest indifference curve touches the wage line). The optimal use of labour comprises of OA hours in food production, AB hours in wage employment and BT hours of leisure.

Figure 4.1 Dual labour market hypothesis (Ellis, 1993)

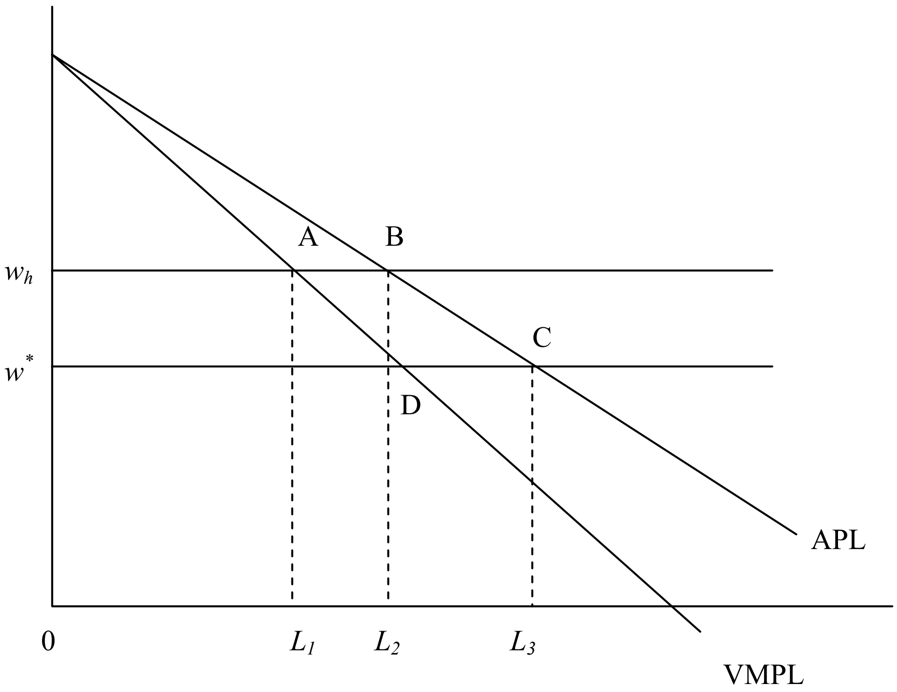
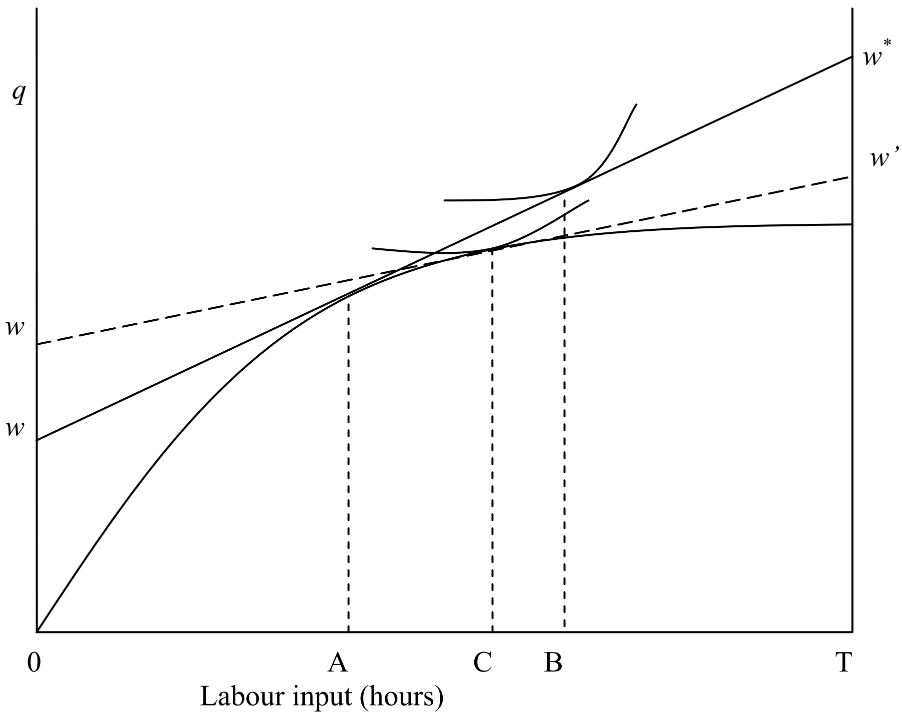


Figure 4.2 Farm household labour demand and supply under imperfect food markets



For the household facing imperfections in the market of the staple food, the selling and buying prices are different. The buying price is higher, probably because of seasonality of production where the price is low immediately after harvest and high before harvest when the household is facing deficit and has to buy some of the food from the market. Bulkiness and perishability of the food item also lead to different selling and buying prices because of high transport and storage costs. Risk and uncertainty influence the effective price used for decision making and thus increase the width between selling and buying prices where the farmer discounts selling prices negatively and buying prices positively. The household facing any of these food market imperfections will have its effective food price higher than the going market price and the optimal level of farm production will be higher than the case if the market imperfections are absent as illustrated in Figure 4.2. The wage line for the household facing the market imperfections is *ww'* with slope that is equal to the slope of the production function at point C and OC hours are used in food production instead of OB hours in the case when the food market is perfect.

The equilibrium for consumption between food and leisure will depend on the household's preferences for leisure, land suitability (fertility) and substitutability between food and consumer goods. The household with poor land and a large family invests or uses more labour in food production, and maintains off-farm work to meet the household's food requirements. The household's leisure time is reduced in favour of food production. Crops such as beans with substitutes on the market that are more expensive (meat and fish) are expected to have lower marginal products (MPs) (higher intensity of labour use), while crops such as bananas that can easily be substituted with cheaper consumer goods from the market (e.g. maize flour) will have higher MPs (lower intensity of labour use). But this will depend on the household's preferences for bananas versus maize.

4.2.5 Production function estimation

The production function is comprised of farm inputs that are representative of the production system, including labour and other variable inputs, and fixed inputs (land and organic amendments). Included in the production function are factors that are hypothesized to affect the production potential.

In absence of fertilizer and other chemical inputs, the production function can be specified as:

$$y_i = f(l_{ij}, x_{ik}; \xi) + \varepsilon_i;\ i = 1,\ldots n,\ j = 1,2 \text{ and } k = 1,\ldots,m. \quad (4.29)$$

where y_i is output realized from farm i; l_{ij} refers to the different types of labour input (family and hired labour) used by the farmer; x_{ik} refers to fixed factors: land (x) and organic inputs (animal manure, crop residues and grass mulch) and ξ refers to farm and plot characteristics (pest and disease incidence, soil characteristics and access to technical information as proxy for technology). ε_i is the error term $\sim N(0,\sigma^2)$. Family and hired labour is further categorized as male, female and child labour.

A number of problems arise in the estimation of the production function specified in (4.29). First is the assumption of the perfect substitutability of different types of labour (male, female and child labour) in the labour aggregation process. Adjustments are made in the summing up the different types of labour for possible non-substitutability between male, female and child labour.

Total labour input, *l*, can be expressed as follows:

$$f_m + a_1 f_f + a_2 f_c + b(h_m + a_1 h_f + a_2 h_c) = l \qquad (4.30)$$

where *f* and *h* refer to family and hired labor respectively. The subscripts *m*, *f* and *c* refer to male, female and child labour respectively. a_1 and a_2, measure the efficiency with which female and child labour substitute for male labour, while b measures the productivity differences between family and hired labour.

Secondly the inclusion of manure, grass mulch and crop residues in the production function conflicts with one of the properties of the production function, which requires strict essentiality for inputs in the production process. Crop output is determined by available water and nutrients in the soil, energy from the sun and yield reducing factors such as weeds, pests and diseases. Plant nutrients already exist in the soil from natural sources (parent material or soil organic matter). Nutrient availability depends on the nutrient concentration in the soil and chemical (e.g. pH) and physical (top soil depth and structure) characteristics of the soil. Thus land with a higher concentration of nutrients and favourable chemical and physical properties produces more output than the same amount of land with lower nutrient concentration and less favourable chemical and physical characteristics. Likewise, addition of external inputs (manure and other soil amendments) serves to increase the capacity of land to produce higher output by increasing the nutrient concentration and improving the chemical and physical characteristics of the soil. The relationship between output, land and organic amendments can be expressed in the form:

$$y = \alpha[x(1+\mu_1 M)(1+\mu_2 G)(1+\mu_3 C)]^{\theta} l^{\beta} e^{\varepsilon} \qquad (4.31)$$

where *x* and *l* respectively refer to crop area and total labour input, while α, θ and β are the parameters that are estimated, which respectively refer to the constant, and elasticities of crop area and total labour input. M, G and C refer to quantities of manure, grass mulch and crop residues with μ_1, μ_2 and μ_3 as their respective coefficients, which measure their contribution to land productivity. The variable ε refers to the random error term. With small values of $\mu_1 M$, $\mu_2 G$ and $\mu_3 C$, equation (4.31) can be Taylor approximated into the following equation:

$$y = \alpha[xe^{\mu_1 M} e^{\mu_2 G} e^{\mu_3 C}]^{\theta} l^{\beta} e^{\varepsilon} \qquad (4.32)$$

The third problem regards the implicit assumption that farmers know in advance the error, ε_i, in their production function either from past experience or from observing plot characteristics at the time of labour application. Thus the disturbances for the production function and labour demand function are correlated due to the adjustment in labour input due to response to shocks. The problem can be rectified if instruments are available that are determined prior to the shock. The number of workers in the household in each age category is correlated with total labour input but uncorrelated with the disturbance in the production function (Jacoby, 1993). In particular, the number of household members in each category is less likely to be correlated with the production shock.

The production function is estimated in two stages. First, a labour demand function is estimated to determine the instruments that are used in the second stage, the actual estimation of the production function. When a range of instruments are available to choose from, a two stage least squares (2SLS) is an appropriate procedure to use since the full range of instruments can be included in the estimation without the problem of over-identification arising.

The instruments used could increase the bias in the estimated coefficients if the their explanatory power in the first stage regression is low (Hahn and Hausman, 2002). The extreme case is when their explanatory power in the first stage is nil. The model is in effect unidentified with respect to the endogenous variable, and the bias of the instrumental variable (IV) estimator is the same as that of OLS estimator. The IV becomes inconsistent and nothing is gained from instrumenting. One way out, for a single endogenous variable, is to have an F-Statistic, from the first stage tests, that is above 10 (Staiger and Stock, 1997). It is also important to keep the size of instruments small, since the size of the IV bias is increasing in the number of instruments (Hahn and Hausman, 2002). In our analysis, we exclude from the instruments all variables that have no significant effect (at 5%) on labour. We obtain OLS estimates of the production function in cases where the F-value is not statistically significant (at 1% level).

4.3 Productivity and allocative efficiency estimation

4.3.1 Model specification

The production function

A Cobb-Douglas production function was estimated with the output and input variables (labour and crop area) transformed into logarithm form. For female labour, a_1 was fixed at 0.8 while a_2 for child labour was fixed at 0.5. The coefficient for hired labour, b, was initially varied between 0.8 and 1.2 and finally fixed at 1.0 because there was no significant impact on the parameter estimates. The production functions were estimated under the assumption of varying returns to scale. Parameters estimated gave an insight in the sources of productivity differences between regions and groups of farmers.

The 2SLS procedure was used to estimate the production function and labour equations. Household characteristics (age, gender, education and household size and structure), distance from tarmac road, and credit access were included in the labour equation to capture any effects from market imperfections in the labour, commodity and financial markets. Farm size and number of extension visits in previous six months were included in the production function as proxy for farm characteristics and production technology. Regional dummies were included to capture the diverse soil and agro-climatic characteristics of the different regions (central, Masaka and southwest).

Allocative efficiency scores

The marginal products of labour estimated from the production functions were used to test for allocative inefficiencies within different production regions and groups of farmers. For the proposition of allocative efficiency to hold, the marginal product of labour should be equal to the real or normalized wage rate.

$$MPL = w^* \tag{4.33}$$

where w*=w/p.

To test for allocative inefficiency, the following function was estimated:

$$Ln(MPL) = a + bLn(w^*) + e \tag{4.34}$$

The null hypothesis of allocative efficiency holds if the joint F-test for parameters, a and b, being equal to 0 and 1 respectively is not rejected.

4.3.2 Data sources and description

Wood et al. (1999) classifies market access as high or low based on an index of "potential market integration" reflecting travel time for each location to the nearest five markets weighted by the population in the markets. Three characteristics are noted in this classification: (1) quality of road access (2) urbanization and (3) population size. We maintain these three characteristics in classifying our study sample between accessible and remote, but with some modifications in the indicators used. For example, instead of travel time, we use distance to paved roads as this will affect the time and cost of travel to market centers, thereby influencing market participation. In our sample, distance to paved roads was used to classify the villages between isolated and easily accessible. We also considered the level of urbanization; agricultural potential and population density in the urban areas stratify the sample into three different regions: (1) the southwest (medium – high) (2) Masaka (low – medium) and (3) the central region (low – high) (Table 4.1). Market access is highest close to the urban centers of Kampala and Jinja, in parts of the densely populated highlands in the south and near to the highway network in the rest of the country (Pender et al., 2003).

Table 4.1 Sample stratification by level of urbanization, population density and market access

Location	Farm household characteristics			Elevation (m asl)	Urbanization	Population pressure	Market access
	Farm size	Dummy land[1]	Household size[2]				
southwest							
<10 km	2.68	0.3	5.13	>1400	medium	high	High
>10 km	3.17	0.56	4.52	>1400	low	medium	Medium
masaka							
<10 km	3.24	0.31	4.5	1200-1330	low	medium	Medium
>10 km	6.67	0.34	4.23	1200-1300	low	low	Low
central							
<10 km	4.13	0.42	4.66	<1200	high	low	High
>10 km	4.41	0.45	4.96	<1200	low	low	Low

Survey methods and primary data collection procedures are described in Chapter 2. The units of observation are the village and the household. Village level data includes prices and distance to tarmac road (highway). Household level data include demographic characteristics, production, income and inputs. The variables used in the production function are defined in Table 4.2. Table 4.3 summarizes the exogenous variables used in both the first and second stage estimations.

Table 4.2 Definition of variables used in production function

Variable	Definition
y	Crop output (kg/year)
A	Area under crop (cultivated) (acres)
L	Amount of labour used in crop production (hours/year)
M	Amount of manure applied to crop (kg/year)
G	Amount of grass mulch applied to crop (kg/year)
C	Amount of crop residue applied to crop (kg/year)

Table 4.3 Descriptive for exogenous variables used in production analysis

Variable	Definition	central	Masaka	southwest
n		293	129	138
farm size	farm size (acres)	4.429	4.377	2.898
		(5.47)	(14.35)	(5.64)
ext	number of extension visits	0.616	0.791	0.732
		(2.06)	(1.76)	(1.49)
w	casual wage rate	433.5	267.8	227.4
		(157)	(106.1)	(27.2)
p	price of bananas (U.Sh/kg)	158.7	120.4	94.2
		(46.8)	(32.1)	(21)
hhsz	family size (adult	6.11	5.341	6.036
	equivalent)	(2.72)	(2.62)	(2.54)
depr	proportion of dependants in	0.497	0.49	0.492
	household	(0.24)	(0.27)	(0.2)
Gender	male = 1, female = 0	0.805	0.767	0.833
		(0.4)	(0.42)	(0.37)
Age	age household head (years)	46.5	44.1	43.7
		(16.5)	(16.02)	(14.6)
Age^2	age squared	2434	2196.2	2119
		(1681)	(1581.2)	(1417)
edhh	education household head	5.799	4.868	4.862
	(years)	(4.58)	(3.24)	(3.99)
D	distance from tarmac road	12.271	20.285	10.57
	(km)	(8.91)	(31.75)	(13.2)

Values in parentheses are standard deviations

4.4 Results and discussion

4.4.1 Production function estimates

Production function estimates were obtained for the majors crops grown. The results from the first stage estimation of the production function are included in Appendices 4.1-4.3. Final estimates of the production functions are presented in Tables 4.4-4.6. The estimated coefficients have the expected positive sign for land and labour inputs.

For the Central region, high elasticities of labour are obtained for bananas and beans, and lowest for coffee and cassava (Table 4.4). Both coffee and cassava have had serious disease incidences in the recent past (Fusarium wilt for coffee and cassava mosaic disease (CMD) for cassava). Output share from labour, compared to crop area, is high for most of the crops except for cassava and maize for which crop area contributes more than labour to output. Manure has a positive and significant effect (1%) on banana productivity. Technologies used in crop production in the region display decreasing returns to scale except for maize (where the sum of elasticities of land and labour is slightly greater than one). Decreasing returns imply that efficiency is reduced when farmers increase plot sizes (scale of production). However, farm size has a positive effect on output (with the exception of maize and cassava), in contrast with what is reported in much of the literature on farm size and productivity effects (Barret, 1996; Benjamin, 1995; Byiringiro and Reardon, 1996; Carter, 1984; Ellis, 1993; Pender et al., 2004).

Small farmers are assumed to commit more labour per unit area in crop production (Berry and Cline, 1979) since they confront a low opportunity cost of labour and higher prices for land and capital (Ellis, 1993). On the other hand, large farmers are likely to be more committed to farming as a business, while smaller farmers diversify into other activities as they cannot sufficiently depend on farm production. The results also contrasts the view that large farms may have on average less fertile soils than small farms as high population density and fragmentation of holdings tend to occur in locations of high natural soil fertility. However, it is possible for large farmers to maintain higher soil fertility through the traditional methods of fallow and crop rotation, especially in developing countries where use of purchased inputs is virtually absent. The negative impact of farm size on productivity of maize and cassava is explainable. Large farmers are more likely to allocate the best of their land to the most important crops, in terms of income, and allocate less productive land within their total farm area to maize and cassava. Small farmers would allocate the same type of land to maize and cassava for the purpose of own consumption.

Table 4.4 Production function estimates for different crops for Central region, 2SLS (robust standard errors)

Variables	All crops	bananas	Coffee	maize	s. potato	cassava	beans
n	294	246	105	177	141	170	183
Constant	9.448**	2.784	2.455**	3.232*	4.711*	5.065**	1.979
	(10.69)	(1.62)	(3.57)	(2.29)	(2.32)	(8.67)	(1.61)
Ln(a)	0.064**	0.182	0.059	0.614**	0.213	0.282*	0.17
	(0.49)	(0.93)	(0.31)	(3.22)	(0.92)	(2.18)	(1.27)
Ln(L)	0.44**	0.647*	0.301*	0.564	0.37	0.182	0.565**
	(3.51)	(2.310	(2.2)	(2.68)	(1.06)	(1.56)	(3.16)
M		0.0002**					
		(3.77)					
G		0.00004					
		(0.31)					
C		0.00002					
		(0.3)					
Farm size	0.021*	0.03*	0.02	-0.032*	0.027**	-0.016	0.011
	(2.32)	(2.25)	(0.74)	(-2.36)	(2.6)	(-1.32)	(1.15)
ext	0.013	-0.011	0.041	-0.039^	0.031	0.063	0.049^
	(0.72)	(-0.51)	(0.78)	(-1.65)	0.98	(1.43)	(1.7)
R^2	0.38	0.409	0.202	0.541	0.151	0.127	0.364
F(k, n-1)[1]	17.00	40.15	27.68	5.66	12.56	2.45[NS]	34.75

[1] F-test for strength of instruments excluded from the second stage
[NS] Not significant (equation estimated using OLS)

In Masaka region, high labour elasticities are obtained for coffee, sweet potato and beans, but low for bananas, maize and cassava, relative to crop area elasticities (Table 4.5). The impact of soil organic amendments is not significant. Farm size has a positive significant impact (1%) on bananas, which is the main crop grown in the area. The impact for sweet potatoes is negative and significant. The effect of farm size on the value of crop production (all crops) is positive and significant (5%). Positive effects of extension are realized for bananas, maize, coffee and beans but only significant for maize (1%) and beans (10%). This could be associated with multiplication and delivery of improved varieties (in case of beans), and high-yielding clonal material (in case of coffee) to farmers.

Table 4.5 Production function estimates for different crops for Masaka, 2SLS (robust standard errors)

Variables	All crops	bananas	coffee	maize	s. potato	cassava	beans
n	129	126	69	60	30	35	65
Constant	9.832^	6.646*	1.714	5.69**	3.753**	6.53**	3.411**
	(1.76)	(5.88)	(0.87)	(9.5)	(3.65)	(5.5)	(3.54)
Ln(a)	0.221	0.276**	0.522**	0.458**	0.032	1.055**	0.548**
	(1.22)	(2.65)	(2.79)	(2.99)	(0.09)	(3.07)	(4.13)
Ln(L)	0.429	0.186	0.643^	0.031	0.348*	0.183	0.478**
	(0.56)	(1.07)	(1.82)	(0.38)	(2.52)	(0.81)	(2.88)
G		0.00002					
		(1.01)					
C		0.00003					
		(0.82)					
Farm size	0.008*	0.009**	0.127	0.0003	-0.063	-0.012**	-0.003
	(2.26)	(3.15)	(1.59)	(0.14)	(-0.46)	(-4.02)	(-1.4)
ext	-0.006	0.04	0.127	0.14*	-0.084	-0.207	0.118**
	(-0.16)	(1.49)	(1.59)	(2.34)	(-1.36)	-0.52	(1.83)
R^2	0.154	0.328	0.198	0.363	0.219	0.329	0.228
F(k, n-1)[1]	13.07	31.4	11.62	1.98[NS]	11.7	5.34	11.23

[1] F-test for strength of instruments excluded from the second stage

[NS] Not significant (equation estimated using OLS)

In the southwest, labour elasticities for bananas are quite high compared to other regions (Table 4.6). Manure and crop residues have a positive and significant effect (5% and 1% respectively) on banana output. The effect of farm size on productivity of bananas, millet and sweet potatoes is positive and significant (5% for bananas and 1% for millet and sweet potatoes. Extension has a positive and significant effect (1%) on banana and sweet potato productivity. Bananas are the major food and cash crop in the region, while millet and sweet potatoes are important in the slack period.

