ECONOMETRIC ANALYSIS OF SMALLHOLDER AGRICULTURAL HOUSEHOLDS FOR ZIMBABWE

BY

CHRISTOPHER ZINDI

A Thesis
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Department of Agricultural Economics and Farm Management
The University of Manitoba
Winnipeg, Manitoba

0-612-23573-4

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ABSTRACT

The objectives of this study were to test for separation of agricultural household models and to estimate separable and nonseparable econometric models of maize output supply, yield response to price, acreage demand, consumption demand and marketed surplus supply. Regression models run include OLS, 2SLS, SUR and 3SLS. The study uses a cross-sectional data set of peasant households spread across five natural regions of Zimbabwe. The sample size used in this study is 215.

Three main methods are used to test for separation of household production and consumption decisions. Results of the tests support separation thus implying that production and consumption decisions of households are nonjoint. Despite the lack of support for nonseparation, nonseparable models are estimated as well since they are relevant to the environments in which peasant households operate.

Results of hypothesis tests suggest that maize and fertiliser prices generally have insignificant effects on separable and nonseparable models of the functions investigated. However these variables have some significant effects on some family farm labour demand functions. Dropping the numeraire price in the maize consumption function improves the statistical significance of maize price in this function. Significance of the numeraire price in the maize output supply, marketed surplus and consumption function suggests that dependent variables of these functions increase with an equiproportional increase in all prices. Results have to be interpreted with caution since insignificance of prices may be due to errors in the model such as difficulties in measuring expected prices and constraints on production. Although separation is supported, there are no marked differences in results obtained using separable or nonseparable agricultural household models. Results imply that household production and consumption decisions are not conditioned by the nature of the household model used.

To my mother, and in loving memory of my father.

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CHAPTER 1

Introduction

1.1 Background and Problem Statement

About three quarters of the population of Zimbabwe[1] is mainly dependent on agriculture, including wage remittances. The sector accounts for over 12% of GDP, about 24% of formal employment and is the major source of foreign currency, bringing in about 40% of the total (Thirtle *et al*, 1993). The agricultural sector is dualistic, large scale commercial farmers exist alongside smallholder[2] semi-subsistence[3] farmers. Whereas the commercial farms are mainly located in prime farming areas, 75% of the smallholder farms are concentrated in the low potential natural regions[4] where droughts are frequent and severe and normal rainfall levels are barely adequate for intensive crop production. The contribution of peasant farmers to marketed surplus of key grains such as maize has increased considerably since 1980[5].

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[1]The total area of Zimbabwe is 390 757 sq.km, the total population in 1992 was 10.4 million (Ministry of Lands, Agriculture and Water Development, 1995).

[2]The smallholder farming sector comprises of small scale commercial, communal and resettlement farmers. The study focuses on communal farmers.

[3]The terms semi-subsistence and peasant(s) are used interchangeably.

[4]Zimbabwe is divided into five natural regions (agro-ecological zones) on the basis of annual rainfall, vegetation, edaphic factors and other agricultural related factors. Natural region I receives the highest rainfall whilst natural region V receives the lowest.

[5]Zimbabwe attained independence in April 1980.

Ellis (1988:12) presents the following definition of peasants:

> *Peasants are farm households with access to their means of livelihood in land, utilising mainly family labour in farm production, always located in a larger economic system, but fundamentally characterised by partial engagement in markets which tend to function with a high degree of imperfection.*

A key characteristic of households in semi-subsistence agriculture is that they produce food partly for sale and partly for own consumption. They also purchase some of their inputs (e.g. fertiliser) and provide some (e.g. family labour) from their own resources (Singh *et al*, 1986). The analysis of the microeconomic behaviour of peasant households is best done within the framework of the agricultural household model (AHM). This framework has the capacity to incorporate both production and consumption aspects. Depending on the set of assumptions concerning production and consumption decisions, market conditions, labour off-farm opportunities and farmer preferences, separable or nonseparable models can be applied in the analysis. Utility and profit maximisation are major objectives of farm households. The interdependence of utility and profit maximisation decisions is reduced to the effects of farm profits on household income (Lopez, 1984). Objectives of peasant households are complex and varied. These include the achievement of some minimum standard of material consumption, the maintenance of valued social relationships, and the acquisition of a target level of surplus (Lobdell and Rempel, 1995). Profit maximisation has generally been regarded as a secondary objective of peasant households.