Table 4.6 Production function estimates for different crops for southwest Uganda, 2SLS

Variables	all crops	bananas	millet	sweet potato	beans
n	138	138	49	36	99
Constant	10.4**	4.404*	4.094	5.432**	3.719*
	(5.54)	(2.51)	(1.45)	(9.37)	(2.43)
Ln(a)	0.202^	0.206*	0.278	0.305	0.577**
	(1.85)	(2.05)	(1.04)	(1.46)	(6.5)
Ln(L)	0.399	0.579*	0.177	0.075	0.434
	(1.5)	(2.21)	(0.4)	(0.55)	(1.53)
M		0.00001*			
		(2.14)			
G		8.2e-07			
		(0.04)			
C		0.00002**			
		(2.68)			
Farm size	0.017	0.017*	0.195**	0.025**	-0.008
	(1.37)	(2.55)	(2.85)	(3.1)	(-0.6)
Ext	0.135*	0.123**	-0.05	0.211**	0.037
	(2.14)	(4.51)	(-0.86)	(6.27)	(0.97)
plotage		0.004			
		(0.62)			
plotage^2		0.00003			
		(0.6)			
sigatoka		-0.479			
		(-1.01)			
weevil		-0.097			
		(-0.7)			
R^2	0.457	0.684	0.528	0.409	0.584
F(k, n-1)[1]	34.3	23.3	2.04	1.82[NS]	58.4

[1] F-test for strength of instruments excluded from the second stage
[NS] Not significant (equation estimated using OLS)

4.4.2 Allocative efficiency

The results on marginal value products of labour (MVP) are summarized in Table 4.7. The marginal value products of labor for all the crops are below the average value products (AVP), implying that farmers operate in the second stage of the production function where returns to labour are decreasing. In the Central region, MVPs are high for bananas and sweet potatoes and low for coffee, maize, beans and cassava. In Masaka, the marginal value product of labour is highest for coffee and lowest for maize. The means of MVP for coffee are higher than the mean village wage rate implying that labour used is less than optimal in coffee production. This can be attributed two main reasons: (1) farmers abandoned coffee production in the late 1970s due to low farm gate prices and reestablished the coffee fields the mid 1990s during the coffee boom, and (2) re-adoption of coffee has been slow because of the perennial nature of the crop. Most farmers had replaced coffee with bananas and are reluctant to reallocate from bananas to coffee because bananas is the main staple crop in area, grown both for food and cash income (Bagamba et al., 1999; Ssennyonga et al., 1999). The MVPs for the other crop are within close range except that of maize, which is close to zero. The area experiences prolonged dry periods, which affect productivity of annual crops that have a longer growth cycle and stay longer time in the field (e.g. maize). In the southwest, the highest VMP is obtained for bananas and the lowest is obtained for sweet potato. However, the AVP for sweet potato is highest, close to twice that obtained from bananas.

Table 4.7 Average and value marginal products of labour, selected crops

Crop	central			Masaka			southwest		
	n	AVP	MVP	N	AVP	MVP	n	AVP	MVP
All crops	293	255 (166.6)	112 (73.3)	129	336 (135)	144 (58.0)	138	522 (190)	208 (76)
Bananas	248	395.1 (231.3)	255.8 (149.8)	126	636 (466)	118 (86.7)	138	593 (2.83)	343.4 (164)
Coffee	105	178.4 (264.6)	53.7 (79.6)	69	542.8 (427)	348.7 (274.3)	-	-	-
Beans	183	243.3 (213.6)	137.6 (120.8)	65	363.6 (355.6)	169 (170)	99	397 (383)	189.8 (183)
Maize	177	181 (149)	101.9 (84.2)	60	649.1 (1178)	20.1 (36.5)	-	-	-
Sweet potato	141	704.5 (656.6)	260.3 (242.6)	30	373.9 (386.4)	130.2 (134.6)	36	1034 (2150)	77.5 (161)
Cassava	170	398 (739)	72.4 (134.4)	35	691 (1170)	126.4 (213.8)	-	-	-
Millet	-	-	-	-	-	-	49	294 (222)	52.1 (39.3)

Values in parentheses are standard deviation
AVP = average value product of labour, MVP = marginal value product of labour.

Apart from coffee, in Masaka, and bananas in the southwest, the rest of the crops have their value marginal products well below the going market wage rates implying that more labour than optimal is used in their production. However, average value products for most crops are close to or even higher than the market wage rates implying that farmers try to equate wage rates to their average value products in their labour allocation decisions.

The joint null hypothesis, a = 0, b=1, is rejected in all cases, implying that farmers in all the three regions exhibit allocative inefficiency in terms of farm labour employment (Table 4.8). Same results have been obtained in literature for developing countries (Abdulai and Regmi, 2000; Jacoby, 1993). The deviation from the textbook condition: vmpl = w is a sign of imperfections in the labour market. The high values of F-statistic for the central region confirm the existence of binding labour constraints in the region. This is in complete disregard of the fact that the region is in close proximity to major urban centers where the nonfarm sector is more developed. However, it is possible that the labour market is segmented and some household members are segregated in the labour market. Udry et al. (1995) indicates that many categories of household labour are "held captive" within the household for reasons of age and gender, as customs prohibit them from working outside their home.

Table 4.8 Wald test for allocative inefficiency (F-values)

Crop	central	Masaka	southwest
All crops	1512	480	25.2
Bananas	323	174.6	51.4
Coffee	474.6	89.4	ND
Beans	661	285	24.5
Maize	439	243.9	ND
Sweet potato	116.3	65.7	54.7
Cassava	623	64.7	ND
Millet	ND	ND	227

ND = no data

To investigate the labour allocation decisions in the three regions further, we compare returns to land and labour on an acre basis for all the crops considered for analysis. The results are presented in Table 4.9. In the central region, farmers obtain highest returns to labour from bananas and lowest returns from coffee. There are differences in returns to land for the different crops, which either imply imperfections in the land market or differences in land quality or rent for different crops. Prime land is allocated to sweet potatoes, bananas and cassava. The least productive land is allocated to coffee and maize. However, the low returns in coffee could be due to the effect of coffee wilt disease, and farmers are just reluctant to replace old tree with another crop because of the high labour requirements to uproot the trees. As already observed, coffee is grown by farmers who are located far away from the market access, and where land rent is relatively low.

Returns to labour in Masaka differ for different crops (crops that are highly commercialized e.g. coffee and bananas have high returns while the returns for subsistence crops e.g. beans, maize, cassava and sweet potato are very low). Returns to land from the subsistence crops and coffee are low and within close range (with the exception of maize), implying that land quality and price for land allocated to coffee and the subsistence crops are almost the same. Labour allocation decisions are guided by subsistence needs, where more labour than optimal is allocated to maize, sweet potatoes and cassava because of the need to satisfy subsistence requirements. This observation is explained by returns obtained for coffee and maize. Whereas labour returns are higher in coffee relative to returns from maize, the reverse is true for returns to land, implying that labour intensification is higher in maize production, which leads to higher returns to land and lower returns to labour. Returns to land in bananas are high, implying that prime land is allocated to bananas, while returns are lowest in cassava and beans implying that marginal land is allocated to cassava in the region.

In the southwest, highest returns to land and labour are obtained from bananas, implying that the best land is allocated to banana production. However, imperfections in the commodity market and/or labour market force farmers to allocate labour to beans and millet, when they could still earn more from banana production. Returns to land are lowest for beans and millet. Returns to labour are lowest for sweet potato and millet.

Table 4.9 Returns to land and labour per acre, selected crops

Crop	Returns to land per acre (1000 U.Sh)			Returns to labour per hour (U.Sh)		
	central	Masaka	southwest	central	Masaka	southwest
All crops	323.9	260.0	458.5	112.1	144.3	208.3
	(516.3)	(252.3)	(302.0)	(73.3)	(58.0)	(76.0)
Bananas	187.1	498.0	457.7	255.8	118.3	343.4
	(217.5)	(357.0)	(326.7)	(149.8)	(86.7)	(164.0)
Coffee	79.8	132.1	ND	53.7	348.7	ND
	(116.2)	(135.3)		(79.6)	(274.3)	
Beans	125.9	34.4	138.3	137.6	169	189.8
	(105.5)	(28.0)	(76.7)	(120.8)	(170)	(183.2)
Maize	89.5	219.8	ND	101.9	20.1	ND
	(63.7)	(117.0)		(84.2)	(36.5)	
Sweet potato	239.7	92.9	246.9	260.3	130.2	77.5
	(199.2)	(49.8)	(180.6)	(242.6)	(134.6)	(161.1)
Cassava	181.7	152.0	ND	72.4	126.4	ND
	(162.6)	(42.9)		(134.4)	(213.8)	
Millet	ND	ND	162.1	ND	ND	52.1
			(88.9)			39.3

Values in parenthesis are standard deviations
ND = not determined

The amount of labour allocated to crops is positively correlated to the returns per acre in the central region while the correlation between the two variables in Masaka and the southwest is negative but not significant (Table 4.10). In the central region, farm production competes with the nonfarm sector (specifically the self employment sector) for unskilled labour and hence farmers allocate less labour to farm production if the per acre returns are low. In Masaka and the southwest, most of the unskilled labour is allocated to farming and the amount allocated is not determined by the per acre returns, but probably by the household food requirements. The return to land per acre is negatively correlated to the area allocated to crops in all cases. This is consistent with results obtained from the production function analysis, which depict decreasing returns to scale. The proportion of area allocated to bananas out of total crop area is positively correlated with the returns to land per acre in all the cases. This result implies that farmers allocate the most productive land to bananas.

The correlation coefficient is greater in the central region, which implies that banana production in the region is limited by land productivity. The other implication is that bananas are more integrated in the market economy and their production is mainly influenced by farm profit rather direct household consumption needs.

Table 4.10 Pair wise correlations between per acre returns and labour input, crop area and banana production by region

variable	central region	Masaka	southwest
		per acre returns	
Total crop labour input (hours/year)	0.14*	-0.003	-0.142
total crop area (acres)	-0.379**	-0.372**	-0.605**
banana area/crop area	0.514**	0.268**	0.333**

4.5 Conclusions

The analysis in this chapter answers the question of whether smallholder banana farmers in Uganda allocate their labour efficiently in crop production. The null hypothesis for equating value of marginal products to wage rate is rejected, which confirms imperfections in the labour and food markets and inefficient allocation of labour in the different crop enterprises.

Results from the production function estimation show that land and labour inputs have the expected positive impact on output. The marginal value products for crop production in the Central region are quite low compared to the casual wage rate implying that production decisions are guided by subsistence needs. Thus, more labour and land is allocated to crops that satisfy the subsistence needs of the farmers. Basing on the average value products, it is rational to allocate more labour to sweet potato and cassava than is allocated to bananas. The distance to the market also plays some role in the allocation decisions. Remote households allocate more labour and land to production of coffee and maize, despite the low marginal value products. In Masaka, the marginal value products for bananas are quite lower than those of annual crops (beans, sweet potato and cassava). Farmers are likely to benefit more by increasing labour use intensity in coffee production. The marginal value products from the important food crops (bananas, beans, sweet potato and cassava) are within close range which shows some element of optimization behavior for crops produced with the same motive. In the southwest, high marginal value products favour banana production.

Returns to land also gives the same picture of production decisions made between the different crops. In the central region, returns to land are highest for sweet potato production. However, returns to labour are highest for bananas. In Masaka, farmers benefit more from bananas in terms of returns to land. In the southwest, farmers benefit most from bananas, both in terms of returns to land and returns to labour.

The results from this study are consistent with the theory relating farm production decisions and imperfections in the labour and food markets. Take for example bananas, which has one of the best functioning market among the commodity markets in Uganda (Mugisha and Ngambeki, 1994). Lowest marginal value product of labour is obtained for Masaka, where access to off- work is more limited. This is consistent with the theoretical result that access to off-farm opportunities influences farm production and consumption decisions. In the central region, the marginal value products of maize, sweet potato and cassava are quite low despite the fact that the off-farm labour market is more developed. However, these results are consistent with the theory, presented in section 4.2.3, which shows that households facing imperfections in the food market employ more labour than is optimal at perfect markets; hence the low marginal value products for maize, sweet potato and cassava.

Results also show that larger farm size is associated with higher productivity for the major crops, which is inconsistent with much of the literature on farm size and productivity effects. Diversification into off-farm activities by smallholder farmers is one reason for being less committed to farm production; hence the low productivities obtained on small farms. On the other hand, farmers with large farm sizes are more likely to maintain higher soil fertility through crop rotation and fallow, and keep pest pressure low through crop rotation, both of which help to maintain higher crop productivities.

The results in this chapter confirm the conclusions made from the descriptive analysis in Chapter 2 that the need to meet subsistence needs for households in the Central region is one of the main factors that contributed to decline in labour used in banana production, and thus contributing to the decline in production. The results also show that farmers in the southwest benefit more from banana production and it is rational for them to have increased resources in that direction. However, farmers would benefit from reallocating some of the labour to coffee production. The amount of labour allocated to crops is positively correlated to the returns per acre in the central region but the correlation is negative although not significant for Masaka and the southwest. The positive correlation between labour and per acre returns in the central region is indicative of a more competitive labour market relative to that in Masaka and the southwest. Banana production is positively correlated with the returns to land per acre, the correlation being stronger in the central region. This result implies that farmers allocate the most productive land to bananas. The strong positive correlation between banana production and per acre returns is indicative of the integration of bananas in the market economy and hence their production is more influenced by farm profits rather than direct household consumption needs.

CHAPTER 5 Household labour supply and demand decisions

5.1 Introduction

A typical agricultural household in developing countries is hypothesized to make decisions between farm and nonfarm employment, and engage in a number of production activities, which include production of own subsistence and for the market. Household supply to farm and nonfarm sectors is depicted as a function of returns to and risks of farm and nonfarm activities, preferences and the household's capacity to undertake the activities, determined by access to public assets such as roads and social assets (e.g. education). Rural household members are motivated to enter the nonfarm labour market to earn high incomes from the nonfarm sector (pull factors) and push factors (e.g. risk in farming, and missing insurance, consumption and input credit markets) (Reardon et al., 2001). However households may fail to join the nonfarm sector due to high entry costs of migration, low education levels and limited access to information. Where markets do not operate in a competitive way, personal and institutional constraints play an important role in determining participation in off-farm activities (Reardon et al., 1998). Household wealth, private and public asset endowments and regional characteristics (e.g. agro climate) can play a critical role as they may enhance or hamper the profitability of the household endowment base (Escobal, 2001).

Development policies for the rural sector have always targeted at improving farm productivity in the effort to combat rural poverty. Despite this bias, there is growing evidence in developing countries that the rural sector is more than farming (Reardon et al., 1998). There has been considerable diversification of income, between farm and nonfarm activities, which is closely linked to the assets or endowments of rural households and access to public goods and services (Elbers and Lanjouw, 2001; Janvry and Sadoulet, 1996; Reardon et al., 1998). The diversification can also be seen as a response to poorly functioning financial markets and missing insurance markets. Access to private assets (education and credit) can improve participation in nonfarm self-employment as well as wage employment (Escobal, 2001). Most nonfarm activities are indirectly linked to the farm sector. Hence participation in the nonfarm sector is expected to be higher in the more dynamic agricultural areas (Escobal, 2001).

Segmentation in the labour market prohibits some family members from being hired in the nonfarm labour market possibly due to lack of required education level, skills and capacity. Moreover, transaction costs in the form of search and relocation costs and work preferences prohibit farmers from supplying labour to the nonfarm labour market. Households with poor endowments are less able to respond to attractive off-farm employment opportunities. Some household members are not able to work outside the household for reasons of age, gender and customs (Udry et al., 1995).

Farmers with more access to liquid assets are able to finance land improvements, hire labour and smooth household consumption throughout the agricultural production cycle. In the absence of insurance markets, reliable access to credit allows farmers to invest in more risky but higher yielding crop management practices (Heltberg, 1998). However, due to the risks and asymmetrical information inherent in agriculture, formal financial institutions ration the amount of credit supplied to the farm sector, leading to a cash constraint, in particular among the smallholder farmers (Carter, 1988). The response from farmers is to allocate their family labour to either farm and nonfarm enterprises whose production characteristics enable the farmers relax the liquidity constraint or those enterprises that depend less on purchased inputs.

A recent study shows that non-farm activity has grown in Uganda although agriculture remains the main occupation, where about 80% of the rural population is engaged in agriculture as the primary activity (Canagarajah et al., 2001). High population pressure and limited labour market opportunities in the nonfarm sector favour investment in the farm sector. Existence of a nearby town can offer direct employment in the manufacturing and service sector within the city or induce the development of the nonfarm sector by offering market for processed agricultural products. Thus households in the vicinity of the cities or towns are more likely to engage in nonfarm self employment (e.g. trade in agricultural products) thereby withdrawing some family labour from farm production.

Households considered to be well off in Uganda are those that engage in diverse nonfarm activities (trading, milling, shop keeping, brick making, lodgings and bars) (Ellis and Freeman, 2004; Newman and Canagarajah, 2000). Relative remoteness from markets and services tends to be associated with high reliance on self-provisioning, even among wealthy households. In particular, proximity to an urban area both lowers the subsistence share in general and increases participation in off-farm work. Nonfarm income enables the household to hire labour to undertake timely cultivation practices and helps to fund the purchase of farm cash inputs. Conversely hiring out labour by poor households causes their own farm productivity to stagnate or fall. Similar results obtained in Ethiopia show that farmers undertake nonfarm self-employment in order to reap an attractive return while others undertake wage employment due to push factors (Woldehanna and Oskam, 2001).

The main objective of this chapter is to analyse the factors influencing labour supply and demand among resource poor farmers in Uganda. A multinomial logit (mlogit) model is used to estimate the probabilities of individual household members' choices between farm and off-farm work labour supply. The analysis helps in the identification of factors that determine labour allocation decisions of farm households. Since labour is one of the major inputs in farm production by resource poor farmers, analysing the factors that influence its use can lead to an understanding of the farm household production decisions in general. Specifically, the link between exogenous and endogenous factors is exploited to determine the impact of market wages and road access on labour supply decisions of smallholder farmers.

Also explored is the effect of market incentives on household labour demand decisions. Findings have implications for policies to support agricultural production and employment, and contributing to on-going debate about the response of poor households to market incentives in developing economies.

The chapter is organised as follows. The theory on household labour supply and demand behaviour is reviewed in section 2. Section 3 provides a brief description of the model specification and estimation procedure, and a description of the data used in the analysis. Estimation results are presented and discussed in section 4. Finally, some concluding remarks are given in section 5.

5.2 Theoretical background

5.2.1 Household labour supply and demand

The theory of labour supply and demand was developed in chapter 4. In that chapter, we tested for separability between production and consumption decisions in the sense that they are recursively determined: production decisions are undertaken first (specifically the demand for labour), and the consumption decisions follow (specifically demand for leisure and hence the supply of labour). The expected marginal product is not equated to the wage rate in determining the demand for labour (family + hired) under the assumption of nonseparability (Jacoby, 1993). Furthermore, since the expected utility is a function of consumption characteristics, the demand for labour is a function of the consumption side variables as well. In turn, the consumption side variables are contingent on the measures of household composition such as family size and the age and sex composition of the family. Thus nonseparability implies that the demand for labour by the household is also affected by the demographic variables (Benjamin, 1992; Pollak and Wales, 1981). The test whether the demographic characteristics are significant determinants of the household demand for labour (holding constant the wage rate and other exogenous variables) is often used to test the nonseparability hypothesis (Benjamin, 1992; Kanwar, 1998). The results obtained in chapter 4 support the nonseparability hypothesis. First, the expected marginal values are well below the average village wage rates. Second, the demographic characteristics significantly influence labour used in farm production. Under these circumstances, the labour supply choices for farm households cannot be treated independently from their labour needs on the family farm. It follows that the shadow wage (expected marginal value product), rather than the market wage, determines the labour supply and demand choices of the household (Benjamin, 1992; Jacoby, 1993; Strauss, 1986). The shadow wage is determined within the household and is a function of household preferences, technology and fixed inputs and market prices affecting household choices (Strauss, 1986).

The empirical framework adopted enables one to distinguish between the determinants of labour supply and demand in a nonseparable model of the farm household. The endogenous shadow wages and income are sufficient to bring to light the interdependence between production and consumption decisions of the household (Skoufias, 1994). This allows one to obtain direct estimates of wage and income elasticities that are useful for welfare analysis as the nonseparable models estimated in a reduced form cannot provide direct elasticity estimates, since household profits are replaced by the presumably exogenous variables that determine them (Huffman, 1988).

Two sets of factors are hypothesized to affect labour demand: (1) technological factors and (2) non-technological factors (Kanwar, 1998). According to Kanwar (1998), the demand for labour is more of technical relationship, which follows from the fact that it is a 'derived demand', arising from the demand for the products that it enables to be produced.

Technological factors include (1) labour using, (2) labour saving and (3) physical and institutional factors. Labour using technologies are those that require use of more labour than traditional or conventional farming methods. They include irrigation, fertilisation, and use of modern high yielding crop varieties. Irrigation extends the area of land that can be cultivated, enables multiple cropping, extends the effective cropping period and facilitates changes in the production mix towards crops that are relatively labour-intensive. Fertilization and high yielding crop varieties lead an increase labour productivity, which induces a demand for more labour (Lipton and Longhurst, 1989). Moreover, use of fertilizers generally leads to growth of weeds and hence increases labour demand.

The second group of factors are those that save labour, and include farm implements and machines, although these are seen to be more or less complementary to labour input, reducing the drudge factor but not really substituting labour use.

The third group of factors are of physical and institutional nature and include such factors as climatic and soil characteristics, tenancy and tied labour. Climatic and soil factors can be taken as given for a given sample. Thus their effect may be picked up via the intercept term. One of the institutional factors reported in literature is share tenancy, which is considered to lead to sub optimal productivity and therefore a sub optimal labour input because the tenant receives only a part of his marginal product of labour. Also considered among the institutional factors is tied labour, which is mainly permanent labour as it is bound to the employers by relatively long term contracts. Tied labour is a way of supervising casual labour, with the landlords offering permanent contracts in the lean season in order to avoid recruitment costs and ensure availability of labour in the peak season (Bardhan, 1979). Farmers are reported to offer permanent contracts to casual labourers in the attempt to convert hired labour into family labour in order to reduce supervision costs (Eswaran and Kotwal, 1985).

Non-technological factors include household demographic variables and characteristics of the individual workers (e.g. gender, education level and age). Larger households require less hired labour while the larger the number of prime age members, the larger would be the capacity, although the less the need to seek outside help. The household will hire outside help as the number of dependents increase. Education increases the chances of working off-farm since educated individuals are likely to earn higher returns by working off-farm. This implies that higher schooling in the family would lead to a higher demand for outside labour to deploy on the farm. This effect tends to get reinforced if the educated tend to be averse to manual labour (Bardhan, 1984). If however, job opportunities are limited in the off-farm market, higher education may not translate into higher demand for outside labour.