The aim in this paper is to test for separability of AHMs and to estimate output supply, supply response, consumption demand and marketed surplus supply functions of maize among peasant farmers in Zimbabwe. If household production and consumption decisions are separable, this means that these decisions are not made jointly. An opposite scenario holds in the case of nonseparation. To date, no studies have explicitly modelled the above functions for Zimbabwe. Since grains are the major source of food and maize is the staple crop, the study hopes to derive policy implications of the empirical estimates of the above functions.

Successful estimation of the proposed AHMs is contingent on having price variation at the household level. This study uses net prices which show significant variation at the household level. Factors possibly accounting for price variation at the household level include differences in region, transport and marketing costs and access to different buyers and sellers.

This study is based on a household survey carried out during the 1991/92 agricultural season. Data collected is for the 1990/91 and 1991/92 agricultural seasons. The former was a normal agricultural season whilst the latter experienced the worst drought in living memory.

1.2 Objectives of the Study

The major objective of this study is to test for separation of AHMs and to estimate econometric models of smallholder agricultural households in Zimbabwe. Specific objectives are:

(a) To test for separation of agricultural household models in Zimbabwe.

(b) To estimate maize output supply, consumption demand, supply response and marketed surplus supply functions for smallholder agricultural households in Zimbabwe.

1.3 Sources of Data

This analysis is based on a household survey of 215 peasant farmers drawn from all five natural regions of Zimbabwe. The data allows for comparisons across regions. Micro level data collected includes household demographic characteristics, assets, production, marketing, expenditure and prices. The poor season has a better data base compared to the normal one.

1.4 Models to be Estimated

Econometric models of maize output supply, consumption , supply response and marketable surplus will be estimated. These models will be estimated within the framework of separable or nonseparable models depending on the results of the tests for separation. Hypothesis tests pertaining to smallholder agriculture in Zimbabwe will be carried out. Results of these hypothesis tests will be used to draw possible policy implications.

1.5 Organisation of Thesis

This study is organised as follows. Chapter Two gives a description of the data used. Chapter Three describes separable and nonseparable AHMs and reviews literature on separation tests and concludes with a presentation of tests for separation using Zimbawean smallholder agricultural data. Chapter Four presents estimates of maize production, consumption, supply response and marketed surplus supply functions. A summary and areas for future research are contained in Chapter Five.

CHAPTER 2

The Data

2.1 Introduction

Chapter 1 outlined the aim and objectives of this study. This chapter describes the data sources, coverage of the study, the nature of data used in the analysis, data manipulation procedures and lastly limitations inherent in this study.

2.2 Data Sources

The study is based on a household-farm level data set collected under the joint University of Zimbabwe/Oxford University 'Household Decision Making for Food Security Research Project'. The data collection phase lasted from April 1991 to May 1992. The April/May time is the period when households harvest crops in Zimbabwe. Data collected therefore covers one harvest season[6]. A full data set exists for the 1991/92 agricultural season[7] and partial data is available for the 1990/91 agricultural season. Whereas the 1990/91 agricultural season was a normal one, the 1991/92 agricultural season experienced a major drought. Study results have to be interpreted within the framework of the drought.

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[6]The harvest season is described as the period from one harvest to the next.

[7]The Zimbabwean agricultural season runs from October/November to April/May.

2.3 Coverage of the Survey

The survey was carried out in Manicaland Province of Zimbabwe. Manicaland Province has the unique advantage over other provinces in Zimbabwe in that it is the only province which has all five natural regions represented. The project research objective was to sample peasant households from each of the five agroecological regions in order to carry out comparisons within and across regions. The original sample size was 250 households; 50 households being drawn from each of the five agroecological regions. The final sample size used in this study is 215 households. These households are distributed as follows: Region I (49), Region II (47), Region III (46), Region IV (25) and Region V(48). This study uses a cross-sectional data set.

2.4 Nature of Data Collected

The household was used as the unit of analysis. The term 'household' was defined as 'all the people who live together, eating from the same kitchen, for more than six months of the year'. This functional definition was used to establish the composition of each household. For other questionnaires, the definition was relaxed in-order to include those household members who spent more than six months away from home. Different questionnaire modules were designed to capture different data. Data on crop sales and purchases was collected on a quarterly basis. Data collected includes information on demographic characteristics, crop production, sales, purchases, input use, asset inventories and income. Rainfall data is not easily available because of the way meteorological stations are distributed in Manicaland Province. Regional dummies are used to capture variation in rainfall, soil type, vegetation and therefore agricultural potential. Data availability and reliability will determine the depth of analysis.

2.4.1 Household Demographics

The household is taken as the basic unit of analysis. A distinction is made between resident and nonresident household members depending on the amount of time they spent on the farm. Resident household members are those who spent at least six months on the farm over the year long survey period. This definition caters for production and consumption aspects of the household as it allows for coordinated production and consumption decision making. Resident household members therefore include permanent workers and relatives staying on the farm.