5.2.2 Simulations of labour supply

The primary motivation of agricultural household models is to analyse impacts of policies and other exogenous shocks on household farm behaviour (Taylor and Adelman, 2003). Comparative statics analysis is used to determine the sign of and, in empirical models, also the magnitude of impacts of exogenous factors on production, consumption and household resource use. For households that face missing markets, the decision of whether or not to participate in a market is endogenous and is shaped by the household's reservation or shadow price and by the price band, including transaction costs (Taylor and Adelman, 2003). Policy makers can only influence exogenous prices and other factors to bring about desired change in the target variable (e.g. production and resource employment). Comparative static results are often explored to analyse the impact of exogenous prices and other factors when dealing with a situation where households face missing markets.

The general form of the comparative static model is:

$$\frac{dZ}{dX} = \frac{\partial Z}{\partial X}_{\overline{P}} + \frac{\partial Z}{\partial P}\frac{dP}{dX} \qquad (5.1)$$

where Z is the target variable (e.g. labour supply), X is an exogenous variable (e.g. market wage rate), and P is a vector of endogenous variables (e.g. shadow wage and shadow income). The first-right hand term in equation (5.1) represents the direct effects of the change in the exogenous variable on Z. The second right-hand term represents the indirect effects of the change in X through its influence on the endogenous variables. In the perfect markets case, all prices are given to the household exogenously by the markets and the second right-hand term vanishes.

5.2.3 Time allocation between farm and off-farm activities

There are two basic approaches in the analysis of time allocation in literature: (1) perfect labour markets thus the assumption that household production and consumption decisions are separable (Ahn et al., 1981; Barnum and Squire, 1979b; Rosenzweig, 1980), (2) missing labour markets or constraints in the labour market, which gives rise to the assumption of nonseparability between production and consumption decisions (Abdulai and Regmi, 2000; Benjamin, 1992; Jacoby, 1993; Lopez, 1984; Skoufias, 1994).

In general, the markets exist but selectively fail for particular households, while working for others. Wide price bands force peasant households to internalise the effects of external shocks that displace the shadow prices of food and labour (Janvry et al., 1991). Whenever the shadow price of labour is within the price band, the household does not participate in the labour market. It is advantageous for the household to be self sufficient in the factor in which the shadow price falls within the price band.

Under the assumption of perfect labour markets, individuals are willing to participate in off-farm work as long as their marginal value of farm labour (reservation wage) is less than the off-farm wage rate (Becker, 1965; Gronau, 1973). Thus poor households have a stronger incentive to diversify into off-farm activities because they earn a lower marginal value of farm labour. However, with rationing in the labour market, farmers may not be observed to participate in the off-farm labour even if the reservation wage rate is less than the marginal value of labour (Blundell and Meghir, 1987). Moreover, substantial entry or mobility barriers within the rural nonfarm sector limit the poorly endowed households from accessing high return niches (Barrett et al., 2001). Thus the actual participation of farmers in off-farm activities depends on the incentive and the capacity to participate (Reardon, 1997). Variables that raise the reservation wage reduce the probability and level of participation in off-farm work while the variables that raise the value of marginal product of labour in off-farm employment increase the probability and level of participation in off-farm work. Hence the direction of the influence of individual characteristics (age, gender and education), location and household assets (farm and nonfarm equipment) on off-farm employment is indeterminate since they may affect both the reservation and the off-farm wage. In presence of credit and insurance constraints, farm income, assets and other income may improve the households' access to off-farm work.

Conversely, the opportunity to earn non-farm income can lead to higher average agricultural incomes. Crop output is reported to be significantly related to non-crop income and liquid assets after controlling for production inputs (Collier and Lal, 1986). When there are several production activities, with higher productivity being associated with greater variability in output, having an alternative source of income that does not fall with a bad agricultural outcome makes farmers more willing to choose the high risk/high return options.

Furthermore, in absence of low cost credit, additional income from outside farming facilitates the purchase of costly inputs, which are required to take advantage of high return options (Lanjouw and Lanjouw, 2001). This implies that the wealthier and more diversified farmers make higher productivity cropping choices.

Studies cited show that the relationship between the share of nonfarm income and total income or assets is U-shaped (Lanjouw and Lanjouw, 2001). At low incomes, there is high participation in nonfarm work due to push factors and at higher incomes participation is high due to access to asset endowments and a high return in nonfarm work. This view is supported by the Indian data, which shows that the wealthiest and poorest households (per capita) have the highest shares of income from nonfarm sources (Hazell and Haggblade, 1990). However, other studies show that the share of nonfarm income rises monotonically with overall income levels. The land rich households receive the largest returns from nonfarm enterprises in Java (White, 1991). In central province of Kenya, the wealthier benefit most from nonfarm opportunities with the richest quartile receiving 52% of income from nonfarm sources compared to 13% received by the lowest quartile (Evans and Ngau, 1991). Similar results were obtained for Burkina Faso where the total household income was strongly related with the share of income derived from nonfarm sources (Reardon et al., 1992).

In the next section, we specify the models, outline the data collection methods and define and describe the variables used in the empirical analysis.

5.3 Empirical estimation

5.3.1 Labour supply

Hours worked (farm + off-farm) by the individual household member are regressed on the shadow wage rates and shadow income, individual characteristics (gender, age and education level), demographic characteristics (household size, dependency ration and babies in household) and characteristics of the household head (gender, age and education level). Instrumental variable methods are used to account for the potential endogeneity of the estimated shadow wages and shadow income (Skoufias, 1994). Labour supply estimates are obtained for household head and separate estimates for the spouse or any other household member in case of absence of spouse in the household.

The two stage least squares technique (2SLS) is used to estimate labour supply since some of the variables on the right-hand side are endogenously determined (i.e. shadow wage and shadow income). Abdulai and Regmi (2000) apply the Instrumental variable (IV) procedure to obtain consistent estimates of the labour supply functions. IV procedure is appropriate if the ordinary least Squares (OLS) procedure is used to estimate the labour supply. In our case, we first estimate the shadow wage and shadow income functions and obtain predicted values of shadow wage and shadow income (Appendices 1 to 4). We exclude some of the variables used in the first stage to identify the model in the second stage. Household size, dependency ratio and in some of the cases village wage rates and distance to tarmac road are used as identifying instruments. Shadow wage rates were determined from marginal value products of household crop production while shadow incomes were obtained from the following equation (see also chapter 4):

$$M = f(l_F; x) - w_h l_h - w_f l_f + w_f E + y \tag{5.2}$$

Where M = household full income, $f(l_F; x)$ = value of crop production, w_h = village wage rate for casual labour, w_f = opportunity cost of family labour (marginal value product), l_h = amount of labour hired from outside, l_f = family labour hours in crop production, E = total household time endowment and y = exogenous household income (remittances + rent + interest). The household shadow income was divided by the number of individual household members who work to obtain the shadow income per individual household member.

5.3.2 Hired labour demand

For hired labour demand, data was not observed for some of the cases in the sample as the optimal choice for such cases would be a corner solution, y = 0. The interest, in corner solution applications, is not in data observability but in the features of the distribution of y given **x** (where **x** refers to a vector of the explanatory variables), such as E(y|**x**) and P(y = 0|**x**) (Wooldridge, 2002). E refers to the usual mathematical expectation and P the probability function. If the interest is only on the effect of **x** on the mean response, E(y|**x**), we would just assume E(y|**x**) = $\mathbf{x}\beta$ and apply OLS on the random sample. Two problems arise if we apply OLS on the model. First, when $y \geq 0$, E(y|**x**) cannot be linear in **x** unless the range of **x** is fairly limited (Wooldridge, 2002). Second, the predicted values of y can take on negative values for some combinations of x and β.

For randomly drawn observations *i* from the population, the problem can be transformed into the statistical model:

$$y_i^* = x_i\beta + u_i \qquad u_i \mid x_i \sim N(0, \sigma^2) \tag{5.3}$$

$$y_i = \max(0, y_i^*) \tag{5.4}$$

Equations (5.3) and (5.4) constitute what is known as the standard censored Tobit model (Tobin, 1956).

For corner solution outcomes, the interest centres on probabilities or expected values $E(y|\mathbf{x}, y>0)$ and $E(y|\mathbf{x})$, which depend on β, but in a non-linear fashion. We derive the inequality that bounds $E(y|\mathbf{x})$ from below: $E(y|\mathbf{x}) \geq max\ [0, E(y^*|\mathbf{x}]$.

But $E(y^* \mid x) = x\beta$. It follows that

$$E(y \mid x) \geq \max(0, x\beta) \qquad (5.5)$$

Equation 5.5 shows that E(y|**x**) is bounded from below by the larger of zero and $\mathbf{x}\beta$.

$$E(y|x) = P(y=0|x).0 + P(y|x, y>0).E(y|x, y>0)$$

$$= P(y|x, y>0).E(y|x, y>0) \qquad (5.6)$$

Define a binary variable d=1 if y>0 and d=0 if y=0. Then d follows a Probit model:

$$P(d=1|x) = P(y^*>0|x)$$

$$= P(u > -x\beta \mid x)$$

$$= P(u/\sigma > -x\beta/\sigma) = \Phi(x\beta/\sigma) \qquad (5.7)$$

$\gamma \equiv \beta/\sigma$ can consistently be estimated from a Probit of d on x but not β and σ separately.

$$E(y \mid x, y > 0) = x\beta + E(u \mid u > -x\beta)$$

$$= x\beta + \rho\sigma\left[\frac{\phi(x\beta/\sigma)}{\Phi(x\beta/\sigma)}\right] \qquad (5.8)$$

where $\phi(.)$ is the standard normal density function. The quantity $\frac{\phi(.)}{\Phi(.)} = \lambda$ is called the inverse mills ratio. The second term on the right-hand side in equation (5.8) causes sample selection bias if ρ is non-zero. Positive values of λ imply that there are unobserved variables that both increase the probability of selection and a higher than average score on the dependent variable. Negative values of λ imply that there are unobservable variables, which increase the probability of a lower than average score on the dependent variable. OLS estimation of y on x, using the sample for which y>0, results in inconsistent estimates of β due to the correlation between λ and x in the selected subpopulation. The model parameters are estimated more efficiently by Heckman maximum likelihood procedure in order to avoid the sample selection problem.

5.3.3 Estimation of time allocation decisions

The multinomial logit (mlogit) is used to analyse the individual household member's (13 years and above) choice between farm work, home production and off-farm work. Let utility that an individual *i* gets from choosing alternative *j* be denoted by U_{ij} and

$$U_{ij} = u_{ij} + e_{ij} = X_{ij}\beta_j + e_{ij} \qquad (5.9)$$

where β_i varies and X_i remains constant across alternatives; X is a column vector of variables that affect the response probabilities, $P(y = j|X_i)$, j = 1, …J; and e_{ij} is a random disturbance reflecting intrinsically random choice behaviour, measurement or specification error and unobserved attributes of the alternatives. The error terms are also identically and independently distributed across the alternative activities. $P(y = j|X_i)$ denotes the probability associated with farm, off-farm and home production activities choices of an individual household member *i* with: j = 1 if the individual participates in farm production but not off-farm and home production; j = 2 if the choice is off-farm employment; j = 3 if the choice is home production; j = 4 if choice is leisure.

The mlogit model has response probabilities

$$P(y = j \mid X_i) = \frac{\exp(X_i\beta_j)}{\sum_{j=1}^{4}\exp(X_i\beta_j)} \qquad (5.10)$$

Setting $\beta_1 = 0$, the mlogit model can be rewritten as

$$P(y = j \mid X_i) = \frac{\exp(X_i\beta_j)}{1+\sum_{j=2}^{4}\exp(X_i\beta_j)} (j = 2,3,4) \qquad (5.11)$$

and $P(y = 1 \mid X_i) = \dfrac{1}{1+\sum_{j=2}^{4}\exp(X_i\beta_j)}$

When j = 2, β_2 is a K x 1 vector of unknown parameters, and we get the binary logit model. In our data set, each individual participated in either one, two or in all the three work choices: farm, off-farm and home production. To capture the level of involvement in the alternative activities, we included the importance weight (*iweight*) in the mlogit model that captures the hours worked by the individual per day in each of the three work choices. Equation (5.11), on inclusion of weights, becomes

$$p(y = j \mid X_i) = w_j \frac{\exp(X_i\beta_j)}{1+\sum_{j=2}^{4}\exp(X_i\beta_j)} \Bigg/ \sum_j w_j \qquad (5.12)$$

and $p(y = 1 \mid X_i) = w_j \dfrac{1}{1+\sum_{j=2}^{4}\exp(X_i\beta_j)} \Bigg/ \sum_j w_j$

where w_j = weights (hours per day in activity j).

Explanatory variables used include: predicted shadow wage, predicted shadow income, individual household member characteristics (gender, age, age squared and schooling years), credit access; and location characteristics (distance to tarmac road and regional dummies).

5.3.4 Data

Village, household and individual level data was collected from March 2003 to April 2004 from the stratified random sample depicted in Chapter 2. Village level data included elevation, distance to tarmac road, wage rates and prices. Household level data included demographic characteristics, production, income and access to credit. Plot level data included crop production characteristics, inputs and outputs. Individual household member characteristics included gender, age, education level and relation with other household members (e.g. if the individual is the household head, spouse, child or relative).

Data on individual and household characteristics (gender, age and education level for the household member, and gender, age and education level of household head) were collected at the beginning of the survey in March 2003. Data on time allocation, by the individual household member, between farm production, home production, off-farm work, schooling and leisure was obtained once every month for seven months (September 2003 – March 2004). Each individual was asked to narrate how s/he used her/his time the previous day prior to the interview and allocate the 12 hours (7.00 to 19.00 hours) between farm production, home production, off-farm work and leisure.

The variables are defined in Table 5.1. The descriptive statistics for variables used in econometric analysis are summarized in Tables 5.2 and 5.3. The individual household member was assumed to be the lowest decision making unit regarding labour supply decisions. In this study, individuals who are below 13 years of age are excluded from the sample. Finally, to avoid the statistical bias that arises from the interdependence between individuals belonging to the same household, only one individual per household was retained in the sample to analyse the determinants of individual participation in farm, off-farm and home production. In the first analysis, we used only the household heads and in the second analysis, we retained the second household member who in most cases is the spouse.

Table 5.1 Definition of variables

variable	Variable definition
workhrs[1]	Total hours worked (farm + off-farm) by individual (hours/day)
farmhrs	Hours in farm production (hours/day)
offfarm	Hours in off-farm activities (hours/day)
homehrs	Hours in home production activities (hours/day)
leisure	nonproductive time (hours/day)
a	area cultivated by household (acres)
w	village wage rate for casual labour (U.Shs/day)
w*	Shadow wage rate (marginal value product) for household
M*	Shadow income for individual household member
D	Distance to tarmac road (km)
hhsize	Family size (adult equivalent)
depratio	Dependency ratio (dependants/family size) = $\frac{<14 years + >64 years}{hhsize}$
babies	Number of babies in household
gender	gender individual household member (1 = male and 0 = female)
age	Age of individual household member (years)
age^2	age squared
educ	education level of individual household member (years)
postprim	number household members that attended post primary school
credit	amount credit (x 1000) received by household in six months prior to interview
y	non earned income by household (x 1000) (remittance + rent + interest)

[1] excludes home time

Table 5.2 Descriptive statistics (household head)

variable	central		Masaka		southwest		Overall sample	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
workhrs	6.74	2.66	6.582	2.12	6.882	2.15	6.741	2.42
farmhrs	3.877	2.28	5.116	1.81	4.113	2.35	4.215	2.25
offfarm	2.863	3.47	1.466	2.24	2.769	3.491	2.526	3.28
homehrs	1.484	1.69	1.877	1.74	1.484	1.57	1.572	1.66
leisure	3.78	2.13	3.541	1.82	3.633	1.82	3.687	1.98
w	435.5	150.6	270.9	109.7	227.1	27.3	345.0	153.9
w*	112.6	73.65	139.4	51.3	208.1	76.3	143.2	80.37
M*	489676	257962	608455	181738	920096	345787	627056	323176
a	1.904	1.898	1.749	1.854	1.684	1.383	1.813	1.769
D	12.47	9.22	19.71	31.31	10.854	13.47	13.68	17.87
hhland	4.507	5.64	4.626	15.31	3.011	5.79	4.149	8.81
hhsize	6.16	2.77	5.345	5.35	6.115	2.45	5.966	2.68
depratio	0.496	0.233	0.465	0.26	0.484	0.19	0.486	0.23
postprim	1.015	1.42	0.743	1.20	0.877	1.26	0.919	1.34
gender	0.802	0.4	0.752	0.43	0.846	0.36	0.802	0.399
age	45.87	16.72	43.03	14.76	42.5	13.79	44.37	15.63
age^2	2382	1684	2067	1351	1995	1295.4	2212.2	1528.3
educ	5.706	4.48	4.832	3.09	5.115	4.01	5.358	4.1
credit	22.08	124.95	3.92	23.96	4.192	18.27	13.412	91.54
N	262		113		130		505	

Table 5.3 Descriptive statistics (second household member)

variable	central		Masaka		southwest		Overall	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
workhrs	4.932	1.81	5.444	1.45	5.528	1.46	5.199	1.67
farmhrs	4.044	1.51	5.2	1.31	5.15	1.57	4.582	1.588
offfarm	0.889	2.05	0.24	0.67	0.378	1.08	0.617	1.64
homehrs	4.271	1.63	4.245	1.65	3.794	1.32	4.14	1.57
leisure	2.797	1.62	2.311	1.74	2.677	1.72	2.66	1.68
w	431.9	151.5	258.9	97.38	227	27.4	340.7	152.9
w*	109	72.8	146	62.3	202.2	75.5	141.8	81.5
M*	465611	244867	608391	208598	884030	324040	607981	315478
a	2.039	2.096	1.908	2.025	1.685	1.405	1.917	1.92
D	12.44	9.45	23.58	34.75	10.77	13.68	14.31	19.21
hhsize	6.576	2.6	6.239	2.34	6.378	2.35	6.452	2.48
depratio	0.509	0.21	0.503	0.21	0.488	0.179	0.502	0.205
postprim	1.082	1.47	0.946	1.32	0.916	1.279	1.01	1.39
babies	0.909	0.940	0.967	1.01	0.832	0.847	0.900	0.930
gender	0.069	0.254	0.065	0.25	0.042	0.201	0.061	0.24
age	32.745	12.06	35.66	12.98	33.84	11.77	33.65	12.21
age^2	1217.1	936.2	1439	1042	1283.6	898.9	1281	951.2
educ	4.74	3.96	4.76	3.13	4.202	3.54	4.6	3.69
credit	14.81	58.7	4.815	26.5	4.412	19.00	9.928	45.44
N	231		92		119		442	

5.4 Results and discussion

5.4.1 Individual household member labour supply

Estimates of labour supply of household head are presented in appendix 5.5 while the estimates for the second household member are presented in Appendix 5.6. Table 5.4 shows the elasticities of labour supply with respect to shadow wage and shadow income. The labour supply response to shadow wage rate and shadow income have the expected signs, positive for shadow wage rate and negative for shadow income. The positive wage effect on labour supply is supportive of the rational behaviour hypothesis for peasant households. The positive effect of shadow wage on labour supply is consistent with results obtained by Jacoby (1993) and Abdulai and Regime (2000), suggesting an upward sloping labour supply. However, this finding contrasts the backward sloping labour supply functions reported by Skoufias (1994) and Rosenzweig (1980) for Indian farmers. The shadow wage elasticities are higher for household heads (mostly men) than for household members that are not household heads (mainly women), with the exception of Masaka region. Results where own wage elasticities are higher for men than for women are also reported by Abdulai and Regmi (2000).

Elasticities of labour supply with respect to shadow wage rate are highest for Masaka region for both the household head and the second household member. This implies that farmers from Masaka would benefit most from productivity increase as this is translated to high increases in labour supply. Labour supply elasticities with respect to shadow wage are quite low for the second household member in the central region. Most likely changes in productivity in the Central region are insufficient to have any significant effect on labour supply decisions of other household members (other than the household head) who most of the time are employed on the farm.

The effect of shadow income on labour supply is negative but only significant for the overall sample and Masaka region. The negative effect of shadow income is indicative of leisure being a normal good and thus increases in income levels result to a decrease in work hours. However, the estimates for central and southwest regions are quite inelastic. Previous studies also report estimates of shadow income that are inelastic (Jacoby, 1993; Skoufias, 1994). With the exception of central region, the income elasticities for household heads are greater than those of other household members (who are mostly spouses).

Table 5.4 Elasticities of labour supply

Region	household head		second household member	
	Shadow wage	Shadow income	Shadow wage	Shadow income
central	1.382	-1.114	0.169	-0.661
Masaka	2.743	-1.355	13.781	-10.894
southwest	1.059	-0.279	0.439	-0.414
overall	1.384	-0.887	1.173	-0.89

5.4.2 Simulations of labour supply

Wage rate

Simulation results presented in Table 5.5 show that increase in village wage rate is associated with an increase in shadow wage and shadow income with the exception of the southwest where the wage rate is negatively related to shadow wage and shadow income. Differences in results obtained for the central and the southwest can be explained by the nature of labour markets prevailing in the two different regions. In the central region, labour is rarely hired in for farm production. On the contrary, the off-farm labour market is more vibrant due to the proximity of the region within easy reach of the key urban centres (Kampala, Entebbe and Jinja), which increase employment opportunities for the farmers in the region. The conditions of the labour market are such that farmers are net suppliers, rather than hirers, of labour. Thus, a wage increase results in an increase in work effort of household members reflected in higher values of marginal productivities. The effect of wage rate through the marginal productivity (price) effect is unambiguously positive while the income effect is negative. The Price effect dominates the income effect. However, the direct effect of wage rate is negative and, together with a negative income effect, results in a total effect on labour supply that is negative.

In Masaka, a wage increase has a positive effect on shadow price and show income but the elasticities are quite low compared to those obtained for central region. Unlike farmers in central region, farmers in Masaka have limited access to off-farm employment. The opportunities to hire labour are also limited. A wage increase is most likely associated with higher farm productivity, unlike in the central region where wages are associated with productivity in the off-farm sector. The price effect on labour supply is positive while the income effect is negative. The price effect dominates the income effect and the overall effect of wage rate is positive.

In the southwest, a wage increase has a negative effect on shadow wage and shadow income, implying that farm productivity reduces as wages increase. The negative effect of wage rate on farm productivity is not unexpected since the households are net hirers of labour for farm production. Higher wages are associated with a high cost of labour and low use of hired labour in farm production. In particular, use of intensive labour practices (e.g. construction of soil conservation structures and management of post-harvest residues) in crop production is compromised resulting in low farm labour productivity. The effect of wage rate through household farm productivity, on labour supply is unambiguously negative while the income effect is positive. Increase in wages reduces the income available to the individual household members. Leisure is normal good; hence individuals reduce its consumption in favour of work hours. However, the price effect dominates the income effect and, together with a negative direct effect of wage rate, results in a total effect on labour supply that is negative.