2.4.2 Crop Production, Sales and Purchases

Maize is Zimbabwe's staple food grain. This study focuses on the maize enterprise. Other grains are mhunga, rapoko, rice and sorghum. Data collected on crop production includes information on cultivation costs and labour use. Costs of crop production include draught animal and labour hire, planting, weeding and harvesting costs. Information on labour use was not collected on a crop by crop basis or by gender. Labour use is disaggregated into the following categories: family, permanent and hired. Labour use is collected in terms of man-days. One manday is defined as eight hours of work.

Information on grain purchases was collected on a quarterly basis. Data collected includes the weight of grains sold or purchased, gross value, marketing costs and information on the type of buyer or seller. Major grain buyers are other households and the Grain Marketing Board (GMB). Both cash and in-kind values are captured. Marketing costs relate to transport and bagging.

2.4.3 Inputs

Information on non labour purchased inputs captures quantities and the related costs. The number of hired farm labour mandays and the related hire costs are derived from crop production questionnaires. This data was collected on a quarterly basis. Transport costs are taken into account in calculating the total cost. These included cash and in-kind payments. Chemical fertilizer is a major input in crop production. A major assumption for the 1991/92 agricultural season is that all inputs purchased were used. This is a broad assumption since households usually have some carryover inputs that are used in the following year. Data was not collected on input use by crop type.

2.4.4 Prices

The study uses net farm-gate prices. Net prices were computed by dividing net values by the related weight. Net prices are computed by taking into account transport and other related transaction costs in both purchase and sale categories. A major problem of using cross-sectional price data is that one might not get enough variation across aggregates. However the availability of different buyers and sellers might add some variation to the net prices. Following the approach adopted by Benjamin (1992), households not reporting input use are imputed to the geographically nearest price.

2.4.5 Asset Inventories

Information relating to the value and quantities of assets was collected. The major focus here is on farm assets. The value of farm assets used in this study is based on the farmers' perception of the current value of the asset taking into account the remaining life of the item.

No depreciation rules are used in determining the value of the farm assets.

2.4.6 Income

Off-farm income was collected on a quarterly basis. Income data was obtained as the sum of cash and in-kind payments. Wage rates used in the analysis are derived from the division of total income received and effective working days. Wage rate categories relate to the following employment categories: off-farm farm, plantation, construction, government, office, and private company work. Full income categories include off-farm work, crop and livestock enterprises, self-employment (e.g. craft making), total stock of household time and leisure. Following Becker (1965), the household's 'full income' comprises net money income from all sources, plus the opportunity cost of household time not spent in the labour market (Young and Hamdok, 1994). An estimate of full household income was derived.

2.4.7 Maize Consumption

Maize consumption was derived as a residual since consumption data was not recorded. This was done by computing the difference between a summation of carry-over stocks, production, purchases, remittances received, food aid and that of sales, and remittances given out. This variable is therefore a second best estimate.

2.5 Data Manipulation

This section discusses data manipulation methods used in this study. Approaches had to be adopted to make up for missing data. In the case of crop sales prices, regional averages are used to replace missing cases i.e. for those households that did not sell any crops. Regional price means are applicable to cases where at least some households sold some crops and are not relevant to cases where all households in the region did not sell a particular crop. Thus farm gate prices are used in the analysis. Following Benjamin (1992), farmers that do not report the use of fertilizer are imputed to the geographically nearest price for the input. The same approach is adopted for households not hiring labour for use on the farm.

2.6 Limitations of the Study

Part of the data collection phase covered a drought and results should be interpreted within the context of the 1991/92 drought and are therefore atypical of a normal season. The study would have produced more valuable information had a full data set been available for the normal season. Such a scenario would have allowed for comparisons in household response to be made across the two contrasting seasons. Rainfall data by region cannot be accurately determined because of the manner in which meteorological stations are distributed in Manicaland province. Such data would be easily extracted if meteorological stations were well positioned in each of the five regions. Regional dummies are therefore used to capture rainfall variability. The cross sectional nature of the data introduces limitations in terms of price variation. The fact that price data on substitute crops are not available due to limited sales information means information on possible substitution possibilities is not captured in this study. Despite these limitations, the study gives an insight into modelling household decisions and responses given risky environments which characterise smallholder agriculture in developing economies such as Zimbabwe.