Table 5.5 Response to a 10% increase in wage rate (% increase) (household head)

Variable	central	Masaka	southwest	overall
shadow wage	5.11	1.26	-1.97	2.71
shadow income	2.93	0.31	-6.89	1.35
labour supply				
direct effect	-5.64	ND	-3.72	-1.62
price effect	7.06	3.46	-2.09	3.75
income effect	-3.26	-0.42	1.89	-1.2
total	-1.84	3.04	-3.91	0.93

ND = Not determined

Labour supply responses to wage rate by other household members are similar to those of household heads except in a few cases (Table 5.6). The elasticities of labour supply (total effect) are close to those obtained for the household heads by region.

Table 5.6 Response to a 10% increase in wage rate (% increase) (second household member)

Variable	central	Masaka	southwest	overall
shadow wage	4.23	-0.51	-4.15	1.8
shadow income	2.78	-0.72	-9.21	0.64
labour supply				
direct effect	ND	3.11	-5.95	ND
price effect	0.72	-7.02	-1.82	2.11
income effect	-1.84	7.84	3.81	-0.57
total	-1.12	3.93	-3.96	1.54

ND = Not determined

Road access

Access to tarmac roads is predicted to have a small impact on labour supply (Tables 5.7 and 5.8). Pender et al. (2004) also obtained statistically insignificant results of the impact of access to all-weather roads on crop production. In central region and Masaka, marginal productivities and shadow incomes are predicted to be higher for households located away from the tarmac road. The magnitude of the impact is higher for central region. The direct effect of distance to tarmac road is negative in all cases implying that remoteness reduces work hours for individual household members. The overall effect of distance to tarmac on labour supply is negative for central and positive for Masaka implying that household heads in remote areas supply less labour for central region and more labour for Masaka region.

For the southwest, the impact of road access on shadow wage is found to be positive implying that remote households have lower marginal productivities. The effect of distance to tarmac on labour supply, through both the price effect and income effect, is negative. The overall effect on labour supply is negative implying that remote households work less hours. This is attributed to differences in market participation rates for remote and accessible households. Increased road access seems to improve market conditions in favour of labour supply. Insufficient road infrastructure is associated with poor development of markets through high transaction costs (Janvry et al., 1995; Omamo, 1998a). In contrast, rural infrastructure is associated with reduction in transport and transaction costs and improving market integration. Under conditions where road access is poor, high transport and transaction costs may lead to autarky (Janvry et al., 1995; Obare et al., 2003; Omamo, 1998a; Omamo, 1998b).

The results show that development of rural road infrastructure is likely to benefit the southwest more than Masaka and the central region. This is not surprising since the southwest is quite isolated from the urban markets, most of which are located in the central region.

Table 5.7 Response to an additional 1 km to the distance from the tarmac road (% increase) (household head)

Variable	central	Masaka	southwest	overall
shadow wage	0.011	0.001	-0.007	0.001
shadow income	0.005	0.0003	0.012	-0.0001
labour supply				
direct effect	-0.025	-0.0004	-0.013	-0.004
price effect	0.015	0.0027	-0.007	0.0014
income effect	-0.006	-0.0004	-0.003	0.0001
total	-0.015	0.0019	-0.024	-0.0025

Table 5.8 Response to an additional 1 km to the distance from the tarmac road (% increase) (second household member)

Variable	central	Masaka	southwest	overall
shadow wage	0.008	0.0006	-0.007	0.0003
shadow income	0.004	-0.0003	-0.012	-0.001
labour supply				
direct effect	-0.003	-0.01	-0.012	ND
price effect	0.0014	0.0083	-0.003	0.0004
income effect	-0.0026	0.0033	0.005	0.0009
total	-0.0043	0.0015	-0.01	0.0012

ND = Not determined

5.4.3 Household hired labour demand

Estimates for hired labour demand are presented in Table 5.9. The Wald test of independent equations rejects the null hypothesis that $\rho=0$ for both the central region and Masaka but not the southwest. This implies that there would be selection bias if the two equations (work hours of hired labour and whether to hire labour or not) are estimated independently for central and Masaka. The inverse mills ratio (λ) has a negative sign, which implies that there are unobserved variables, which increase the probability of hiring labour but reduces the level of employment (work hours) of hired labour.

The effect of wage rate on labour demand is negative except for the Central region where the effect of wage rate is positive but not significant. However, wage rate increase in central Uganda significantly reduces the probability of using hired labour by farm households. This is consistent with the low use of hired labour by households in the central region, which is attributed to high cost of labour (wage rate). The positive relationship between wage rate and work hours of hired labour is only possible if two labour markets exist. The farmers hire out their own labour in response to higher wage rates but hire in labour for farm production at cheaper rates. In Masaka, the probability of using outside labour, by farm households, is positively associated with higher wages. This is possible if high wages are associated with high farm productivities; hence farmers with higher farm productivities use higher outside labour. It is only in the southwest where both use of hired labour and amount used are negatively related to wage rate. Increase in wage rate increases the cost of production and it is rational for farmers to use less outside labour.

The effect of farm size on amount of hired labour is positive but not significant for the central region, negative for Masaka, and positive and statistically significant for the southwest. The negative effect for Masaka signifies limitations in access to hired labour in the region. Thus farmers with large farm sizes opt for less labour intensive activities (e.g.

livestock grazing) and thus use less outside labour. In the southwest, however, outside labour is cheap and accessible; hence larger farm sizes are associated with higher use of outside labour.

Household size has no significant effect on amount of outside labour used by farmers in all the study regions, although it is associated with less number of farmers using outside labour (statistically significant at 10% level) in the central region. Economic rationing of hiring labour has more to do with market wage than family size and composition. The effect of education on amount of outside labour used is not significant. However, education has a positive effect on the number of households that use outside labour, the effect being statistically significant at 1% level for central region and 10% for Masaka.

An increase in distance away from the tarmac road significantly reduces the amount of outside labour used by farmers in the southwest but not in Masaka and central region. The effect on number of farmers that use outside labour is also negative, the effect being stronger and more significant for farmers in the southwest. Development of road infrastructure in the southwest seems to be one of the key factors that influence production decisions in the region since it is isolated from the major market centres that are located in the central region.

The impact of credit access on amount of labour hired is negative for both central and southwest but statistically significant (10%) only for the southwest. This is, most likely, because borrowers are less likely to afford paying for hired labour. High cost of credit limits its use in farm production and instead is used on consumption expenditure, which has a shorter repayment period and thus lower amount of interest charged. Moreover, farmers are reported to prefer investing credit money into off-farm activities (e.g. trading) than investing it in farm activities (Katwijukye and Doppler, 2004). Exogenous income has a positive effect on hired labour demand, but only statistically significant (1%) for the southwest, implying that unearned labour income influences labour allocation decisions in favour of hired labour demand. The income most likely relaxes farmers' liquidity constraints and thus increasing their ability to hire labour.

Table 5.9 Maximum likelihood estimates of household demand for hired labour (robust standard errors)

variable	central		Masaka		southwest		overall sample	
	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value
ln(work hours)								
Constant	2.507	0.92	11.879**	4.38	13.147*	2.28	6.746**	3.22
Ln(w)	0.247	0.66	-1.297**	-3.06	-1.856^	-1.73	-0.486^	-1.75
Ln(a)	-0.005	-0.04	0.216	1.21	0.07	0.47	0.162^	1.86
hhland	0.029	1.58	-0.006*	-2.24	0.032**	2.83	0.003	0.44
hhsize	0.025	0.46					0.039	1.16
gender	0.198	0.58	0.809*	2.37	0.54	1.6	0.404*	2.24
age	0.046	1.02	0.034	0.76	0.094	1.42	0.035	0.94
age^2	-0.0005	-1.10	-0.0003	-0.73	-0.001	-1.28	-0.0003	-0.87
educ	-0.002	-0.06	-0.025	-0.52			0.004	0.24
D	0.022	1.46			-0.106**	-3.44	-0.0001	-0.02
credit	-0.002	-0.83			-0.006^	-1.88	-0.001	-0.92
y	0.0004	0.77	0.005	1.04	0.0003**	4.12	0.0004**	3.69
southwest							0.255	0.75
Masaka							0.333^	1.67
X^2	12.06		21.23		100.22		78	
Probability	0.359		0.007		0.000		0.000	
n	291		129		136		556	
Uncensored	129		72		70		271	
selection								
Consatant	9.093**	4.31	-6.468	-2.36	11.14	1.31	3.889	1.48
Ln(w)	-1.474**	-5.19	1.265**	2.82	-1.622	-1.05	-0.615	-1.56
Ln(a)	0.227**	2.76	0.061	0.38	0.311^	1.77	0.109	0.95
hhland	0.04^	1.69	0.03	0.83			0.035*	2.19
hhsize	-0.06^	-1.77					-0.038	-1.48
gender	-0.432^	-1.81	-0.554^	1.77	-0.838*	-2.23	-0.368**	-2.76
age	-0.006	-0.19	-0.026	-0.73	-0.081	-1.54	-0.018	-0.71
age^2	0.0001	0.43	0.0004	1.09	0.001^	1.77	0.0002	0.98
educ	0.057**	2.81	0.078^	2.06	0.057	1.33	0.05**	2.71
D	-0.021^	-1.90			-0.063**	-4.11	-0.006	-0.95
credit	-0.003^	-1.92			0.008	1.25	-0.001^	-1.83
y	0.0002	0.62	-0.005	-1.17	0.007^	1.69	0.001^	1.82
southwest							-0.036	
Masaka							0.125	
ρ (SE)	-0.886	(0.064)	-0.941	(0.061)	-0.23	(0.3)	-0.701	(0.161)
σ (SE)	1.362	(0.146)	1.278	(0.156)	0.973	(0.091)	1.201	(0.156)
λ (SE)	-1.207	(0.207)	-1.203	(0.211)	-0.224	(0.302)	-0.841	(0.297)
X^2 (ρ=0)	22.39**		10.69**		0.55		7.51**	

5.4.4 Determinants of time allocation decisions

Central region

The estimated results of the determinants of time allocation by household heads to different activities (including home time and leisure) for the central region are presented in Table 5.10. The effect of shadow wage and shadow income on time allocation decisions is not significant. However, results show that individuals with high shadow wages tend to employ their labour in off-farm activities. This is consistent with Ellis's assertion (1993) that family members whose real opportunity cost of time (shadow wage) is lower than the marginal productivity of labour (MPL) on the farm engage in work on the farm (subsistence production) while family members whose real opportunity cost of time is higher than MPL on the farm engage in off-farm wage work in order to maximise household income. Time allocation is highly influenced by farm characteristics, individual household member characteristics and market access.

Household farm size has a negative effect on time allocated to off-farm activities implying that the larger the farm size the less likely is participation in off-farm activities. This is consistent with the assertion that farmers undertake off-farm activities because of constraints in getting access to land that is suitable for farming (Matshe and Young, 2004).

Gender has no significant effect on the amount of time allocated to farm production but time allocated to off-farm activities is positively associated to male household individuals while it is negative for home production activities. This result is consistent with results obtained by Newman and Canagarajah (2000), who found that men are more likely than women to participate in nonfarm activities. Men are reported to be more active than women in nonfarm activities (Abdulai and Delgado, 1999), which contrasts the view by most scholars that growth in nonfarm activities would benefit women more than men since women are said to participate more in these activities (Newman and Canagarajah, 2000). Women in Uganda are reported to be predominantly occupied in farming, have little access to resources and capital, and participate more in home production activities, which provide low returns to their labour (Mugyenyi, 1998).

The effect of age on time allocation is not statistically significant. However, results show that young and very old individuals are employed most in farm production while middle aged individual members tend to work in off-farm activities. Education has a negative effect on time allocated in farm production while the effect is positive for time allocated to off-farm activities. However, the effects are statistically insignificant. The result is consistent with that obtained by Newman and Canagarajah (2000) for Uganda and Ghana where they find that high education is an important determinant of participation in nonfarm activities. They conclude that education is more rewarded in nonfarm activities than in agriculture.

The effect of distance away from tarmac road, on work hours, is positive for farm production but negative for off-farm activities. This implies that households situated near the tarmac road have more off-farm opportunities available than household members in remote areas. High transaction and transport costs for households further away from the roads prohibit individuals from supplying their labour to the off-farm activities and instead work more hours in farm production. The effect of distance on time allocated in home production is positive implying that near the road, family labour is more expensive and individuals prefer to work in higher paying activities and possibly hire cheaper labour in household production activities.

Table 5.10 Determinants of time allocation decisions of household head, Central region

Variable	Farm		Off-farm		Home activities		Leisure	
	dy/dx	z	dy/dx	z	dy/dx	z	dy/dx	z
Share	0.346		0.204		0.106		0.344	
w*	-0.004	-0.81	0.004	0.92	0.0007	0.28	-0.0005	-0.1
m*	3.83e-07	0.38	-3.04e-07	-0.37	-5.04e-08	-0.10	-2.88e-08	-0.03
w	0.00004	0.12	-0.0003	-0.97	-0.00001	-0.06	0.0003	0.80
a	-0.003	-0.16	0.023	1.32	0.0002	0.02	-0.02	-1.15
hhland	0.006	0.98	-0.013*	-2.00	-0.001	-0.29	0.007	1.12
postprim	0.009	0.52	0.017	1.09	-0.003	-0.35	-0.024	-1.17
gender	0.016	0.31	0.195**	5.69	-0.236**	-4.94	0.024	0.49
age	0.009	1.06	-0.012	-1.56	-0.002	-0.41	0.005	0.63
age^2	-0.0001	-1.02	0.0001	1.13	0.00003	0.65	-0.00003	-0.39
educ	-0.008	-1.25	0.007	1.3	0.0008	0.24	0.0001	0.01
D	0.002	0.5	-0.01**	-3.02	0.003	1.56	0.005	1.16
Credit	-0.0002	-0.68	-0.0001	-0.69	0.00003	0.32	0.0003	1.37

y = Pr(choice = j), j = 1…4 and 1 = farm production, 2 = off-farm production, 3 = home production, 4 = leisure

Table 5.11 shows results for time allocation decisions for the second household individual. More time is spent on farm (35%) and home production (36%) activities and little on off-farm work (4.6%). The results show that spouses spend less labour on leisure and more time on home activities than household heads.

The determinants of time allocation have almost same effects on time allocation as for the household heads except a few differences in statistical significance levels. The effect of gender is significant only on time allocated to home production, in which male individuals are less likely to participate. Education level has a positive and significant (1%) effect on off-farm work participation. The effect of distance from tarmac road is negative for both farm production and off-farm work, but the effect is not significant. However, the distance from tarmac road significantly increases participation in home production.

Table 5.11 Determinants of time allocation decisions of second household member, Central region

Variable	Farm		Off-farm		Home activities		Leisure	
	dy/dx	z	dy/dx	z	dy/dx	z	dy/dx	z
Share	0.352		0.046		0.361		0.241	
w*	-0.001	-0.2	0.002	1.22	-0.004	-0.8	0.003	0.7
m*	-2.32e-07	-0.17	-5.67e-07	-1.08	1.31e-06	0.93	-5.16e-07	-0.45
hhland	0.002	0.38	-0.004	-1.36	0.002	0.30	-0.0001	-0.02
a	0.005	0.32	0.0007	0.12	-0.009	-0.57	0.003	0.25
gender	0.082	0.81	0.102	1.41	-0.255**	-4.73	0.071	0.75
age	0.002	0.17	0.005	1.07	-0.00004	-0.00	-0.006	-0.73
age^2	-5.29e-06	-0.04	-0.0001	-1.19	0.00001	0.09	0.0001	0.58
educ	-0.006	-1.02	0.009**	4.43	-0.002	-0.36	-0.001	-0.18
D	-0.0005	-0.22	-0.001	-0.68	0.005*	2.03	-0.003	-1.70
Credit	-0.00004	-0.09	4.33e-06	0.02	1.82e-06	0.00	0.00003	0.09

y = Pr(choice = j), j = 1…4 and 1 = farm production, 2 = off-farm production, 3 = home production, 4 = leisure

Masaka

Results for the household head show that participation rate in off-farm production is quite low compared to central region, while participation rate is high in farm production (Table 5.12). Time spent on home activities and leisure, by household heads, is comparable to that spent on the same activities in the central region.

Results show that the shadow wage increases the probability of working in both farm production and off-farm work while the shadow income reduced time allocated to both activities. However, the effects are not statistically significant. The only variable that has statistically significant effect on time allocation is gender. Being male has a positive and significant (1%) effect on time allocated to off-farm activities. The effect on time allocated to home production is negative and significant at 1%. There is no significant effect on farm production and leisure.

Table 5.13 shows results of time allocation decisions by the second household member for Masaka region. Slightly less time is spent in farm production than that spent by household heads. There is almost no time spent in off-farm activities. Like for the central region, more time is allocated to home activities and less to leisure activities compared time allocated to both activities by the household heads.

Gender is the only variable that significantly influences time allocated to production activities. Being male significantly reduces the time allocated to farm production (statistically significant at 10%) and home production (statistically significant at 5%). Being male increases the time spent on leisure activities. The effect of age variable is such that Middle aged individuals allocate more labour to farm production while young and old individuals allocate more time to the leisure activities.

Table 5.12 Determinants of time allocation decisions of household heads, Masaka

Variable	Farm		Off-farm		Home activities		Leisure	
	dy/dx	z	dy/dx	z	dy/dx	z	dy/dx	z
Share	0.477		0.072		0.127		0.323	
w*	0.007	1.2	0.002	0.82	-0.002	-0.68	-0.007	-1.34
m*	-6.73-07	-0.62	-3.5e-07	-0.55	1.83e-07	0.32	8.4e-07	0.9
a	-0.0009	-0.04	-0.003	-0.11	-0.005	-0.36	0.008	0.4
hhland	-0.007	-0.97	-0.006	-1.1	0.003	0.7	0.011^	1.8
postprim	0.009	0.28	0.006	0.5	-0.027	-1.35	0.012	0.39
gender	-0.039	-0.41	0.125**	3.32	-0.205**	-2.75	0.119	1.61
age	0.011	0.65	0.0003	0.05	-0.01	-1.12	-0.001	-0.08
age^2	-0.0001	-0.59	-0.0003	-0.17	0.0001	0.97	0.00003	0.16
educ	-0.002	-0.2	0.008	1.6	-0.002	-0.27	-0.004	-0.31
D	0.0005	0.38	0.00003	0.05	-0.001	-1.59	0.0009	0.78
Credit	0.0004	0.32	0.0001	0.29	-0.0004	-0.47	-0.0002	-0.14

y = Pr(choice = j), j = 1…4 and 1 = farm production, 2 = off-farm production, 3 = home production, 4 = leisure

Table 5.13 Determinants of time allocation decisions of second household member, Masaka

Variable	Farm		Off-farm		Home activities		Leisure	
	dy/dx	z	dy/dx	z	dy/dx	z	dy/dx	z
Share	0.453		1.4e-22		0.363		0.184	
w*	0.017	0.69	1.66e-19	-	0.004	0.16	-0.021	-0.15
m*	-3.38e-06	-0.72	0	-	-4.15e-07	-0.09	3.79e-06	1.25
a	0.014	0.55	1.55e-19	-	-0.012	-0.44	-0.003	-0.15
hhland	-0.009	-0.65	0	-	-0.004	-0.28	0.013	1.4
postprim	-0.077	-0.72	0	-	0.017	0.16	0.061	0.86
gender	-0.326^	-1.72	-1.74e-22	-	-0.3*	-2.38	0.626**	2.61
age	0.018	1.11	0	-	0.007	0.47	-0.026*	-2.4
age^2	-0.0002	-1.14	0	-	-0.0001	-0.54	0.0003**	2.6
educ	0.017	0.5	1.9e-19	-	0.003	0.09	-0.02	-0.88
D	-0.001	-0.5	0	-	-0.001	-0.53	0.002	1.58
Credit	0.0004	0.28	0	-	-0.00002	-0.01	-0.0004	-0.35

y = Pr(choice = j), j = 1…4 and 1 = farm production, 2 = off-farm production, 3 = home production, 4 = leisure

Southwest

Results of time allocation decisions for household heads in the southwest are presented in Table 5.14. Most of the time is allocated to farm production followed by leisure activities. Time allocated to off-farm activities is almost the same as that allocated to home activities.

The effect of shadow wage and shadow income on time allocation decisions is similar to that of central region, where increase in shadow wage reduces time allocated to farm production and increases time allocated to off-farm activities. An increase in shadow income results in more time allocated to farm production and less time allocated to off-farm production.

None of the variables included in the model has a significant effect on time allocated to farm production. Off-farm work is significantly affected by farm size, gender of individual worker and road access. Farm size has a negative effect on off-farm work, the effect being significant at 10% level. This result shows that push factors such as limited access to farming land contribute to farmers' diversification into nonfarm activities. The effect of being male on time allocated to off-farm work is positive and significant at 1% level. This result is indicative of existence of segregation in the labour market in favor of men. Male individuals also spend more time on leisure activities.

Road access has a positive impact on time allocated to off-farm work and negative impact on time spent on home activities.

Table 5.14 Determinants of time allocation decisions of household heads, southwest

Variable	Farm		Off-farm		Home activities		Leisure	
	dy/dx	z	dy/dx	z	dy/dx	z	dy/dx	z
Share	0.413		0.1		0.109		0.378	
w*	-0.006	-1.33	0.004	1.6	-0.001	0.00	0.003	0.64
m*	5.68e-07	1.05	-2.7e-07	-0.98	1.38e-07	0.54	-4.34e-07	-0.82
a	0.052	1.36	-0.026	-1.17	-0.002	-0.1	-0.024	-0.64
hhland	0.021	1.10	-0.02^	-1.78	0.0045	0.54	-0.006	-0.31
gender	-0.166	-0.92	0.177**	4.50	-0.234	-1.42	0.223*	2.04
age	0.005	0.35	-0.003	-0.48	-0.004	-0.55	0.002	0.16
age^2	-0.0001	-0.42	0.00002	0.32	0.00004	0.57	-4.59e-06	-0.03
educ	-0.008	-0.83	0.001	0.25	0.003	0.66	0.004	0.4
D	0.001	0.24	-0.01**	-3.68	0.0047*	2.59	0.004	1.15
Credit	0.0001	0.04	0.0008	1.22	-0.002	-1.39	0.001	0.76

y = Pr(choice = j), j = 1…4 and 1 = farm production, 2 = off-farm production, 3 = home production, 4 = leisure

Results for the second household member are presented in Table 5.15. Most of the time is allocated to farm production and home activities. Very little time is allocated to off-farm activities. Like in the other regions, Household heads spend more time on leisure activities than other household members.

The shadow wage and shadow income have the same effect on time allocation as that observed for household heads. The effect of education on off-farm is positive and significant at 10% while farm size has a negative impact on time allocated to off-farm activities. Education acts as a pull factor, enabling the individuals to get a higher pay and thus supply more labour to the nonfarm sector while farm size acts as a push factor where household individual members who do not have access to enough farming land are forced to seek for off-farm employment because they earn a lower marginal value from the farm.

Table 5.15 Determinants of time allocation decisions of second household member, southwest

Variable	Farm		Off-farm		Home activities		Leisure	
	dy/dx	z	dy/dx	z	dy/dx	z	dy/dx	z
Share	0.445		0.013		0.319		0.223	
w*	-0.003	-0.81	0.0005	1.36	-0.001	-0.36	0.003	1.3
m*	2.19e-07	0.44	-9.14e-09	-0.14	3.59e-07	0.82	-5.69e-07	-1.44
a	0.022	0.7	0.00005	0.01	-0.022	-0.78	-0.0002	-0.01
hhland	0.015	1.02	-0.009**	-3.06	0.009	0.07	-0.007	-0.63
gender	0.142	0.68	-0.009	-1.27	-0.248**	-3.23	0.115	0.59
age	0.018	0.94	-0.001	-0.93	0.013	0.81	-0.029*	-2.00
age^2	-0.0002	-0.93	0.00003	1.2	-0.0002	-0.81	0.0004^	1.94
educ	-0.01	-0.97	0.003^	1.92	-0.0003	-0.03	0.008	0.87
D	-0.004	-1.38	0.0004	1.34	0.002	0.85	0.002	0.68
Credit	0.001	0.67	-0.0003	-1.00	-0.0001	-0.09	-0.001	-0.53

y = Pr(choice = j), j = 1…4 and 1 = farm production, 2 = off-farm production, 3 = home production, 4 = leisure

5.5 Conclusions

The main objective of this chapter is to analyse the factors that influence labour supply and demand among smallholder farmers in Uganda. Factors that influence household members' choice between farm and off-farm work are also determined. Findings have implications for policies to support improved labour supply decisions in the rural sector.

Under the influence of imperfect labour and institutional constraints, shadow wages and shadow incomes are the appropriate variables to analyse individual labour supply response to changes in economic conditions facing the household since household decisions reflect production technology and individual household preferences, and not the market wages and prices. Moreover, the market wages and prices do not reflect the distorted market conditions to which the households are subjected. Results obtained support the behavioural assumption that individual household members allocate their time in a way that contributes to the maximization of the family's utility function.

Farmers from Masaka would benefit most from productivity increases. Farmers from central Uganda would have the least benefits from productivity increases, especially the women because their shadow income (profit effect) is higher and dominates the shadow wage (productivity effect) to cause negative effect on labour supply. Similarly, results from simulations show that farmers from Masaka would benefit most from a wage increase while negative elasticities are observed for other regions and especially the southwest. In contrast, farmers in central and southwest would benefit most from improvement in road infrastructure while negative benefits from road improvement in terms of labour supply are realised for Masaka farmers. These results show that where labour markets are least developed, farmers would benefit most from productivity increases. However, for farmers to benefit from market development, the labour market must be accompanied by development in road infrastructure to reduce on the transaction costs associated with insufficient road infrastructure.

Results from the hired labour demand estimation show that economic rationing of hiring labour has more to with market wage rather than the family size and composition, which we find to have no statistically significant effect. Road access is found to have a statistically significant positive effect on labour demand in the southwest. The same effect is observed for unearned income. These results confirm the assertion that opening the southwest to markets in the central region, through development of road infrastructure, and increased opportunities for earning household incomes contributed favourably to the growth and development of the banana sub-sector in the region.

Results of the time allocation decisions are consistent with the assertion that households maximize their incomes through allocating the time of household members whose shadow wage is lower than the MPL on the farm to farm activities while the time of individuals whose real opportunity cost of time is higher than the MPL on the farm is engaged in off-farm activities. Farm size has a significant negative effect on the amount of labour supplied to off-farm work. This result is consistent with the assertion that farmers seek off-farm employment due to push factors (constraints in accessing land for farm production). The results also confirm that factors such as education and road access, which improve the opportunity cost of labour in the off-farm sector, affect positively the amount of time allocated in off-farm activities. The implication of this result is that investment in education and road infrastructure would favour the off-farm sector against on-farm employment. Men would benefit most from development of the off-farm sector as most of the household individuals employed in the sector are men.

CHAPTER 6 Conclusions

6.1 Introduction

Uganda has undergone major changes since the late 1990s towards economic growth and reducing poverty. Since the 1990s, the gross domestic product has grown by more than 6% per annum compared to the 1980s when it grew by 6% (World-Bank, 2004) and the population living under poverty line has reduced from 56% in 1992 to 35% in 2000 (Appleton, 2001). The economic growth and poverty reduction are attributed to policies linked to structural adjustment and economic liberalization policies undertaken by the Government of Uganda with support from the donor community (Benin, 2004). However, although the liberalization and structural policies succeeded in stabilizing the economy and stimulated economic recovery in the 1990s, sustainable development has not yet been achieved (Collier and Reinikka, 2001). Poverty is still severe in the rural areas and its incidence has recently been reported to have increased from 35% in 2000 to 38% in 2003 (Appleton and Ssewanyana, 2003). Moreover, agricultural production and productivity have stagnated or declined for most farmers (Deininger and Okidi, 2001; Pender et al., 2004).

The government needs appropriate policies that will enhance the competitiveness of smallholder farmers and their ability to reach markets and participate in them (Benin, 2004). This study evaluates the effect of factor (labour) and product (commodity) markets development on the development of the banana sub-sector in central and southwestern Uganda. In particular, we analyze the impact of improvement in market (labour and food) opportunities on resource allocation between bananas and other crops, and between agriculture and nonfarm activities. The banana crop is selected because it is the main staple food crop for smallholders in the region; hence understanding the dynamics of its production leads to an understanding of the smallholder agricultural production dynamics in general.

The study addresses the following research questions:

(1) What are the characteristics of the different study regions and how do they influence the banana production dynamics?
(2) What influences banana productivity and technical efficiency of banana farmers in the study regions?
(3) How efficient are smallholder farmers in using farm resources?
(4) How changes in economic factors impact on resource allocation decisions of smallholder farmers?
(5) What are the factors that influence family labour supply and farm household labour demand in the study regions?

The next section summarizes and discusses the answers to the above research questions.

6.2 Main study findings

6.2.1 Banana production characteristics and performance

Chapter 2 of this study characterizes the farm households and production systems in three regions (central, Masaka and southwest) selected from the main banana producing area in Uganda. There is no significant difference in demographic characteristics (age, gender and education of farmer) between the three regions. However, farmers in the central region are, on average, slightly older and more educated than those in Masaka and the southwest. Family sizes are smaller in Masaka while farm sizes are smaller in the southwest. Crop production is more diversified in the central region, implying that it is more risky to produce crops in the region than it is in the other two regions.

Wage rates are highest in the central region implying that the wage sector is more developed in this region than in the other two regions. Also the nonfarm sector for unskilled labour, in the central region, is more remunerative than the farm sector and most labourers are employed off-farm. The proportion of land under fallow is highest in the central region and lowest in southwest. However, animal manure and other soil amendments are least used in the central region. The proportion of farm households that receive credit is highest in the central region and the amount received is also higher than that for the other two regions. Commodity prices are highest in the central region and lowest in the southwest. Imperfections in the commodity markets make farm households obtain food cheaply from own farm production than when purchased from the market.

Differences in economic conditions contribute to the differences in production patterns and consumption behavior in the three regions. In the central region, higher wages in the nonfarm sector reduce farmers' need to rely on farm production for cash income. Higher wage rates are associated with higher cost of production and lower use of outside labour in farm production. Farmers shift from labour intensive activities and adopt technologies and crops that are less intensive in terms of labour use (e.g. cassava and sweet potatoes). On the other hand, high food prices induce farmers to rely on own farm production for their household food needs. Hence they shift resources (land and labour) from crops that appear to be more profitable (e.g. bananas) but rely heavily on purchased inputs (including hired labour) to crops that are more suited to satisfying household food needs and use less of outside inputs (e.g. sweet potatoes, cassava and beans).

In the southwest farm sizes are small but hired labour is more accessible. Hence farmers adopt technologies and activities that are relatively more labour intensive but more rewarding in terms of cash benefits. Specifically, bananas are adopted because they satisfy both the cash needs and household food requirements. A few other crops (e.g. millet and beans) are grown to complement bananas in terms of food.

6.2.2 Determinants of banana productivity and technical efficiency

Farmers in the three study regions use different technologies for banana production, which affect the intensity of labour use and hence adoption of different activities. Results of output labour response for bananas in the three regions justify the higher intensity of labour use in the southwest in comparison to Masaka and central region. The technology used in Masaka is such that output response to labour use is high at low levels of labour use but quickly diminishes as more labour is employed. Hence, it is not rational for farmers in Masaka to increase labour intensity in banana production unless the technology changes. In the central region, higher intensity of labour use in banana production is limited by the high cost of labour. Hence, farmers in Masaka and central region use less labour per unit area in banana production than farmers in the southwest.

The sum of elasticities of production with respect to land and labour show decreasing returns to scale, which implies that farmers lose efficiency if they increase scale of production. The exhibition of decreasing returns to scale contrast the perceived view of constant returns to scale technology in agricultural production. However, farm size is found to be positively associated with banana productivity contrary to evidence in literature which seems to reveal an inverse relationship between farm size and yields per unit area (Berry and Cline, 1979).

The inverse relationship between farm size and productivity is attributed to: (1) underutilization of land available to large farmers (2) adoption of land extensive enterprises by large farms (3) multiple cropping by small farms (4) less fertile soils on large farmers (5) proportion of land that can be irrigated and (6) high labour intensity on small farms (Ellis, 1993). Our analysis differs from those reported in literature in three ways: (1) we used same product (e.g. bananas) for all the farms in contrast to studies which considered different farms with different enterprises (2) our measure of productivity is based on only the farm area under productive use in contrast to the studies that used the whole farm area to measure productivity and (3) farm size groups differ (most households in our sample have less than 10 acres of land compared to studies which include farms of up to 500 ha and over). The positive relationship between farm size and banana productivity that is observed in our study can be attributed to commitment of large farmers to farming business and sustainability of crop yields through crop rotation and use of fallow on large farms.

Empirical results show that technical efficiency of banana farmers in Uganda is low, implying that there is potential of increasing banana production through improved efficiency. The average technical efficiency scores show that output can be increased by 30-58%, depending on region, at the current levels of inputs. The technical efficiency scores obtained are quite low compared to what is reported from some studies in developing countries including Africa (Seyoum et al., 1998).

The factors that affect technical efficiency among banana farmers are different for each region. In the central region, greater access to credit and better roads increase technical efficiency in banana production. In Masaka, technical efficiency significantly increases with improved access to formal education. Formal education is the most studied farmer attribute in the efficiency literature, of which the results reveal that the association between schooling and individual farm technical efficiency is quite mixed (Nyemeck et al., 2003). Some studies have found positive correlation between education and technical efficiency (Bravo-Ureta and Pinheiro, 1997) while others have reported statistically insignificant relationship between the two variables (Bravo-Ureta and Evenson, 1994). Farmers with more years of formal education tend to respond more readily in using new production methods while more years of education for farmers involved in more traditional farming methods do not result in increases in technical efficiency (Seyoum et al., 1998). In both Masaka and the southwest, technical efficiency is positively related to distance from tarmac road implying that farmers located near to the tarmac are less efficient.

Results show that the effect of soil nutrients on banana output is not significant, which contradicts the view by farmers that decline soil fertility contributed to banana production decline in the central region. However, soil pH and texture were found to have an effect on banana productivity. Pests (specifically the banana weevil) and diseases (Sigatoka) negatively affect banana production in study areas.

6.2.3 Market access and allocative efficiency

Results on the effect of farm size on farm productivity show a positive relationship between farm size and productivity for the major crops (bananas, coffee, maize, millet, beans, sweet potato and cassava) in the study area, consistent with results obtained in chapter 3 (see also section 6.2.2). However, farm size has a negative effect on output of maize and cassava. The results are consistent with results obtained for China, where a positive relationship exists between land size and economic efficiency in modern agricultural regions, which suggests that small farm sizes may pose a constraint to technical change and adoption of modern farming practices (Xu and Jeffrey, 1998). The negative impact of farm size on productivity of maize and cassava is explainable. Larger farmers are more likely to allocate the best of their land to the most important crops and the less productive land to less important crops (e.g. maize and cassava). On the contrary, small farmers allocate the same type of land to all crops since their major objective is production for home consumption and crops considered less important by large farmers could be more important to small farmers if they contribute significantly to food security.

Results further show that the marginal value products (mvpl) obtained from the production functions are well below the going village wage rates (w). The null hypothesis of allocative efficiency is rejected for all the cases, implying that farmers are allocatively inefficient in terms of labour use. The deviation from the condition: mvpl = w is an indication of imperfections in labour and food markets. It is a confirmation that production and consumption decisions are nonseparable. The results are consistent with the theory relating household production decisions and imperfections in the labour and food markets. The lowest mvpl for bananas is obtained for Masaka, where access to off-farm opportunities is more limited. This is consistent with the theoretical assertion that access to off-farm opportunities influences production and consumption decisions. In the central region, the marginal value products of labour for annual food crops (maize, sweet potato and cassava) are quite low compared to bananas. The results are consistent with the hypothesis that the optimal level of production for crops in which the households face imperfections in the food market is higher than the case if market imperfections are absent.

Returns to land also guide farmers in taking decisions on which crop enterprise to allocate resources to. In the central region, returns to land are highest in sweet potato production and lowest in coffee production. Hence it is rational for farmers to allocate prime land to sweet potato production. In Masaka and the southwest, returns to land are highest in banana production. Hence it is rational for farmers in these regions to allocate more land to bananas than is allocated to any of the other crops. Banana production is positively correlated with the returns to land per acre, the correlation being stronger in the central region. The strong positive correlation between banana production and per acre returns in the central region is indicative of the integration of bananas in the market economy and hence their production is more influenced by farm profits rather than direct household consumption needs.

The results from efficiency analysis confirm the assertion made in chapter 2 that the need to satisfy subsistence requirements influence labour allocation decisions in favour of annual food crops production and against banana production. In contrast, the results show that farmers in the southwest benefit more from bananas and it is rational for them to increase resources (land and labour) allocated to banana production.

6.2.4 Household labour supply and decisions

Under the influence of imperfect labour and institutional constraints, shadow wages and shadow incomes are the appropriate variables to analyse individual labour supply response to changes in economic conditions facing the household since household decisions reflect production technology and individual household preferences, and not the market wages and prices. The results obtained show that household members respond positively to changes in shadow wages and negatively to changes in shadow income. These results imply that total work time of individual household members is influenced by changes in the household's economic conditions, consistent with the results obtained by Skoufias (1994) and Abdulai and Regmi (2000).

Results from simulations of labour supply show that farmers from Masaka would benefit from a wage increase while negative elasticities of total labour supply are observed for other regions (central and southwest). In the central region, the direct effect of wage and income effect are negative and dominate the price effect to cause an overall effect on labour supply that is negative. In the southwest, the direct effect of wage rate and the price effect are negative and dominate the income effect to cause an overall effect of wage rate on labour supply that is negative.

The direct effect of improved road access on labour supply is positive, in all the cases, which implies that individual household members residing in remote area work less hours. The price effect of improved road access is negative for individual household members in central region and Masaka but not in the southwest. For the southwest, improved road access increases the marginal productivities (shadow wages) of the individual household members; hence the positive effect on labour supply. The overall effect of improved road access on labour supply is positive for individuals in the central region and the southwest, implying that they work more hours near the roads and less hours in remote areas. In Masaka, where off-farm opportunities are fewer, remoteness increases work hours for the individual household members. In Masaka, conditions in remote area (e.g. larger farm sizes) are favourable for higher marginal productivities and hence higher labour supply. These results imply that households in Masaka would benefit from policies that lead to an increase in farm productivity in the region. Households in the southwest and central would benefit from improvement in road infrastructure.

Results from the hired labour demand estimation show that economic rationing of hiring labour has more to do with market wage rather than the family size and composition, which we find to have no statistically significant effect ($P>0.1$) on hired labour demand. Road access is found to have a statistically significant positive effect on labour demand in the southwest. The same effect is observed for unearned income. These results confirm the assertion that opening the southwest to markets, through development of road infrastructure, and increased opportunities for earning household incomes contributed favourably to the growth and development of the banana sub-sector in the region.

Results of the time allocation decisions are consistent with the assertion that households maximize their incomes through allocating time of household members whose shadow wage is lower than their marginal productivity on the farm, to farm activities, while the time of individuals whose real opportunity cost of time is higher than the marginal productivity on the farm is engaged in off-farm activities. The results also confirm that factors such as education and road access, which improve the opportunity cost of labour in the off-farm sector, affect positively the amount of time allocated in off-farm activities. The implication of this result is that investment in education and road infrastructure would favour the off-farm sector against on-farm employment.

6.3 Policy implications

The study contributes to the ongoing debate about the significance of the theory of farm household, which integrates the household production and consumption decisions and allows for the determination of both the farm profit and wage income – the link between the production side and consumption side of the model. Secondly, we apply the farm household model in the analysis of the shift in banana production from central to southwest Uganda. Understanding of the dynamics of banana production in the region leads to the understanding of the smallholder agricultural productions dynamics in general. Thirdly, the study contributes to the ongoing policy debate on ways to improve the incomes and food security of rural households in Uganda, and Africa in general.

In terms of policy, the results of the study put to question the development strategy that emphasizes small-farmers as the central focus for agricultural development. The hypothesis that small farmers are more efficient than large farmers is rejected and instead large farms are found to be more productive and sustainable, given the limited application of purchased inputs (fertilizer and pesticides). This implies the current strategy of targeting the small farmer through research and development might not yield desired results as small farmers are less likely to adopt new farming technologies that result to higher farm productivity but demand more in terms of labour and purchased inputs. Instead, efforts should be directed to improving productivity and competitiveness of the nonfarm sector to absorb more labour from the small-farm sector. This would lead to expansion of farm sizes and increase adoption of new farming methods and efficiency. Increased access to formal education and road infrastructure is necessary for improving efficiency in both the nonfarm and farm sector.

Different policies are required to improve technical efficiency in the different regions. In the central region, promoting financial institutions that are more suited to providing credit to smallholder farmers is vital to improve on the technical efficiency of these farmers. The credit accessed could be used in starting up nonfarm enterprises and the profits reinvested in farming (e.g. buying land, buy inputs and hiring outside labour). In Masaka, increasing access to formal education is necessary for improving technical efficiency of farmers in the region while increased access to extension services is likely to improve productivity and efficiency in the southwest. Increasing access to education and training is important to enable farmers receive and understand information relating to new agricultural technologies.

Policies that reduce transaction costs in the labour and food markets are necessary for improving farm allocative efficiency and overall economic efficiency. In particular, there is need for improving the road infrastructure to reduce on the time of travel and cost of transport. There is need to increase on the education level of farmers to be able to access and analyze information related to input and output prices.

Appendices

Appendix 2.1a Household Schedule

Identification:

Enumerator Name ________________________ Interview start time _____ Interview end time_____ Date___________
Name of household head ________________________ Name of Respondent ____________________
To be completed by supervisor:
Stratum code _______1; Sub-county (LC3/ward) _____2; Parish (LC2) _____________3; Village (LC1) ______4; Household code _______5;
Field edit ________ Call back required _______ Call back completed _______ Office edit ________ Data entered __________

Question 1 Please list the members of your household

PERSON NUMBER	NAMES	**Relationship to household head**: 1=husband 2=wife 3=child 4=grand child 5=sister 6=brother 7=in-law 8=father 9=mother 10=other (specify) ________	**Language spoken best:** 1=Luganda 2=Lusoga 3=Runyankole 4=Rukiga 5=Swahili 6=Kihaya 7=Kinyambu 8=Other (specify) ________	**Speak or read English**? 1=speak 2=read 3=both 4=neither	**Age** (*years*)	**Gender:** 1=male 2=female	**Education** (*years in school*)	**Number of months in 2002 residing here**	**Location of other residence when not here** 1=same village 2=another village, same district 3=another district in this country 4=outside of this country
1 6		7	8	9	10	11	12	13	14
2 15		16	17	18	19	20	21	22	23
3 24		25	26	27	28	29	30	31	32
4 33		34	35	36	37	38	39	40	41
5 42		43	44	45	46	47	48	49	50
6 51		52	53	54	55	56	57	58	59

7 60		61	62	63	64	65	66	67	68
8 69		70	71	72	73	74	75	76	77
9 78		79	80	81	82	83	84	85	86
10 87		88	89	90	91	92	93	94	95
11 96		97	98	99	100	101	102	103	104

Question 2 Please tell us about your farm, in general.