CHAPTER 3

Testing for Separation of Agricultural Household Models

3.1 Introduction

This chapter presents three tests for separation of agricultural households models (AHMs) using farm level data collected in the communal areas of Zimbabwe. The chapter starts by describing the underlying assumptions and implications of separable and nonseparable models before presenting tests for separation. The aim in this chapter is to evaluate whether AHMs are separable or nonseparable using Zimbabwean peasant household data. The analysis is carried out within the framework of the AHM.

3.2 Separable Models

Separability holds under the following restrictive conditions: complete and competitive markets, zero transaction and commuting costs, perfect substitutability in production between farm family and hired labour, perfect substitutability between non-farm and off-farm employment, independence of farm productivity from farm household consumption and perfect substitutability between consumption out of home production and out of market purchases (Strauss; 1984, 1986). Complete and competitive markets imply a separation of the consumption (labour supply) and production (labour demand) decisions of the farm household (Benjamin, 1992). This means that consumers and producers face the same prices and that hiring-in and hiring-out wages are similar. Households are assumed to be indifferent between working on their own farms and off-farm. In this case the off-farm wage rate acts as a unique exogenous price of leisure under the implicit assumption that households do off-farm work (Lau *et al*, 1978). Thus separable AHMs use one labour function. The most important implication is that when markets are complete and efficient, market prices support a separation of household consumption and production decisions (Benjamin, 1992). If markets for all goods and labour exist and prices are exogenous to households, then separation holds. Separation implies recursiveness. The separation or recursive property implies that for utility maximisation, profits are maximised independent of the utility function (Benjamin, 1992). Under separation, a household behaves as if it maximizes its profits subject to its production constraint and then maximises utility subject to its full income and time constraints (Strauss, 1984). Separation also implies that households are price takers for all commodities and so the amount of a commodity to be produced can be determined independently of the amount to be consumed since the difference can be purchased from the market.

3.3 Nonseparable Models

Whereas separable models are theoretically sound, they do not approximate reality given the environments in which peasant households operate in. In many developing countries, peasant households, despite their large numbers, have not formed an important pressure group in terms of bargaining for e.g. higher product prices. In Zimbabwe, the Commercial

Farmers Union (CFU) which represents about 4500 large scale commercial farmers has been a strong pressure group compared to the Zimbabwe Farmers Union (ZFU) which represents over a million smallholder agricultural households. Ellis (1988) notes that markets in developing economies tend to function with a high degree of imperfection. In this regard, it is important to model nonseparable household models as well since they are more realistic. Key differences between separable and nonseparable models lie in the treatment of important variables such as labour. Whereas separable models treat own farm family and hired labour as perfect substitutes, these variables are treated differently in nonseparable models. Market imperfections leading to hiring-in or off-farm employment constraints, or differing efficiencies of family and hired labour are commonly suggested as sources of nonseparation (Benjamin, 1992). This implies that farm labour and hired labour are no longer perfect substitutes, and farm labour and off-farm family labour are not perfect substitutes in the utility function (Lopez, 1984, 1986). Thus on-farm and off-farm wage rates are different. Nonseparable models can endogenize aspects of market and household structure (Coyle, 1994). The literature has mainly focussed on nonseparability arising from the labour market (e.g. Lopez, 1984, 1986; Rosenzweig, 1988; Benjamin, 1992; Browning and Meghir, 1991; Coyle, 1994).

Besides the labour market, nonseparability has been attributed to dynamics, financial constraints in credit markets and risk in production and marketing. Coyle (1994) notes that credit markets can be imperfect in the sense that interest rates on credit may be endogenous or specific to the borrower, or credit may be rationed to firms. This has led to the inclusion of financial constraints into AHMs by authors such as Iqbal (1986) and Fafchamps *et al* (1991). The presence of risk implies that household production decisions are made without perfect information about future product prices and/or weather conditions. In a study of Kenyan smallholder agriculture, Wolgin (1975) arrived at the following conclusions: risk plays an important role in farmer decision making, farmers are efficient in their allocation of resources and lack of credit availability is a major bottleneck in obtaining increased agricultural productivity. These conclusions appear to support Shultz's `poor but efficient` hypothesis which was later refuted by Lipton. Assuming consumption decisions are made after output prices and weather are observed, the presence of risk entails that consumer prices will be a function of output realised. This would therefore imply that production and consumption decisions are not separable (Coyle, 1994).

3.4 Tests for Separation of Agricultural Household Models

The null hypothesis of the tests is that AHMs are separable. Rejection of the null hypothesis implies that on-farm and off-farm wage rates may be modelled separately. By failing to reject the null hypothesis of separation due to labour market conditions, we do not rule out that nonseparation can result from other sources such as dynamics, financial constraints and risk. Thus hypothesis tests are carried out within the *ceteris paribus* framework. Another implication of failing to reject the null hypothesis of separation is that decision making within the AHM may be modelled as recursive. This implies that household decisions on production and consumption are made independently. The rationale for separation in decision making lies in the fact that any shortfalls from production can be made up through purchases. On the other hand rejection of the null hypothesis implies that AHMs may be modelled as nonseparable. The implication of rejecting the null hypothesis is that decision making will be modelled as nonrecursive. This would imply that household decisions with respect to production and consumption are made jointly. Another implication of nonseparability is that on-farm and off-farm wage rates may have to be modelled separately. Thus on-farm and off-farm opportunities are different due to differences in returns on and off the farm.

Lopez (1984) employs non-nested hypothesis techniques to compare separating and nonseparating models by testing whether utility and profit maximisation decisions are likely to be independent. Results suggest that utility and profit maximising decisions are not likely to be independent. Benjamin (1992) develops an empirical model to test whether household labour demand (farm employment) is independent of family composition. Results show no evidence to reject the null hypothesis that farm labour allocation decisions are independent of family composition. The data suggests AHMs are separable. Other tests for separation of AHMs have been done by Browning and Meghir (1991) and Jacoby (1992). Browning and Meghir (1991) investigate the effects of male and female labour supply on household demands using UK family expenditure data. Their analysis rejects separability of male and female labour supply on commodity demands. Jacoby (1992) analyses the productivity of men and women and the gender division of labour in peasant agriculture of the Peruvian Sierra. His study reveals that gender division of labour on the farm implies that female and male labour are not perfectly substitutable. This implies nonseparability in the gender division of labour on the farm. Jacoby (1992) analyses household behaviour in the absence of labour markets. As discussed before, there are various causes of nonseparability. Benjamin (1992) observes that complete and competitive markets imply a separation of the consumption (labour supply) and production (labour demand) decisions of the farm household. Given these perfect market conditions, market prices cause a separation in the two decisions. Benjamin (1992) develops a test for separation based on the premise that in the absence of labour markets, household composition is an important determinant of farm labour use. This study will perform three main tests for separation of AHMs using cross-sectional household level data.

The first test is for separation of household maize production and consumption decisions. This test makes use of the maize output supply and tests for the significance of target consumption side variables in influencing production decisions. Target consumption side variables are the numbers of resident adults and children on one hand and the total number of consumption adult equivalent units for resident household members (Appendix 1) on the other. Such an adult equivalent scale is simply a device for specifying the needs or requirements of an individual of a particular age and sex as a percentage of a standard or base individual (Buse and Salathe, 1978). The base is generally taken to be an adult male. This measure can be used to compare household food consumption requirements. These exogenous variables influence household consumption decisions. Under assumptions of separability, household consumption decisions can be modelled independently of production decisions. A test of the null hypothesis that utility and profit maximising decisions are independent boils down to testing the hypothesis of independence between consumption and production decisions. Before carrying out the tests for separation, it is important to test whether the target exogenous variables from the consumption side really explain consumption. These tests are carried by estimating a maize consumption function and then testing for the significance of the coefficients for the target consumption side variables. A joint test is done for significance of demographic variables using Chi-square tests. These demographic variables are postulated to capture taste and socio-economic factors influencing maize consumption.

The second test for separation uses non-nested hypothesis tests based on the J-test (Davidson and MacKinnon, 1993; White, 1993). The rationale for this test is that under separability between consumption and production, the on-farm and off-farm family labour variables in the output supply equation can be replaced simply by the off-farm wage rate. The off-farm wage rate is a measure of the opportunity cost of family labour under separation. This provides the basis for a relatively simple non-nested test for separation.

The third and final test is for separation of household farm labour demand decisions from household demographic characteristics. Under separability, farm labour demand decisions are not a function of household demographics. A joint test for the significance of household demographic variables in the farm labour demand model is done to implement this test.

Standard diagnostic tests for multicollinearity and heteroscedasticity are done for each of the models described below. The models estimated in this study incorporate the numeraire price. This approach has the has the advantage of taking care of two possible scenarios where only relative prices matter and the other case where they do not matter. If only relative prices matter, then the coefficient of the numeraire price should not be statistically significant. Significance of the coefficient of the numeraire price implies that the dependent variable increases if all prices are increased by an equiproportional amount. Tests of significance will be evaluated at the 0.01, 0.05 and 0.1 levels.