A. Land holdings

Parcel Number or Name	**Area** (*acres*)	**Tenure**: 1=mailo 2=kibanja 3=customary 4=rented (hired in) 5=borrowed 6=leased 7=other (specify)	***Land Use*** (Acres or % share of total parcel)								
			Crops	Natural pasture	Improved pasture	Forested	Swamp	Water body	Settlement	Fallow	Other (specify) ________
105	106	107	108	109	110	111	112	113	114	115	116
117	118	119	120	121	122	123	124	125	126	127	128
129	130	131	132	133	134	135	136	137	138	139	140
141	142	143	144	145	146	147	148	149	150	151	152
153	154	155	156	157	158	159	160	161	162	163	164
165	166	167	168	169	170	171	172	173	174	175	176
177	178	179	180	181	182	183	184	185	186	187	188
189	190	191	192	193	194	195	196	197	198	199	200
201	202	203	204	205	206	207	208	209	210	211	212
213	214	215	216	217	218	219	220	221	222	223	224
All parcels	225		226	227	228	229	230	231	232	233	234

B. **Farm equipment, implements and structures**

Implement/ Structure	**Source**: 1=own farm 2=outside farm	**Number used currently**				**Unit cost of implement if owned (in U.Shs)**	
		Borrowed	Hired	Exchanged	Owned	At time of buying	Year last bought
Hoes	235	236	237	238	239	240	241
Forked hoes	242	243	244	245	246	247	248
Pangas/cutlass	249	250	251	252	253	254	255
Spades	256	257	258	259	260	261	262
Wheel barrows	263	264	265	266	267	268	269
Sickles	270	271	272	273	274	275	276
Axes	277	278	279	280	281	282	283
Pruning knives	284	285	286	287	288	289	290
Bow saw	291	292	293	294	295	296	297
Gunny bags	298	299	300	301	302	303	304
Knapsack sprayers	305	306	307	308	309	310	311
Slashing Implement	312	313	314	315	316	317	318
Stable for pigs	319	320	321	322	323	324	325
Stable for cattle	326	327	328	329	330	331	332
Goat pen	333	334	335	336	337	338	339
Chicken house	340	341	342	343	344	345	346
Lawn mower	347	348	349	350	351	352	353
Bicycles	354	355	356	357	358	359	360
Motorcycle	361	362	363	364	365	366	367
Car	368	369	370	371	372	373	374
Truck	375	376	377	378	379	380	381
Tractor	382	383	384	385	386	387	388
Tractor trailer	389	390	391	392	393	394	395
Disc plough	396	397	398	399	400	401	402
Planter	403	404	405	406	407	408	409
Other (specify)	410	411	412	413	414	415	416

C. Other holdings

	Number	Price per unit if sold today		Number	Price per unit if sold today
Local cattle	417	418	Radio-cassette	435	436
Improved cattle	419	420	Bicycles	437	438
Exotic cattle	421	422	Motorbikes	439	440
Goats	423	424	Furniture (specify)	441	442
Sheep	425	426		443	444
Pigs	427	428		445	446
Local chicken	429	430		447	448
Improved chicken	431	432		449	450
Ducks	433	434		451	452

D. Type of house

Walls		Floor		Roof	
Brick	453	Bricks	456	Iron sheets	459
Concrete blocks	454	Concrete	457	Grass or thatch	460
Mud and wattle	455	Mud	458	Tiles	461

E. GPS reading on house: E ________________462; N ________________463; M ____________464

F. Do you have any crop stored on hand at present?
(*Enumerator estimates conversion factor from key informants*)

Crop	Unit measure	Number of units	Conversion factor (into kg)
465	466	467	468
469	470	471	472
473	474	475	476
477	478	479	480
481	482	483	484
485	486	487	488
489	490	491	492
493	494	495	496

Question 3 During the past 6 months, have you sought to obtain or used credit for farm production or for other purposes? (**yes** or **no**)

If yes:

Purpose Credit Sought	Did you obtain it? 1=yes 2=no	How long did it take to obtain the loan/credit? (*number of days*)	Source of Credit 1=money lenders 2=cooperative 3=farmer group 4=commercial 5=NGO 6=government 7=other (specify) ____________	Amount borrowed last time (*in UShs/TzSh.*)	Amount of interest payment	How long did/will it take to pay back the loan?	What use was it put to? 1=buy fertilizer 2=buy manure 3=buy mulch 4=hire labour 5=other (specify) ____________
Banana production	497	498	499	500	501	502	503
Other farm production	504	505	506	507	508	509	510
Food, clothing, medical, school	511	512	513	514	515	516	517
Special events (wedding, baptism)	518	519	520	521	522	523	524
Other (specify) ____________	525	526	527	528	529	530	531

Appendix 2.1b General Plot Schedule

Identification:

Enumerator Name ________________________ Interview start time _____ Interview end time_____ Date___________ Name of household head ______________________ Name of Respondent ____________________ **To be completed by supervisor:** Stratum code _______1; Sub-county (LC3/ward) _____2; Parish (LC2) ____________3; Village (LC1) ______4; Household code _______5; Field edit ________ Call back required _______ Call back completed _______ Office edit ________ Data entered __________

We would like to estimate the area of each plot cultivated by your household last season (September 2002 – February 2003). We would like to record the names of all the crops you planted.

Please list all the crops that were grown during the **last six months (September 2002 – February 2003)** on your different land parcels and the approximate percentage of area of crops in mixed stand (*by pacing*).

Parcel number	**Plot number**	Plot share of total cultivated area in the parcel (%)	**Crops grown in the plot**	**Cultivar type:** 1=improved 2=traditional	**Grown in** 1=pure 2=mixed stand	**Grown as** 1=major 2=minor crop	Crop share of total plot area (%)	**If grown as major crop**, list the crops grown along in the mixture			**If tree or bush species**, plant count (number)
								First intercrop	Second intercrop	Other intercrops (if any)	
6	7	8	9	10	11	12	13	14	15	16	17
18	19	20	21	22	23	24	25	26	27	28	29
30	31	32	33	34	35	36	37	38	39	40	41
42	43	44	45	46	47	48	49	50	51	52	53
54	55	56	57	58	59	60	61	62	63	64	65
66	67	68	69	70	71	72	73	74	75	76	77
78	79	80	81	82	83	84	85	86	87	88	89

Parcel number	**Plot number**	Plot share of total cultivated area in the parcel (%)	**Crops grown in the plot**	**Cultivar type**: 1=improved 2=traditional	**Grown in** 1=pure 2=mixed stand	**Grown as** 1=major 2=minor crop	Crop share of total plot area (%)	**If grown as major crop**, list the crops grown along in the mixture			**If tree or bush species**, plant count (number)
								First intercrop	Second intercrop	Other intercrops (if any)	
90	91	92	93	94	95	96	97	98	99	100	101
102	103	104	105	106	107	108	109	110	111	112	113
114	115	116	117	118	119	120	121	122	123	124	125
126	127	128	129	130	131	132	133	134	135	136	137
138	139	140	141	142	143	144	145	146	147	148	149
150	151	152	153	154	155	156	157	158	159	160	161
162	163	164	165	166	167	168	169	170	171	172	173
174	175	176	177	178	179	180	181	182	183	184	185
186	187	188	189	190	191	192	193	194	195	196	197
198	199	200	201	202	203	204	205	206	207	208	209
210	211	212	213	214	215	216	217	218	219	220	221
222	223	224	225	226	227	228	229	230	231	232	233
234	235	236	237	238	239	240	241	242	243	244	245
246	247	248	249	250	251	252	253	254	255	256	257
258	259	260	261	262	263	264	265	266	267	268	269
270	271	272	273	274	275	276	277	278	279	280	281
282	283	284	285	286	287	288	289	290	291	292	293
294	295	296	297	298	299	300	301	302	303	304	305
306	307	308	309	310	311	312	313	314	315	316	317
318	319	320	321	322	323	324	325	326	327	328	329
330	331	332	333	334	335	336	337	338	339	340	341

Appendix 2.1c Monthly Labour Schedule (Multi-Visit)

Identification:

Month for which data is being collected ______________Enumerator Name ________________________________ Date___________

Name of household head ____________________________________ Name of Respondent _____________________________

To be completed by supervisor:

Stratum code ________1; Sub-county (LC3/ward) _____2; Parish (LC2) ____________3; Village (LC1) ______4; Household code ______5;

Field edit ________ Call back required _______ Call back completed _______ Office edit ________ Data entered __________

A. Family labour use in farm production plots (for month ______________ 6)

Activities (specify code)		Crop/livestock code													
	Parcel number	7	25	43	61	79	97	115	133	151	169	187	205	223	241
	Plot number	8	26	44	62	80	98	116	134	152	170	188	206	224	242
	Men x days	9	27	45	63	81	99	117	135	153	171	189	207	225	243
	Women X days	10	28	46	64	82	100	118	136	154	172	190	208	226	244
	Children X days	11	29	47	65	83	101	119	137	155	173	191	209	227	245
	Hours worked/day	12	30	48	66	84	102	120	138	156	174	192	210	228	246
	Men X days	13	31	49	67	85	103	121	139	157	175	193	211	229	247
	Women X days	14	32	50	68	86	104	122	140	158	176	194	212	230	248
	Children X days	15	33	51	69	87	105	123	141	159	177	195	213	231	249
	Hours worked/day	16	34	52	70	88	106	124	142	160	178	196	214	232	250
	Men days	17	35	53	71	89	107	125	143	161	179	197	215	233	251
	Women days	18	36	54	72	90	108	126	144	162	180	198	216	234	252
	Children days	19	37	55	73	91	109	127	145	163	181	199	217	235	253
	Hours worked/day	20	38	56	74	92	110	128	146	164	182	200	218	236	254
	Men days	21	39	57	75	93	111	129	147	165	183	201	219	237	255
	Women days	22	40	58	76	94	112	130	148	166	184	202	220	238	256
	Children days	23	41	59	77	95	113	131	149	167	185	203	221	239	257
	Hours worked/day	24	42	60	78	96	114	132	150	168	186	204	222	240	258

Codes for activities:
1=Land clearing; 2=Land ploughing; 3=Planting; 4=Replanting; 5=Weeding; 6=Stumping; 7=Pruning; 8=De-suckering; 9=De-leafing; 10=Sheath removal; 11=Split stems; 12=Cover corms; 13=Remove corms; 14=Fertilizer application; 15=Herbicide application; 16=Pesticide application; 17=Manure application; 18=Cutting grass mulch; 19=Grass mulch application; 20=Crop residue application; 21=Coffee husks application; 22=Harvesting; 23=Drying and processing; 24=Marketing

Codes for crops: (1= bananas; 2=coffee; 3=horticultural crops; 4= maize; 5=millet; 6=sorghum; 7=cassava; 8=sweet potato; 9=Irish potatoes; 10=beans; 11=ground nuts; 12=field peas; 13=cattle; 14=goats; 15=other (specify)

B. Hired labour use in farm production (for month _____________ 259)

Activity (specify code)		Crop/livestock code													
	Parcel number	260	282	304	326	348	370	392	414	436	458	480	502	524	546
	Plot number	261	283	305	327	349	371	393	415	437	459	481	503	525	547
	Men x days	262	284	306	328	350	372	394	416	438	460	482	504	526	548
	Women X days	263	285	307	329	351	373	395	417	439	461	483	505	527	549
	Children X days	264	286	308	330	352	374	396	418	440	462	484	506	528	550
	Hours worked/day	265	287	309	331	353	375	397	419	441	463	485	507	529	551
	Total cost (U.Shs)	266	288	310	332	354	376	398	420	442	464	486	508	530	552
	Men X days	267	289	311	333	355	377	399	421	443	465	487	509	531	553
	Women X days	268	290	312	334	356	378	400	422	444	466	488	510	532	554
	Children X days	269	291	313	335	357	379	401	423	445	467	489	511	533	555
	Hours worked/day	270	292	314	336	358	380	402	424	446	468	490	512	534	556
	Total cost (U.Shs)	271	293	315	337	359	381	403	425	447	469	491	513	535	557
	Men days	272	294	316	338	360	382	404	426	448	470	492	514	536	558
	Women days	273	295	317	339	361	383	405	427	449	471	493	515	537	559
	Children days	274	296	318	340	362	384	406	428	450	472	494	516	538	560
	Hours worked/day	275	297	319	341	363	385	407	429	451	473	495	517	539	561

	Total cost (U.Shs)	276	298	320	342	364	386	408	430	452	474	496	518	540	562
	Men days	277	299	321	343	365	387	409	431	453	475	497	519	541	563
	Women days	278	300	322	344	366	388	410	432	454	476	498	520	542	564
	Children days	279	301	323	345	367	389	411	433	455	477	499	521	543	565
	Hours worked/day	280	302	324	346	368	390	412	434	456	478	500	522	544	566
	Total cost (U.Shs)	281	303	325	347	369	391	413	435	457	479	501	523	545	567

Codes for activities:

1=Land clearing; 2=Land ploughing; 3=Planting; 4=Replanting; 5=Weeding; 6=Stumping; 7=Pruning; 8=De-suckering; 9=De-leafing; 10=Sheath removal; 11=Split stems; 12=Cover corms; 13=Remove corms; 14=Fertilizer application; 15=Herbicide application; 16=Pesticide application; 17=Manure application; 18=Cutting grass mulch; 19=Grass mulch application; 20=Crop residue application; 21=Coffee husks application; 22=Harvesting; 23=Drying and processing; 24=Marketing

Codes for crops: (1= bananas; 2=coffee; 3=horticultural crops; 4= maize; 5=millet; 6=sorghum; 7=cassava; 8=sweet potato; 9=Irish potatoes; 10=beans; 11=ground nuts; 12=field peas; 13=cattle; 14=goats; 15=other (specify) **Note: include wage conversion from in kind payments on back of page**

C. Family labour non-farm employment (For month ________________ 568)

Activity		**Family labor working outside own farm by type of labor and person**													
	Person name														
	Person number	569	606	643	680	717	754	791	828	865	902	939	976	1013	1050
Casual agricultural labor	Activity	570	607	644	681	718	755	792	829	866	903	940	977	1014	1051
	Number of days	571	608	645	682	719	756	793	830	867	904	941	978	1015	1052
	Hours per day	572	609	646	683	720	757	794	831	868	905	942	979	1016	1053
	Location	573	610	647	684	721	758	795	832	869	906	943	980	1017	1054
	Payment unit	574	611	648	685	722	759	796	833	870	907	944	981	1018	1055
	Number of units	575	612	649	686	723	760	797	834	871	908	945	982	1019	1056
Agricultural labor on contract	Activity	576	613	650	687	724	761	798	835	872	909	946	983	1020	1057
	Number of days	577	614	651	688	725	762	799	836	873	910	947	984	1021	1058
	Hours per day	578	615	652	689	726	763	800	837	874	911	948	985	1022	1059

	Location	579	616	653	690	727	764	801	838	875	912	949	986	1023	1060
	Payment unit	580	617	654	691	728	765	802	839	876	913	950	987	1024	1061
	Number of units	581	618	655	692	729	766	803	840	877	914	951	988	1025	1062
Agricultural labor permanent	Activity	582	619	656	693	730	767	804	841	878	915	952	989	1026	1063
	Number of days	583	620	657	694	731	768	805	842	879	916	953	990	1027	1064
	Hours per day	584	621	658	695	732	769	806	843	880	917	954	991	1028	1065
	Location	585	622	659	696	733	770	807	844	881	918	955	992	1029	1066
	Payment unit	586	623	660	697	734	771	808	845	882	919	956	993	1030	1067
	Number of units	587	624	661	698	735	772	809	846	883	920	957	994	1031	1068
Casual non-ag labor	Activity	588	625	662	699	736	773	810	847	884	921	958	995	1032	1069
	Number of days	589	626	663	700	737	774	811	848	885	922	959	996	1033	1070
	Hours per day	590	627	664	701	738	775	812	849	886	923	960	997	1034	1071
	Location	591	628	665	702	739	776	813	850	887	924	961	998	1035	1072
	Payment unit	592	629	666	703	740	777	814	851	888	925	962	999	1036	1073
	Number of units	593	630	667	704	741	778	815	852	889	926	963	1000	1037	1074
Contract non-ag labor	Activity	594	631	668	705	742	779	816	853	890	927	964	1001	1038	1075
	Number of days	595	632	669	706	743	780	817	854	891	928	965	1002	1039	1076
	Hours per day	596	633	670	707	744	781	818	855	892	929	966	1003	1040	1077
	Location	597	634	671	708	745	782	819	856	893	930	967	1004	1041	1078
	Payment unit	598	635	672	709	746	783	820	857	894	931	968	1005	1042	1079
	Number of units	599	636	673	710	747	784	821	858	895	932	969	1006	1043	1080
Permanent non-ag labor	Activity	600	637	674	711	748	785	822	859	896	933	970	1007	1044	1081
	Number of days	601	638	675	712	749	786	823	860	897	934	971	1008	1045	1082
	Hours per day	602	639	676	713	750	787	824	861	898	935	972	1009	1046	1083
	Location (km)	603	640	677	714	751	788	825	862	899	936	973	1010	1047	1084
	Payment unit	604	641	678	715	752	789	826	863	900	937	974	1011	1048	1085
	Number of units	605	642	679	716	753	790	827	864	901	938	975	1012	1049	1086

Location code: 1=in village; 2=same district; 3=same country; 4=outside country

D. If some of the adults in the family were NOT employed in any of the non-farm employment activities in the previous month, ask the lowest payment they would be willing to accept to work:

Person name	Person number (*see hh schedule*)	Lowest payment willing to employed in off-farm work (U.Shs)	
		Agricultural work	Non-agricultural work
	1087	1088	1089
	1090	1091	1092
	1093	1094	1095
	1096	1097	1098
	1099	1100	1101

E. Time allocation by household members (The enumerator asks each household member how his/her time was utilized the previous day prior to the visit**)**

Type of activity		Number of hours spent by each household member (should add up to 12 hours)								
	Person name									
	Person number	1102								
Farm and household work										
Crop production		1103								
Livestock production		1104								
Household work		1105								
Off-farm work (specify)										
		1106								
		1107								
Schooling		1108								
Leisure (resting & social functions)		1109								

Appendix 2.1d Monthly Production and Income Schedule (Multi-visit)

Identification: Date___________
Enumerator Name ___________________ Interview start time _____ Interview end time_____
Name of household head ____________________ Name of Respondent ________________________
To be completed by supervisor:
Stratum code ________1; Sub-county (LC3/ward) _____2; Parish (LC2) ____________3;
Village (LC1) ______4; Household code ______5;
Field edit ___ Call back required ___ Call back completed ____ Office edit ____ Data entered ____

Question 1. Productivity of banana plots (Refer to general plot schedule)
1.1 What is the amount of bananas that your household produced during the previous month by type of use and cultivar? **Month**__________________6
(a) Parcel number ____________7; **Plot number** _______________8

Banana Type and Cultivar	Amount of bananas produced					
	Price per bunch if sold (U.Shs/bunch)	Total number of bunches harvested	Number Sold	Bunch weight *(in kg)*		
				Minimum	Maximum	In most cases
Cooking cultivars						
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31	32	33	34	35	36
37	38	39	40	41	42	43
44	45	46	47	48	49	50
51	52	53	54	55	56	57
58	59	60	61	62	63	64
65	66	67	68	69	70	71
72	73	74	75	76	77	78
79	80	81	82	83	84	85
86	87	88	89	90	91	92
93	94	95	96	97	98	99
Roasting						
100	101	102	103	104	105	106
107	108	109	110	111	112	113
Beer/Juice						
114	115	116	117	118	119	120
121	122	123	124	125	126	127
128	129	130	131	132	133	134
135	136	137	138	139	140	141
142	143	144	145	146	147	148
149	150	151	152	153	154	155
Dessert						
156	157	158	159	160	161	162
163	164	165	166	167	168	169
170	171	172	173	174	175	176

Other (Specify)						
177	178	179	180	181	182	183
184	185	186	187	188	189	190

(b) Parcel number ____________191; **Plot number** _______________192

Banana Type and Cultivar	**Amount of bananas produced**					
	Price per bunch if sold (U.Shs/bunch)	**Total number of bunches harvested**	**Number Sold**	**Bunch weight** *(in kg)*		
				Minimum	Maximum	In most cases
Cooking bananas						
193	194	195	196	197	198	199
200	201	202	203	204	205	206
207	208	209	210	211	212	213
214	215	216	217	218	219	220
221	222	223	224	225	226	227
228	229	230	231	232	233	234
235	236	237	238	239	240	241
242	243	244	245	246	247	248
249	250	251	252	253	254	255
256	257	258	259	260	261	262
263	264	265	266	267	268	269
270	271	272	273	274	275	276
277	278	279	280	281	282	283
Roasting						
284	285	286	287	288	289	290
291	292	293	294	295	296	297
Beer/Juice						
298	299	300	301	302	303	304
305	306	307	308	309	310	311
312	313	314	315	316	317	318
319	320	321	322	323	324	325
326	327	328	329	330	331	332
333	334	335	336	337	338	339
Dessert						
340	341	342	343	344	345	346
347	348	349	350	351	352	353
354	355	356	357	358	359	360
Other (Specify)						
361	362	363	364	365	366	367
368	369	370	371	372	373	374

1.2 Please tell us about the production and sales of cooking bananas (**not by cultivar)** in all the plots involving banana production the previous month

Parcel no.	**Plot no.**	**Number of bunches of cooking bananas harvested last month**			**Average price per bunch (U.Shs)**	**Bunch weight**		
		Consumed at home	Given away	Sold		Minimum	Maximum	Most cases
374a	374b	374c	374d	374e	374f	374g	374h	374i

1.3 Please tell us about the production and sales of crops intercropped with bananas in all the banana plots during the previous month

Parcel no.	***Plot no.***	**Crops intercropped with bananas**	**Unit measure**	**Production Output**	**Sales**			**Given away**
					Quantity	Unit price (USh)	Income (USh)	Quantity
374j	374k	374l	734m	374n	374o	374p	374q	374r

Question 2

Please tell us what the crop harvest and sales (**both fresh and dry**) were for all the other crops (except bananas) in your other plots the previous month (**include intercrops**)

Parcel no.	***Plot no.***	**Crops grown including intercrops**	**Unit measure**	**Production Output**	**Amount sold**			**Given away**
					Quantity	Unit price (USh)	Income (USh)	Quantity
375	376	377	378	379	380	381	382	383
384	385	386	387	388	389	390	391	392
393	394	395	396	397	398	399	400	401
402	403	404	405	406	407	408	409	410
411	412	413	414	415	416	417	418	419
420	421	422	423	424	425	426	427	428
429	430	431	432	433	434	435	436	437
438	439	440	441	442	443	444	445	446
447	448	449	450	451	452	453	454	455
456	457	458	459	460	461	462	463	464
465	466	467	468	469	470	471	472	473

474	475	476	477	478	479	480	481	482
483	484	485	486	487	488	489	490	491
492	493	494	495	496	497	498	499	500
501	502	503	504	505	506	507	508	509
510	511	512	513	514	515	516	517	518
519	520	521	522	523	524	525	526	527
528	529	530	531	532	533	534	535	536
537	538	539	540	541	542	543	544	545
546	547	548	549	550	551	552	553	554
555	556	557	558	569	560	561	562	563
564	565	566	567	568	569	570	571	572
573	574	575	576	577	578	579	580	581
582	583	584	585	586	587	588	589	590
591	592	593	594	595	596	597	598	599
600	601	602	603	604	605	606	607	608
609	610	611	612	613	614	615	616	617

Question 3
Please tell us what your other farm production was the previous month

Production activity	Unit	Stock/ Output	Sales			Given away
			Quantity	Unit price (U.Shs)	Income (U.Shs)	Quantity
Animals (stock)						
Cattle						
Local	618	619	620	621	622	623
Improved	624	625	626	627	628	629
Exotic	630	631	632	633	634	635
Other animals						
Goats	636	637	638	639	640	641
Sheep	642	643	644	645	646	647
Chicken	648	649	650	651	652	653
Ducks	654	655	656	657	658	659
Pigs	660	661	662	663	664	665
Rabbits	666	667	668	669	670	671
Other products (output)						
Milk	672	673	674	675	676	677
Eggs	678	679	680	681	682	683
Trees						
Poles	684	685	686	687	688	689
Timber	690	691	692	693	694	695
Firewood	696	697	698	699	700	701
Other (specify) ____________	702	703	704	705	706	707