3.4.1 Testing for Relevance of Selected Consumption Side Variables

This section estimates a maize consumption function and tests for the relevance of desired consumption variables. Target consumption variables are the total number of adult equivalent units of resident household members on one hand and the numbers of resident males, females and children on the other. In the latter case, a joint test for the significance of household demographic variables will be done. The test is aimed at confirming whether these variables explain maize consumption. The three variables describing the composition of resident household members act as explicit demand shifters. Significance of these consumption variables implies that they can be incorporated in the maize output supply function as exogenous variables affecting consumption before implementing a test of separation between production and consumption decisions. In this study, maize consumption is derived as a residual since direct consumption was not measured. This variable therefore incorporates additive errors from estimates of production, sales, purchases, remittances received and given out and carry-over stocks from the previous season. Another minor weakness in the estimate of maize consumption is that crop losses during storage are not accounted for. Strauss (1984) derived quantities of foods consumed from quantities purchased and quantities consumed from home production with the latter being derived as a residual. Preliminary tests were done to identify the ideal level of aggregation for household demographic variables. Results suggest that disaggregation into the numbers of resident males, resident females and resident children is ideal compared to using a highly aggregated variable such as the total number of resident adults.

Traditional consumer theory assumes that consumption units (households) attempt to maximise utility from the services of goods purchased in the market place subject to a money income constraint (Cox *et al*, 1984). This implies that prices and income are incorporated as key explanatory variables of the consumption function. In estimating consumption in the case of households which produce and consume part of the produce, it is necessary to incorporate non-market socio-economic factors.

Following Strauss (1982, 1984), a consumption function for maize can be defined as:

$$(3.1) \quad y^{Cons} = y^{Cons}\,[p,\ \eta,\ A\ +\ p_N T(m)\ +\ \pi(p,\ z,\ k)]$$

where p is an $N+1$ vector of grain sales prices, p_N is price of labour, η is household characteristics affecting taste, T is time available to the household for work and leisure, m is household characteristics determining T, z is a vector of farm characteristics including fixed inputs, k is a vector of production technology parameters, A is exogenous income, and π is profits.

This section describes the derivation of some determinants of the maize consumption function. Exogenous income is derived from a summation of net off-farm income and remittances received. Cash and in-kind income components are used in computing incomes. The value of total family time can be modelled as:

$$(3.2) \quad p_N T(m) = p_{N_1} X^{l} + p_{N_1} X^{ls} + p_{N_2} X^{Off}$$

where p_{N1} is price of hired farm labour, p_{N2} is a vector of off-farm wage rates, where X^l is family labour hours devoted to on-farm work, X^{Off} represents family labour hours devoted to off-farm work, X^{ls} is leisure hours of adult household members and T is the total stock of family time in hours. Labour hours are measured in mandays. The standard working day in Zimbabwe is eight hours. Total labour hours used on the farm and off-farm are found by multiplying the respective mandays by eight. Strauss (1984) derived household labour from all farm and non farm production and marketing activities and labour sold and excluded household activities such as food preparation, child care and ceremonies. This approach is the same as the one adopted in this study except that labour on marketing activities was not captured.

The literature on AHMs presents two major approaches to modelling leisure in the utility function of households. One school of thought suggests that leisure should not be incorporated into the utility function of peasant households. Lobdell and Rempel (1995) argue that leisure can be excluded in the objectives of peasant households. The authors provide two reasons explaining the rationale for dropping leisure from the utility function.

First, it is argued that in peasant households the typical trade-off is between types of work, or between more or less work effort, rather than between work and leisure *per se*. The other reason is that in a society where significant amounts of time and effort are invested in the maintenance of social relationships, the distinction between work and leisure becomes problematic. Assuming leisure can be excluded from the utility function, the amount of family labour devoted to farm work can be taken as a close proxy to the total stock of time available to the household. In cases where a leisure component is excluded, home activities i.e. the production of Z-goods[8] can be counted as work. A similar approach is to model leisure as being weakly separable from the other arguments of the utility function (Renkow, 1990). The second set of AHM studies explicitly model leisure

[8]Goods and services produced within the household for use rather than for market exchange are referred to in the neoclassical literature as Z-goods (Ellis, 1988). These include activities such as childcare, food preparation and processing e.t.c.

in the utility function. Such studies include Strauss (1982, 1984), Lau *et al* (1978), Coyle (1994) and Young and Hamdok (1994). This study adopts the latter approach and estimates a value of household leisure for use in computing full income.