Question 4
Please tell us if you received other income from other sources in the previous month

Type of Income	**Type of activity**	**Period**: 1=daily 2=weekly 3=monthly	**Amount of income received** (U.Shs)
Agricultural wages	708a	708	709
Non agricultural wages	710a	710	711
Salaries	712a	712	713
Self non-farm employment	714a	714	715
Renting land	716a	716	717
Renting buildings	718a	718	719
Interest	720a	720	721
Remittances	722a	722	723
Gifts	724a	724	725
Other (specify)	726a	726	727
	728a	728	729
	730a	730	731
	732a	732	733

Appendix 3.1 Labor demand estimates (first stage of the production function estimation)

Variable	central		Masaka		southwest		Overall	
	Coef.	t-value	Coef.	t-value	Coef.	t-value	Coef.	t-value
Constant	5.991**	9.02	7.104**	11.37	6.808**	15.62	6.425**	16.19
Ln(A)	0.457**	8.19	0.335**	4.19	0.36**	6.48	0.513**	13.62
Ln(w/p)	-0.755**	-4.78	-0.444*	-1.99	-0.296^	-1.7	-0.397**	-3.93
D	-0.056**	-7.16	-0.009**	-3.25	-0.06	-1.24	-0.009**	-3.94
hhsz	0.043^	1.68	0.057	1.6	0.052*	2.52	0.027	1.57
depr	-0.542*	-1.99	-0.613^	-1.96	0.018	0.09	-0.453**	-2.61
age	0.026	1.04	-0.021	-0.8	-0.005	-0.27	-0.005	-0.34
age_2	-0.0001	-0.6	0.0002	0.92	0.0001	0.43	0.0001	0.72
hplot	0.239^	1.74	0.07	0.33	0.164	1.32	0.264**	2.8
edhh	0.031*	2.23	0.018	0.78	0.009	0.83	0.025*	2.51
plotage	0.055*	2.23	0.012	0.93	0.009	1.46	0.025**	4.52
$plotage^2$	-0.002*	-2.12	-0.0001	-0.89	-0.0001	-1.53	-0.0002**	-3.2
sigatoka	-0.224	-1.10	-0.737*	-2.22	-0.578	-0.96	-4.22**	-2.68
weevilp	0.132	0.67	0.085	0.4	-0.261^	-1.85	-0.005	-0.04
Adj. R-squared	0.421		0.425		0.408		0.482	

Appendix 3.2 Effect of soil pH and texture on soil nutrient availability and productivity

Variable	Ln(SOM) (OLS)		Ln(N) (2SLS[1])		Ln(K) (2SLS[1])		Ln(y) (OLS)	
	Coef.	t-value	Coef.	t-value	Coef.	t-value	Coef.	t-value
Constant	2.131**	14.22	-4.684**	-15.58	-4.516**	-10.1	0.515	0.422
Ln(A)							0.308**	2.63
Ln(L)							0.69**	6.87
sand	-0.012**	-4.96					0.025**	3.11
pH					0.495**	4.69	0.206	1.54
Ln(SOM)			1.057**	5.01	0.957**	2.81		
M			1.6e-05	1.81			9.8e-05**	2.92
C					7.5e-05*	2.19	3.1e-05	0.42
plotage							0.034**	3.36
$plotage^2$							-0.0003**	-2.67
sigatoka							-1.09*	-2.44
Masaka	0.171**	3.14	1.055**	13.42	-0.054	-0.48		
southwest	0.054	1.04	1.207**	21.08	-0.031	-0.36		
Adj. R-squared	0.271		0.832		0.583		0.624	

**, *, ^ imply significant and 1%, 5% and 10% respectively.

Appendix 4.1 Determinants of labour use for different crops, central Uganda (Robust standard errors)

Variables	All crops[1]	bananas	Coffee	maize	s. potato	cassava	beans
n	294	246	105	177	142	171	183
Constant	7.949**	6.632**	2.538**	8.644**	7.393**	7.136**	6.172**
	(10.5)	(6.78)	(2.78)	(6.5)	(4.78)	(7.16)	(7.43)
Ln (a)	0.217	0.474**	0.29*	0.457**	0.627**	0.218^	0.472**
	(1.56)	(4.44)	(2.19)	(4.73)	(3.43)	(1.88)	(3.73)
Ln (w/p)	-0.46	-0.862^	-0.713*	-0.833*	-0.55	-0.679	-1.158**
	(-1.49)	(-2.05)	(-2.49)	(-2.15)	(-0.93)	(-1.45)	(-3.05)
hhsz	0.085*	0.04	0.04	0.004	0.011	0.005	0.028
	(2.55)	(1.57)	(0.93)	(0.09)	(0.33)	(0.19)	(0.71)
depr	-0.669**	-0.526*	0.431	-0.62^	0.113	0.028	-0.442
	(-3.53)	(-2.41)	(0.81)	(-2.12)	(0.27)	(0.55)	(-1.08)
D	-0.001	-0.057*	0.094**	0.09	-0.015	-0.023	-0.013
	(-0.07)	(2.55)	(7.16)	(0.84)	(-0.73)	(-0.79)	(-0.69)
Age	-0.022	0.024	0.008	-0.084^	-0.042	-0.038	0.016
	(-0.82)	(0.88)	(0.2)	(-1.92)	(-1.06)	(-1.1)	(0.57)
Age^2	0.0003	-0.0001	0.0001	0.0008^	0.0004	0.0004	-0.0002
	(1.05)	(-0.48)	(0.23)	(2.05)	(0.98)	(1.11)	(-0.7)
Gender	-0.009	-0.092	0.377	-0.002	0.064	0.232	0.226
	(-0.08)	(-0.47)	(1.51)	(-0.01)	(0.29)	(1.06)	(1.39)
edhh	0.015	0.033	0.064*	0.017	0.042^	-0.0003	-0.023
	(0.84)	(1.72)	(2.16)	(1.56)	(1.89)	(-0.01)	(-0.91)
R^2	0.239	0.431	0.505	0.5	0.239	0.118	0.491

^, * and ** represent 10%, 5% and 1% level of significance
[1]Value of production

Appendix 4.2 Determinants of labour use for different crops, Masaka (Robust standard errors)

Variables	All crops[1]	bananas	coffee	maize	s. potato	cassava	beans
n	129	126	69	60	30	35	65
Constant	6.806**	6.536**	4.939**	8.151**	4.698**	3.856	6.979**
	(15.00)	(11.24)	(3.97)	(4.27)	(2.87)	(1.47)	(4.9)
Ln (a)	0.182	0.362**	0.175	0.663**	0.631**	0.399	0.08
	(3.11)	(4.19)	(0.79)	(3.2)	(2.73)	(1.49)	(0.36)
Ln (w/p)	-0.048	-0.674**	-1.55**	-0.245	2.323*	-0.081	0.521^
	(-0.36)	(-4.1)	(-2.84)	(-0.75)	(2.45)	(-0.13)	(1.88)
hhsz	0.013	0.041	0.002	0.098	-0.121	-0.142	0.065
	(0.5)	(1.11)	(0.04)	(1.29)	(-1.45)	(-1.08)	(1.09)
depr	-0.246	-0.529*	-0.175	-0.608	0.187	-0.002	-1.742
	(-1.08)	(-2.04)	(-0.32)	(-0.69)	(0.23)	(-0.01)	(-2.43)
Gender	0.132	0.111	0.162	-1.166*	1.441**	-0.174	-0.664^
	(1.13)	(0.65)	(0.51)	(-2.53)	(6.01)	(-0.41)	(-1.68)
Age	0.017	-0.007	-0.045	-0.058	0.052	0.05	-0.033
	(0.95)	(-0.25)	(-0.83)	(-0.81)	(0.85)	(0.46)	(-0.58)
Age^2	-0.0001	0.0001	0.0004	0.0004	-0.0004	-0.0005	0.0003
	(-0.83)	(0.52)	(0.73)	(0.49)	(-0.71)	(-0.47)	(0.63)
edhh	0.002	-0.007**	0.008	0.026	0.009	0.087	-0.061
	(0.13)	(-3.08)	(0.21)	(0.46)	(0.18)	(1.62)	(-1.27)
D	-0.001	-0.007**	0.142	0.006	-0.32*	0.012	0.014**
	(-0.74)	(-3.08)	(3.97)	(1.24)	(-2.41)	(1.63)	(3.43)
R^2	0.133	0.457	0.217	0.321	0.599	0.325	0.288

^, * and ** represent 10%, 5% and 1% level of significance; [1] value of production

Appendix 4.3 Determinants of labour use for different crops, southwest Uganda (Robust standard errors)

variable	all crops[1]		bananas		Millet		sweet potato		beans	
	t-value	coef	t-value	coef	t-value	coef	t-value	coef	t-value	coef
n	138		138		49		36		99	
Constant	6.472**	16.88	6.529**	17.36	7.618**	7.88	5.891*	2.27	4.05**	4.9
Ln (a)	0.229**	4.69	0.374**	5.35	0.346**	3.43	0.054	0.13	-0.005	-0.1
Ln (w/p)	0.262*	2.01	-0.246^	-1.9	-0.674	-0.8	-1.12	-1.5	0.943*	2.05
hhsz	0.055**	3.49	0.042*	2.04	0.097*	2.55	0.019	0.15	0.028	0.89
depr	-0.021	-0.13	0.03	0.16	-0.766	-1.7	-0.216	-0.2	-0.095	-0.2
Gender	0.206^	1.98	0.267*	2.47	0.113	0.52	0.11	0.18	0.232	0.92
Age	0.004	0.21	0.009	0.55	-0.08^	-2.0	-0.047	-0.5	0.01	0.36
Age^2	-0.00003	-0.17	-0.0001	-0.34	0.0007^	1.83	0.0005	0.48	-0.0001	-0.2
Edhh	-0.007	-0.81	0.002	0.18	-0.008	-0.5	0.047	0.75	0.032^	1.73
D	-0.0002	-0.07	-0.006*	-2.22	-0.007	-0.9	0.011	0.22	0.033**	4.15
R^2	0.446		0.445		0.451		0.073		0.321	

^, * and ** represent 10%, 5% and 1% level of significance; [1] value of production

Appendix 5.1 First stage estimates of labour supply of household head (prediction of shadow wage), robust standard errors

Variable	central Coefficient	t-value	Masaka Coefficient	t-value	southwest Coefficient	t-value	overall Coefficient	t-value
C	1.199	0.77	4.477**	8.35	6.486**	4.44	2.874**	2.82
Ln(a)	-0.056	-0.55	0.114**	3.68	0.131**	4.07	0.013	0.20
Ln(w)	0.511^	1.97	0.126^	1.67	-0.197	-0.75	0.271	1.64
D	0.011	0.99	0.001	1.80	-0.007**	-3.00	0.001	0.88
hhland	0.021**	3.17	0.008**	9.16	0.018**	7.04	0.012**	4.40
hhsize	-0.055*	-2.44	-0.016	-0.97	-0.028*	-2.26	-0.044**	-3.6
depratio	0.322^	1.95	0.169	1.13	0.041	0.31	0.312**	3.19
postprim	0.008	0.38					0.026	1.60
gender			-0.084	-1.13	-0.215**	-2.76	-0.03	-0.66
age	0.017	1.59	-0.015	-1.38	0.008	0.65	0.009	1.30
age^2	-0.0002^	-1.9	0.0002	1.55	-0.0001	-0.76	-0.0001	-1.6
educ	-0.005	-0.48			0.012^	1.76	-0.006	-0.79
Credit	0.0004^	1.84			-0.001	-0.48	0.0004	1.59
southwest							0.858**	6.10
Masaka							0.381**	2.98
R^2	0.245		0.283		0.344		0.441	

Appendix 5.2 First sate estimates of labour supply of household head (prediction of shadow income), robust standard errors

Variable	central Coefficient	t-value	Masaka Coefficient	t-value	southwest Coefficient	t-value	overall Coefficient	t-value
C	11.108**	10.17	13.37**	37.79	17.552**	12.31	12.30**	17.20
Ln(a)	-0.03	-0.35	0.141**	6.18	0.186**	6.06	0.039	0.78
Ln(w)	0.293	1.53	0.031	0.58	-0.689**	-2.69	0.135	1.14
D	0.005	0.63	0.0003	0.62	-0.012**	-5.22	-0.0001	-0.13
hhland	0.018*	2.64	0.008**	14.00	0.018**	6.72	0.012**	4.54
hhsize	-0.064**	-5.38	-0.039**	-3.19	-0.044**	-4.02	-0.057**	-7.07
depratio	0.501**	3.35	0.314**	2.78	0.308*	2.54	0.476**	5.17
postprim	0.024	1.24					0.031*	2.24
gender			-0.109*	-2.36	-0.204**	-2.72	-0.084*	-2.17
age	0.011	1.26	-0.007	-0.94	0.008	0.74	0.003	0.51
age^2	-0.0001	-1.43	0.0001	0.76	-0.0001	-0.90	-0.00005	-0.76
educ	-0.014*	-2.52			0.013^	1.74	-0.008	-1.39
Credit	0.0004*	2.62			-0.001	-1.51	0.0003	1.64
southwest							0.768**	7.21
Masaka							0.309**	3.70
R^2	0.237		0.479		0.301		0.483	

Appendix 5.3 First stage estimates of labour supply of second household member (prediction of shadow wage), robust standard errors

Variable	central		Masaka		southwest		overall	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
C	2.349	1.22	5.292**	8.27	7.544**	5.23	3.73**	3.26
Ln(a)	-0.044	-0.42	0.099^	1.81	0.117**	3.61	0.009	0.14
Ln(w)	0.423	1.44	-0.051	-0.51	-0.415	-1.55	0.18	0.98
D	0.008	0.63	0.0006	0.61	-0.007**	-3.34	0.0003	0.16
hhland	0.019*	2.63	0.008**	7.48	0.022**	5.73	0.012**	4.44
hhsize	-0.036*	-2.45	-0.027	-1.36	-0.023^	-1.68	-0.026*	-2.21
depratio			0.368	1.54	0.283^	1.93	0.294**	2.87
postprim			0.055	1.46			0.028^	1.71
babies	0.074*	2.56			-0.07*	-2.06		
gender	-0.111	-1.46	0.146^	1.97	0.211	1.00		
age	-0.018*	-2.29	-0.009	-0.83	0.006	0.39	-0.013	-1.98
age^2	0.0002*	2.61	0.0001	0.69	-0.0001	-0.65	0.0002^	1.79
educ			-0.016	-1.08	-0.004	-0.42	-0.008	-1.1
Credit	-0.001	-1.17					-0.0006	-1.44
southwest							0.799**	5.44
Masaka							0.408**	2.85
R^2	0.174		0.247		0.333		0.421	

Appendix 5.4 First sate estimates of labour supply of second household member (prediction of shadow income), robust stand errors

Variable	central		Masaka		southwest		overall	
	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value	Coefficient	t-value
C	11.675**	8.04	13.745**	30.64	18.87**	14.24	12.781**	15.23
Ln(a)	-0.018	-0.2	0.118**	2.97	0.148**	4.97	0.032	0.63
Ln(w)	0.278	1.22	-0.072	-1.04	-0.921**	-3.95	0.064	0.47
D	0.004	0.41	-0.0003	-0.38	-0.012**	-5.74	-0.001	-0.74
hhland	0.018*	2.26	0.008**	10.00	0.021**	5.15	0.012**	4.38
hhsize	-0.037**	-4.83	-0.031*	-2.13	-0.035**	-3.16	-0.038**	-4.92
depratio			0.465*	2.65	0.506**	4.17	0.534**	5.73
postprim			0.03	1.12			0.031*	2.41
babies	0.088**	3.10			-0.032	-0.96		
gender	-0.033	-0.4	0.069	0.96	0.0001	0.55		
age	-0.019**	-3.3	-0.008	-1.07	-0.01	-0.75	-0.014**	-2.9
age^2	0.0003**	3.82	0.0001	0.73	0.0001	0.55	0.0002*	2.62
educ			-0.008	-0.78	0.002	0.17	-0.007	-1.24
Credit	-0.0004	-1.59					-0.000^5	-1.98
southwest							0.733**	6.45
Masaka							0.333**	3.43
R^2	0.14		0.424		0.484		0.474	

Appendix 5.5 Labour supply estimates (farm + off-farm) of household heads (2SLS), robust standard errors

variable	Central		Masaka		Southwest		Overall sample	
	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value
C	-22.07	-1.09	18.392	0.38	-122.55*	2.28	21.194	1.35
Ln(w*)	1.606	1.02	-2.298	-0.62	8.831*	2.28	-1.398	-0.55
Ln(M*)	9.064^	1.86	0.185	0.02	24.633*	2.45	-1.905	-1.41
lnw* x lnm*	-0.59	-1.63	0.192	0.27	-1.724*	-2.4	0.21	1.02
ln(w)	-0.564*	-2.5			-0.372	-1.08	-0.162	-0.76
Ln(a)	0.084*	2.61	-0.016	-0.2	-0.081	-1.10	0.062*	2.54
D	-0.025**	-3.29	-0.0004	-0.35	-0.013**	-3.52	-0.004	-1.11
hhland	-0.016	-1.69	-0.0174*	-2.53	0.021	1.17	-0.012*	-2.14
postprim	0.038^	2.07					0.026	1.62
gender	0.503**	6.5	0.211*	2.25	0.279^	1.83	0.337**	6.02
age			0.026	1.33				
age^2			-0.0003	-1.48				
educ	-0.002	-0.21			-0.003	-0.31	0.007	1.15
Credit	-0.001**	-3.5			0.002	1.43	-0.001**	-3.92
southwest							-0.458	-1.18
Masaka							-0.171	-0.83
R^2	0.348		0.263		0.362		0.199	

^, * and ** represent 10%, 5% and 1% level of significance

Appendix 5.6 Labour supply estimates (farm + off-farm) of second eldest household member (2SLS), robust standard errors)

variable	Central Coeff.	t-value	Masaka Coeff.	t-value	Southwest Coeff.	t-value	Overall Coeff.	t-value
C	-42.498	-1.12	-31.413	-0.35	-114.3*	-2.06	33.667*	2.44
Ln(w*)	11.403	1.53	35.477^	1.91	23.661*	2.03	-4.387	-1.51
Ln(M*)	3.309	1.06	-2.859	-0.31	8.535^	1.74	-2.923	-2.71
lnw* x lnm*	-0.866	-1.45	-1.633	-1.44	-1.703*	-2.32	0.421	1.99
ln(w)			0.311**	3.08	-0.595	-0.71		
Ln(a)	0.018	0.64	-0.088	-0.82	0.002	0.02	0.051	2.08
D	-0.003	-0.73	-0.01	-1.37	-0.012*	-2.56		
hhland	-0.002	-0.39	-0.013	-0.71	0.032	0.61	-0.013	-2.78
depratio	-0.166	-1.69						
postprim			-0.447	-1.53			0.002	0.11
gender	0.349^	1.86	-1.294	-1.57	0.153	0.31	0.223	1.92
age	0.021	1.34	0.103^	1.91	0.028	0.46	0.047	4.04
age^2	-0.0002	-1.22	-0.001*	-2.03	-0.0003	-0.33	-0.001	-4.12
educ	0.012	1.37	0.119	1.24	-0.016	-0.54	0.003	0.36
Credit							0.001	1.21
southwest							-0.13	-0.59
Masaka							-0.005	-0.04
R^2	0.207		0.327		0.191		0.161	

^, * and ** represent 10%, 5% and 1% level of significance

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Summary

The economic performance rapidly deteriorated in the sub-Saharan Africa in the late 1970s and early 1980s and has continued to decline or stagnate for the past two decades. The poor performance has been partly attributed to deep rooted institutional and structural constraints (geographic, demographic and cultural factors). However, this line of argument fails to provide satisfactory explanation for the rapid but unsustainable growth in the immediate post-independence period. Also it does not explain why most countries have had a poor response to structural adjustment programmes, even where the adjustment policies have been vigorously implemented.

Market liberalization and structural adjustment policies succeeded in stabilizing the economy and contributed to reducing poverty, but sustained development has not yet been achieved. Strategies that will lead to sustained development in the rural sector are needed. This study analyses the factors that influence smallholder agricultural production dynamics in Uganda. In particular, the economic factors that have contributed to the decline in banana production in central Uganda and production increase in the southwest are investigated. Findings contribute to the better understanding of changes in smallholder agricultural productions systems in general. In particular, the study comes up with policies that could contribute to the sustained development of the rural sector in Uganda.

The study addresses the following research questions:

(1) What are the characteristics of the different study regions and how do they influence the banana production dynamics?
(2) What influences banana productivity and technical efficiency of banana farmers?
(3) How efficient are smallholder farmers in using farm resources?
(4) How do changes in economic factors impact on resource allocation decisions of smallholder farmers
(5) What are the factors that influence family labour supply and farm labour demand?

Chapter 2 characterizes the study regions and banana production systems in Uganda and assess the competitiveness of the banana sub-sector in three different regions (central, Masaka and southwest). Results show that demographic characteristics are the same between the three regions. Average farm size is highest in the central region and lowest in the southwest. This result is consistent with assertion that population is higher in high altitude areas: hence the small farm sizes in the southwest. Labour allocated to banana production is greatest in the southwest and lowest in the central region. Most labour is allocated to crop sanitation in the southwest while in the central region the proportion of labour allocated to weeding is higher compared to crop sanitation.

Farm wage rates are highest in the central region and lowest in the southwest. The high wage rates in the central region reflect a higher level of market development for

unskilled labour. Households in the central region obtain most of their income from nonfarm self-employment while in the southwest greatest earnings are obtained from crop production. Income share of nonfarm wage employment is highest in the southwest and lowest in the central region. Most household members who work off-farm in the southwest are employed in the wage sector unlike in the central region where most are self employed.

Input use is very low in the study areas. The amount of animal manure used is higher in the southwest where it is three times the amount used in the central region. The pattern of use of other organic amendments (grass and crop residues) is similar to that of animal manure. More farmers use crop residues than those that use animal manure and grass mulch. Access to credit is limited to a few farmers and the amount accessed is also low.

Commodity prices are highest in the central region, where most of the largest urban centres are located. This reflects high demand for food in the region and most households consume from own production as they cannot afford to buy from the market.

Gross margin analysis shows that banana production is more competitive in the southwest. Cost of banana production is lowest in Masaka where returns to family labour are highest. Satisfying subsistence requirements appears to be the overriding factor in making resource allocation decisions in the central region. Hence, farmers decide to grow more of annual food crops (sweet potatoes, cassava and maize) even when bananas appear to be the most profitable in terms of gross margin. Cassava and sweet potatoes, which have low labour requirements, are preferred over maize and millet.