Leisure can be derived as a residual. Leisure time was defined as the difference between total time available and number of working hours/day in paid or on-farm employment (Young and Hamdok, 1994). The Young and Hamdok study uses data for rural areas of Matabeleland South (Zimbabwe). The assumption in calculating the opportunity cost of labour in the Matabeleland study was that the total time available for each (adult) household member was 12 hours/day[9]. The same assumption is adopted in this study. Lau *et al*, (1978), in calculating the value of leisure, assumed the leisure time of dependents has zero value. All labour input on the farm is valued since labour data was collected as an aggregate variable. Whereas Young and Hamdok (1994) classify adults as those 18 years and over, this study uses a lower limit of 16 years. Following Lau *et al* (1978) and Young and Hamdok (1994), the maximum feasible leisure per worker (adults here), is defined as 365 labour days per year. The total stock of time in hours available to the family (resident and nonresident household members) is obtained by the product of family size, 365 and 12. In the Matabeleland study, leisure was valued at the prevailing market wage rate for agricultural labour in the district (50 cents/hour) reflecting the fact

[9]The 12 hours/day hypothesis was based on the available time in rural Africa, roughly the time from sunrise to sunset. Although children are observed to participate at times (e.g. during harvesting) in casual work, it is assumed here that the opportunity cost of their time is negligible. (Young and Hamdok, 1994).

that the rural labour market is dominated by casual labour and piecework, and the prospects for formal sector employment are poor (Cousins *et al.*, 1992, quoted in Young and Hamdok, 1994). In this study, the normalised wage rate of casual labour is used to value leisure and the opportunity cost of household time spent on the farm. The basic assumption in using a single labour price here is that of separation i.e. family labour and hired labour can be regarded as substitutes. Weaknesses arising from adopting such a framework have been highlighted by Young and Hamdok (1994). These include the assumption that all adults have the same total time available and the same opportunity cost of that time.

Total leisure hours consumed by the family can be modelled as:

$$(3.3)\quad X^{l} + X^{off} + X^{ls} = T$$
$$i.e.\ X^{ls} = T - X^{l} - X^{off}$$

where variables are defined as in equation 3.2. Leisure is thus derived as a residual of other time components. Lau *et al* (1978) imputed a value of leisure using Taiwanese data. Leisure was defined as:

$$(3.4)\quad Z = a_1 Z^{*} - L$$

where Z is leisure, a_1 is the number of workers, Z^* is the maximum feasible leisure per worker and is defined as 365 labour days per year and L is family labour in man-equivalent days (1 labour day = 10 labour hours). The leisure value of dependents was taken as zero.

Lau *et al* (1978) use the money wage per day normalised by the price of output to value leisure.

Profit is hereby derived as:

$$(3.5)\quad \pi = \sum_{i=1}^{N-1} (p_i Q_i - p_N X_i)$$

where p_i is price of good i, Q_i is production of good i and p_N is a vector of input prices. Following Strauss (1984), profits derived here relate to cropping enterprises only. Having defined key determinants of consumption, maize consumption is modelled as a function of prices, household characteristics which affect tastes, and full income, $A + p_N T + \pi$.

The profit function is modelled as:

$$(3.6)\quad y^{Cons} = \alpha_0 + \alpha_1 Finc + \alpha_3 p^{M*} + \sum_{i=1}^{3} \delta_i h_i + \sum_{i=1}^{4} \gamma_i R_i + \mu$$

where y^{Cons} is quantity of maize consumed in kilograms, *Finc* is full household income in Z\$, p^M is price of maize and h_i designates consumption related variables i.e. total adult equivalent units or household demographic categories. The three household demographics used are numbers of resident adult males, females and children. These household characteristics affect taste and time available to the household. Lastly, R_i represents dummy variables for region. Dummy variables for region are assumed to capture partial effects of likely differences in tastes plus all excluded exogenous maize consumption variables attributed to regional variations. Normalising by one of the product prices (here full household income) ensures that zero homogeneity conditions are maintained and no restrictions are placed on the consumer function (Coyle, 1989). Household full income, is in turn a function of prices, fixed inputs, production technology, and household characteristics affecting total time available (Strauss, 1984). In analysing AHMs, full income is a more important concept compared to cash income as the former is more comprehensive and has far reaching effects on the socio-economic status of the household. Full income thus measures the household's maximum purchasing power or standard of living. Becker (1965) defined 'full income as the maximum money income achievable by devoting all the time and other resources of the household to earning income, with no regard for consumption'. It thus sets the constraint on expenditure on market goods and the implicit outlay on home production activities, here simply termed 'leisure' (Young and Hamdok, 1994). The two price vectors in the maize consumption function are the price of maize and the other is composed of wage rates for the five wage categories used in the analysis. Net output prices for substitute grains are not available since very few households sold these crops.