In Chapter 3, the productive efficiency of a sample of banana farmers is examined. Results show that labour input contributes most to banana productivity in the central region and the southwest, while in Masaka higher productivity is from increased acreage. Farm size has a positive effect on output, implying that farmers with large farm sizes produce more output per unit land and labour. Access to agricultural extension has a positive and significant effect on banana productivity in the southwest but not in Masaka and the central region. Moreover, farmers in the southwest are the least visited by extension staff and the proportion of farmers visited is also small.

The output share of labour (in comparison with crop area) is highest for the central region and least for Masaka. This implies that farmers in the central region would benefit most from increasing the labour use intensity if the labour market conditions were the same as in the other regions. Increasing labour use intensity in the central region is limited by the high cost of labour in the region and probably the many options that are open for unskilled labour.

The production functions for all the three regions exhibit decreasing returns to scale implying that farmers would lose efficiency by increasing plot sizes under bananas. Results also show that, on average, banana farmers are technically inefficient, implying that there is a potential of increasing production through improved technical efficiency especially in the central region. In the central region, higher access to credit and tarmac roads improves technical efficiency. Households that are more frequently visited by extension staff are more technically efficient than those that are less frequently visited. In Masaka, more education increases technical efficiency while better access to good roads reduces technical efficiency. In the southwest region, technical efficiency is lower for households that are located near to the tarmac road.

Findings show that banana productivity responds positively to changes in soil pH and sand content in the soil. Black Sigatoka has a negative impact on banana productivity while application of manure has a positive effect on banana productivity. The effect of crop residues on banana productivity is positive but not significant.

The question of whether smallholder farmers in Uganda allocate their labour efficiently is examined in chapter 4. The null hypothesis that production and consumption decisions are separable is also tested. Rejection of this hypothesis is an indicator that there are imperfections in the labour market, the food market or both, and production decisions are influenced by consumption side variables.

In the central region, results from production functions show that output share of labour is higher for most crops except maize and cassava. Farm size has a positive effect on crop output, with the exception of maize and cassava, contrasting the view that small farmers are more efficient than large farmers. In Masaka, high elasticities of labour are obtained for coffee, sweet potatoes and beans. Farm size has a positive effect on crop output except for sweet potatoes and cassava. In the southwest, labour elasticities are highest for bananas. Farm size has a positive effect on crop output except for beans.

Apart from coffee in Masaka and bananas in the southwest, the rest of the crops have the marginal value products well below the market wage rates implying that more labour, than is optimal, is used in their production. The joint null hypothesis of a = 0 and b = 1 in the equation: $\ln(mpl) = a + b\ln(w^*) + e$ is rejected in all the cases implying that farmers allocate their labour inefficiently. Inefficient allocation of labour is an indication of the presence of imperfections in the labor market and/or the food market.

Selection of farm crop enterprise and the level of products and inputs used are highly influenced by the returns to land and to labour from each crop, which is indicative of optimization behaviour by the smallholder farmers. In the central region, returns to land are highest for sweet potato while returns to labour are highest for bananas. Both crops are allocated a significant share of the land. In Masaka returns to land are highest in banana production while returns to labour are highest in coffee production. Most of the land under crops (54%) in the region is allocated to these two crops. In the southwest, both returns to land and returns to labour are highest in banana production. Most of the land under crops (51%) is allocated to bananas. Labour allocated to crops is positively correlated with returns to land per acre in the central region but not in Masaka and the southwest. Banana production is positively correlated with returns to land per acre, the correlation being stronger in the central region.

The factors that influence labour supply and demand for hired labour are analyzed in chapter 5. Findings show that household members respond positively to increases in shadow wages and negatively to increases in shadow incomes, which implies that they respond to economic incentives. The positive effect of shadow wage is indicative of the positive response by household members to increases in labour productivity. The negative effect of shadow income is indicative of leisure being a normal good and thus increases in income levels result to a decrease in work hours.

Mixed results are obtained for the effect of wage rate on labour supply. In the central region and southwest, higher wage rate is associated with lower work hours for household members. In Masaka, the price effect of wage rate on labour supply is positive and dominates the negative income effect. The overall effect on labour supply of wage rate is positive.

The overall effect of distance from tarmac road on labour supply is negative for the central region and southwest and positive for Masaka. This implies that household members in remote areas in the central region and southwest supply less labour while the opposite is true for Masaka.

The effect of wage rate on labour demand is negative in the southwest and Masaka but not in the central region. However, the effect of wage rate on the probability of using hired labour in the central region is negative implying that fewer households use hired labour at higher wage rates. In Masaka, higher probability of using hired labour is associated with higher wage rates. In the southwest, both the probability of hiring labour and work hours of hired labour are negatively related to wage rate.

Household size has no significant effect on the amount of hired labour used by farmers implying that the economic rationing of hiring labour is not influenced by family size and composition. High education levels increase the probability of using hired labour, in the central region and Masaka. However, the effect of wage rate on work hours in both regions is not significant. Distance to tarmac road has a negative effect on demand for hired labour in the southwest but the effect is not significant (P=0.05). However, exogenous income positively affects hired labour demand in the southwest.

Results from the analysis of time allocation between farm production and off-farm activities show that household members with higher shadow wages allocate more of their time to off-farm activities while those with lower shadow wages allocate more of their time to farm production. This is indicative of a higher productivity of labour in the off-farm sector compared to the farm sector. The results also show that education level and access to tarmac roads have a positive effect on time allocated to the off-farm activities. This implies that increasing education levels and improving the road conditions increase the opportunity cost of labour in off-farm activities, and thus positively affecting the amount of time allocated to

those activities. Farm size significantly reduces the amount of time allocated to off-farm activities in the central region and southwest. This implies that most household members are pushed into off-farm employment because of constraints in accessing land for farm production.

The study ends with policy implications for improving productivity and employment for smallholder farmers in Uganda. The study reveals over employment of labour in the farm sector. Policies that will improve employment in the off-farm sector are needed to absorb the surplus labour from the agricultural sector. Increased access to education and improving the road infrastructure are necessary to enable the development of the off-farm sector. This would in turn increase the farm size and hence productivity through adoption of modern farming methods. Better roads and promoting financial institutions that are suited to the needs of smallholder farmers are likely to improve productivity and technical efficiency in the central region. In Masaka, increased access to formal education is likely to increase productive efficiency in the region. In the southwest, increased access to extension services is likely to improve productivity and efficiency. Overall, policies that reduce transaction costs are likely to improve productivity and efficiency both in the farm sector and the off-farm sector.

Landbouw en toegang tot de markt: bananen productie in Oeganda.

Samenvatting (Summary in Dutch)

In Afrika bezuiden de Sahara stagneerde de economische groei aan het einde van de jaren 70 en begin jaren 80 en zij heeft sindsdien geen verbetering laten zien. Deze slechte resultaten zijn deels toegeschreven aan diepgewortelde institutionele en structurele beperkingen (geografische, demografische en culturele factoren). Dit argument strookt echter niet met de snelle, zij het kortstondige, groei in de periode kort na de onafhankelijkheid. Het verklaart ook niet waarom de meeste landen geen positieve respons hebben laten zien op de structurele aanpassingsprogramma's, zelfs niet waar deze rigoureus ten uitvoer zijn gebracht.

Liberalisatie van de markten en het structurele aanpassingsbeleid slaagden er in de economie te stabiliseren en droegen bij aan armoedevermindering, maar duurzame ontwikkeling werd nog niet tot stand gebracht. Er is behoefte aan strategieën voor een duurzame ontwikkeling in de landbouwsector. Deze studie analyseert de factoren die een invloed hebben op de ontwikkeling van de landbouwproductie van kleine boeren in Oeganda. In het bijzonder worden de economische oorzaken van de afname van de bananenproductie in centraal Oeganda en toename in het Zuidwesten onderzocht. De bevindingen dragen bij tot een beter begrip van veranderingen in landbouwproductiesystemen in het algemeen. Meer in het bijzonder oppert de studie enkele beleidsmaatregelen die bijdragen aan duurzame ontwikkeling van de landbouwsector in Oeganda.

De studie richt zich op de volgende vragen:

1. Welke zijn de kenmerken van de onderscheiden onderzoeksregio's en hoe werken deze door op de ontwikkeling van de bananenproductie?
2. Welke factoren zijn van invloed op productiviteit en efficiëntie van bananenproducenten?
3. Hoe efficiënt zijn kleine boeren in het aanwenden van hun hulpbronnen?
4. Hoe werken veranderingen in economische factoren door op de toewijzing van de hulpbronnen van kleine boeren?
5. Welke factoren zijn van invloed op het aanbod van familiearbeid en op de vraag naar arbeid op het bedrijf?

Hoofdstuk 2 kenschetst de onderzoeksgebieden en de productiesystemen van bananen in Oeganda en bepaalt het concurrentievermogen van de bananensector in drie verschillende regio's: Central, Masaka en Southwest. De cijfers laten zien dat de bevolkingskenmerken in de drie regio's gelijk zijn. De gemiddelde bedrijfsomvang is het grootst in Southwest en het kleinst in Central. In Southwest wordt arbeid vooral gebruikt om ziektes te bestrijden, terwijl

in Central de meeste arbeid wordt gebruikt voor het wieden. Agrarische lonen zijn het hoogst in Central en het laagst in Southwest. De hoge lonen in Central zijn een afspiegeling van de daar al ontwikkelde arbeidsmarkt voor ongeschoold werk. Huishoudens in de Central regio halen het merendeel van hun inkomen uit eigen ondernemingen buiten het bedrijf, terwijl in het Zuidwesten het de gewassen zijn die het meeste bijdragen. Het aandeel van betaald werk buiten het bedrijf is het hoogste in het Zuidwesten en het laagste in Central.

Het gebruik van andere productiemiddelen is zeer gering; wel wordt in het Zuidwesten veel meer stalmest en ander organisch materiaal gebruikt dan in Central. Vooral gewas- en oogstresten worden er benut. De toegang tot krediet is beperkt tot enkele boeren en de geleende bedragen zijn gering.

Prijzen zijn het hoogst in Central als gevolg van de grote vraag naar voedsel in de steden in de regio. De meeste boeren kunnen zich dit niet veroorloven en beperken zich tot consumptie van eigen productie. Een analyse van de bruto marges laat zien dat bananenproductie meer concurrerend is in het Zuidwesten. De kosten zijn het laagst in Masaka en de arbeidsopbrengsten zijn er het hoogst. In Central lijken het vooral overwegingen van eigen voedselvoorziening te zijn die de allocatie van middelen bepalen en boeren verbouwen veleer zoete aardappel en cassave dan de winstgevender bananen. Deze voedselgewassen hebben een lage arbeidsintensiteit.

In hoofdstuk 3 wordt de efficiëntie van de productie van een selecte steekproef van de boeren bepaald. De resultaten laten zien dat in Central en Southwest de arbeidselasticiteiten hoog zijn, terwijl in Masaka dat de productie-elasticiteit van grond is. De omvang van het bedrijf heeft een positief effect op de productie, zodat grotere bedrijven meer produceren per eenheid land of arbeid. Toegang tot landbouwvoorlichting heeft een significant positief effect in het Zuidwesten, maar niet in Masaka of Central. Bezoeken van voorlichters in het Zuidwesten zijn echter schaars en beperkt tot enkele boeren.

De hoge scores voor de productie-elasticiteit van arbeid in Central en de lage in Masaka zouden aangeven dat boeren in Central baat hebben bij grotere inzet van arbeid, als de lonen hetzelfde waren als elders. De hoge lonen in Central en de ruime mogelijkheden voor ander werk beperken echter die grotere inzet van arbeid.

De geschatte productiefuncties laten in alle regio's afnemende schaalopbrengsten zien en boeren met grotere percelen zouden dus minder efficiënt zijn. Gemiddeld blijken de boeren ook technisch inefficiënt te zijn. Er zijn dus mogelijkheden tot verbetering, vooral in de Central Region. In Central blijkt de efficiëntie positief samen te hangen met bezoeken van voorlichters en met toegang tot krediet en goede toegangswegen. In Masaka, is het vooral opleiding die het verschil maakt, terwijl in Masaka en Southwest de nabijheid van een goede weg de efficiëntie verlaagt.

Er zijn ook resultaten afgeleid voor de invloed van grondsoort. *Black Sigatoka* ziekte werkt negatief uit en het gebruik van mest positief. Het effect van de gewasresten die vaak worden gebruikt is positief, maar niet significant.

De vraag of de kleine boeren in Oeganda hun arbeid efficiënt aanwenden wordt besproken in hoofdstuk 4. De nulhypothese dat productie en consumptie separeerbaar zijn wordt ook getest. Het verwerpen van deze hypothese geeft aan dat er imperfecties optreden in de arbeidsmarkt, de voedselmarkt of beide. In dat geval worden productiebeslissingen beïnvloed door variabelen aan de consumptiekant.
In Central, blijken de productie-elasticiteiten van arbeid hoog te zijn, behalve voor maïs en cassave. Bedrijfsgrootte heeft een positief effect (met weer een uitzondering voor deze twee gewassen) op productie in tegenstelling tot de algemene mening dat kleine boeren meer efficiënt zijn dan grote. In Masaka worden hoge elasticiteiten gevonden voor koffie, zoete aardappelen en bonen. Ook hier heeft bedrijfsgrootte een positief effect, behalve voor zoete aardappel en cassave. In Southwest, zijn de elasticiteiten het hoogst voor bananen en heeft de omvang positieve effecten behalve op bonenproductie.

Op koffie en bananen in Masaka na, geldt voor alle gewassen dat de marginale geldopbrengst van arbeid ver onder het marktloon ligt, zodat er blijkbaar meer arbeid wordt ingezet dan wat optimaal is. De hypothese dat zowel $a=0$ als $b=1$ in de vergelijking $\ln(mpl) = a + b\ln(w^*) + e$ wordt in alle gevallen verworpen. Boeren alloceren hun arbeid dus niet efficiënt. Deze inefficiëntie wijst op het bestaan van imperfecties in de arbeid- en/of voedselmarkt.

De gewaskeuze, het productieniveau en de inzet van productiemiddelen hangen nauw samen met de opbrengsten per eenheid land of arbeid van elk gewas. Dit wijst op een optimaliserend gedrag van de kleine boeren. In Central geven zoete aardappelen de hoogste opbrengst per ha en bananen de hoogste opbrengst per dag. Beide gewassen worden veel verbouwd. In Masaka zijn de ha-opbrengsten het hoogst voor bananen en de arbeidsopbrengsten het hoogst voor koffie. De twee gewassen beslaan meer dan de helft (54%) van de oppervlakte in deze regio. In het Zuidwesten worden de hoogste opbrengsten, per dag en per ha, opgetekend voor bananen en 51% van het land wordt aan de teelt besteed. In Central loopt de inzet van arbeid gelijk op met de ha-opbrengsten, maar in andere regio's niet. Bananenproductie neemt toe als de beloning van grond toeneemt, met de sterkere correlatie in Central.

De factoren die van invloed zijn op aanbod van gezinsarbeid en vraag naar ingehuurde arbeid worden onderzocht in hoofdstuk 5. De resultaten laten zien dat leden van het huishouden positief reageren op veranderingen in het schaduwloon en negatief op die in het schaduwinkomen. Zij zijn dus gevoelig voor economische prikkels. Het effect van het schaduwloon wijst op een positieve respons op verbeteringen in de arbeidsproductiviteit; het negatieve inkomenseffect geeft aan dat vrije tijd een normaal goed is en een hoger inkomen leidt tot minder arbeidsaanbod. De schattingen van de effecten van de heersende loonvoet op het arbeidsaanbod gaven een gemengd beeld. Alleen in Masaka kon een positief effect ervan op het aanbod van gezinsarbeid worden gevonden. Dit positieve prijseffect domineert het negatieve inkomenseffect en het uiteindelijke effect op arbeidsaanbod is positief.

Het effect van afstand tot de verharde weg op het arbeidsaanbod is negatief in Central en Southwest, maar positief in Masaka. Huishoudens in afgelegen gebieden in de eerste regio’s bieden dus minder arbeid aan, terwijl het tegenovergestelde opgaat voor Masaka.

De vraag naar arbeid wordt negatief beïnvloed door de loonvoet in het Zuidwesten en Masaka, maar niet in Central. Niettemin is daar de kans dat men arbeid inhuurt wel weer kleiner als het loon hoger is, evenals in het Zuidwesten. In Masaka is de kans dat er arbeid wordt ingehuurd groter bij hoger loon.

Gezinsgrootte heeft geen significant effect op de hoeveelheid arbeid die wordt ingehuurd. Kennelijk is deze beslissing niet gerelateerd aan het huishouden of zijn samenstelling. Een hogere opleiding vergroot de kans dat arbeid wordt ingehuurd in Central en Masaka. In het Zuidwesten heeft exogeen inkomen een positief effect op de vraag naar ingehuurde arbeid, terwijl afstand tot de verharde weg een, niet significant, negatief effect heeft.

Huishoudens met hogere schaduwlonen investeren meer tijd in werk buiten het bedrijf dan in het werk op het eigen bedrijf. Dit wijst op een hogere arbeidsproductiviteit buiten de landbouw. Hogere opleiding en nabijheid van de verharde weg hebben ook een positieve invloed. In Central en Southwest heeft de bedrijfsomvang een duidelijk negatief effect op werk buiten het bedrijf en gezinsleden op kleine bedrijven worden dus als het ware van het bedrijf uigesloten.

De studie eindigt met de beleidsimplicaties ter bevordering van de productiviteit en werkgelegenheid van kleine boeren in Oeganda. De studie toont bovenmatige inzet van arbeid op het eigen bedrijf aan, en er is beleid nodig dat de inzet deze arbeid buiten het bedrijf bevordert. Verruimde toegang tot opleiding en verbetering van de infrastructuur zijn nodig om werkgelegenheid buiten het bedrijf te scheppen. Dit zou uiteindelijk ook de bedrijfsgrootte laten toenemen en daarmee de productiviteit door aanwenden van nieuwe technieken. Betere toegangswegen en bevordering van financiële instellingen die aansluiten bij de behoefte van de boer zouden waarschijnlijk productiviteit en technische efficiëntie verhogen, althans in Central. In Masaka vergt dit betere opleiding. In het algemeen zal beleid dat de transactiekosten vermindert, de productiviteit in zowel de landbouwsector als in de niet agrarische sector verhogen.

Training and supervision plan

Educational program within Mansholt Graduate School (MGS) completed by F. Bagamba

Courses

Name of the course	**Department/Institute**	**Year**	**Credits***
Advanced Microeconomics 1	CentER Graduate School, Tilburg University	2001	4
Empirics of Economic Growth	NAKE	2002	2
Econometrics II	Wageningen UR	2002	3
Agricultural Models	Wageningen UR	2002	5
Macro-economic Analysis and Policy	Wageningen UR	2002	3
Farm household Economics	Wageningen UR	2002	3
Quantitative Analysis of Development policy	Wageningen UR	2002	3
Bioeconomic Modelling	Mansholt Graduate School	2002	1
Pathways for Agricultural Intensification	Mansholt Graduate School	2001	2
Mansholt Introduction Course	Mansholt Graduate School	2002	1
Social Science Research Methods	Mansholt Graduate School	2001	1
Writing and Presenting a Scientific paper	Mansholt Graduate School	2001	1
Agro-ecological Approaches for Rural Development	Mansholt Graduate School	2002	1
Presentations at conferences and workshops			3
AAEA conference	American Agricultural Economics Association	2004	1
Mansholt Multidisciplinary Seminar	Wageningen University	2005	1
Response Workshop	Response, Wageningen University/IFPRI	2005	1
Total credits			33

1 (one) credit is equivalent to 40 hours of coursework.

Curriculum vitae

Fredrick Bagamba was born on August 15th, 1964, in the district of Bushenyi, Uganda. He did his graduate studies at Makerere University and graduated with a Bachelor of Science degree in Agriculture in March 1992. He immediately registered for M.Sc in Agricultural Economics with the Department of Agricultural Economics in the same University. At the same time, he worked as a Research Assistant at the Faculty of Agriculture on a Rockefeller funded Banana Cropping Systems Research Project. This project formed the basis for his M.Sc thesis: Resource Allocation Efficiency in a Banana Based Cropping System in Uganda. He graduated with M.Sc degree in January 1995 after which he joined the Coffee Research Programme of National Agricultural Research Organization (NARO), Uganda, as a Research Assistant. In 1996, he joined the National Banana Research Programme, NARO-Uganda, to conduct research on socioeconomic factors influencing banana production. He implemented a number of research projects with funding from the Rockefeller Foundation, DFID and IDRC and collaboration with IITA, ICIPE and INIBAP. In September 2001, he was given a fellowship grant from the Rockefeller Foundation through the National Banana Research Programme, Uganda, to undertake a PhD Programme through a Wageningen University Sandwich Fellowship. At Wageningen University, he registered for the PhD training at the Development Economics Group. As part of his PhD research, he spent close to two and half years in Uganda where he participated in the research project: Baseline Assessment of Banana Production and Management Practices in Uganda, a collaboration study between NARO-Uganda, International Food Policy Research Institute (IFPRI), and International Network for the Improvement of Banana and Plantain (INIBAP). Part of the data from this project contributed to the data used for this study.

This study analyses smallholder household response to production constraints (crop pests and diseases, soil constraints) and development of product markets and off-farm employment opportunities. The study was carried out in central region, Masaka and southwest, which have divergent production constraints and opportunities. Results for the cost benefit analysis show that banana is the most profitable of all the crops grown, in terms of gross margin. However, imperfections in labour and food markets cause farmers in the central region to allocate more land and labour to the less profitable annual crops but are more satisfying in terms of household food needs. High food prices and limited off-farm opportunities induce farmers to rely on own farm production for household food needs. Results show that banana farmers in Uganda are technically inefficient, and output can be increased by 30% in the southwest and 58% in the central region. Improved roads, formal education, access to credit and extension are some of the factors that improve productivity and technical efficiency. Infestation by the banana weevil and Sigatoka contributes to the low banana production in the central region. Results from labour supply analysis show a positive to shadow wages and negatively to shadow income, implying that farmers are responsive to economic incentives. Access to off-farm opportunities takes away the most productive labour from farm production. Education and road access have a positive effect on time allocated to off-farm activities while farm size is negatively related to work hours in off-farm activities. The study reveals that policies that promote income diversification into off-farm activities can contribute to sustained development in the rural sector. In particular, policies that reduce transaction costs are likely to improve productivity and efficiency in both the off-farm sector and farm sector. Investment in road infrastructure, education and financial institutions that are suited to smallholder production needs could help in alleviating the bottlenecks in the labour, food and financial markets, and improve resource allocation between the farm and nonfarm sectors.