Assuming separation, family labour and hired labour can be regarded as substitutes, thus the hired labour wage rate can be used to value the stock of household time. Cash and in-kind income components are used in computing incomes. This analysis uses net crop sales prices. Strauss (1984) uses arithmetically weighted regional averages of farm gate sales and market purchase prices as consumption prices whilst using the proportion of the value of regional consumption coming from home production and from market purchases as weights. Estimates of two versions of the normalised linear maize consumption function are presented below (Table 3.1). The first model incorporates the adult equivalent units measure whilst the second one has household demographic variables as explanatory variables.

Table 3.1. Maize Consumption Function Incorporating AE Units. Dependent Variable: Weight of Maize Consumed in Kilograms.

	coeff[a].	t-ratio
Intercept	991.18***[b]	5.817
Maize Price[c]	1028200.0***[d]	-2.589
Full Household Income	0.012783***	4.074
Number of Resident Adult Equivalents	42.053	0.3316
Dummy Variable for Region II	-389.78**	-2.119
Dummy Variable for Region III	377.94**	2.178
Dummy Variable for Region IV	-257.53	-1.217
Dummy Variable for Region V	-499.52***	-2.836
R-Squared	0.3456	
Sample Size	215	

[a] Coefficients.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Prices are normalised by full household income.
[d] The size of coefficient obtained could be attributed to the type of normalisation used. Lack of price data on substitute grains restricts the choice of the numeraire price.

Results of the model incorporating the total number of resident adult equivalent units shows that this consumption variable is not statistically significant. This variable does not appear to explain maize consumption. A priori reasoning would suggest a positive relationship between the number of household consumption units and consumption of a key staple crop such as maize. A possible but minor reason for the insignificance of the resident adult equivalent variable could be that it does not capture the component of consumption attributed to those household members who did not spend at least six months on the farm. It is common practise for household members working off-farm to draw some of their consumption needs from the family's harvest. However, the total number of resident adult equivalent units should be a good determinant of household maize consumption since it focuses on resident household members who are the main consumers of grain on the farm. Household full income is highly significant and has a positive impact on maize consumption.

The second maize consumption function estimated incorporates the three demographic variables. Wage rates are a determinant of the household's off-farm income earning potential. Off-farm income in the form of remittances provides an important source of income for purchasing and processing food as well buying farm inputs. Regression results for this model are presented below (Table 3.2).

Table 3.2. Maize Consumption Function Incorporating Demographic Variables. Dependent Variable: Weight of Maize Consumed in Kilograms.

	coeff.[a]	t-ratio
Intercept	766.46***[b]	3.998
Maize Price[c]	1019600.0***[d]	-2.583
Full Household Income	0.01149***	3.485
Number of Resident Adult Males	-77.013	-1.606
Number of Resident Adult Females	118.96**	2.313
Number of Resident Children	28.748	1.062
Dummy Variable for Region II	-251.64	-1.346
Dummy Variable for Region III	492.44***	2.837
Dummy Variable for Region IV	-241.71	-1.208
Dummy Variable for Region V	-482.78***	-2.99
R-Squared	0.3797	
Chi-square p-value[e]	0.00976***	
Sample Size	215	

[a] Coefficients.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Prices are normalised by full household income.
[d] The size of coefficient obtained could be attributed to the type of normalisation used. Lack of price data on substitute grains restricts the choice of the numeraire price.
[e] Test for joint significance of demographic variables.

Results suggest that among the demographic variables modelled in the consumption function, the numbers of resident adult females is statistically significant at the 0.05 level. The number of resident males has a somewhat high t-ratio which is almost significant at the 0.1 level (p-value of 0.110). A joint test for the significance of the three demographic variables using the Chi-square test statistic shows that these variables are highly significant (0.01 level). Other significant variables are maize price, full household income and dummy variables for Regions III and V. The full household income variable has a positive sign indicating that a unit increase in income leads to a marginal increase in maize consumption. Results drawn from these two models of the maize consumption function suggest that the number of resident males, females and children are relevant explanatory variables influencing maize consumption. These three exogenous variables from the consumption side may therefore be incorporated into the maize output supply function in order to test for separation of household maize production and consumption decisions. No further tests are done using the total number of adult equivalent units since this variable does not explain maize consumption.

3.4.2 Testing for Separation of Household Maize Production and Consumption Decisions

This section presents the first test for separation between household maize production and consumption decisions. A normalised maize output supply function is estimated and used to implement this test. Maize output supply is modelled as a function of production inputs such as total area cropped, value of farm assets, maize price, off-farm wage rates, exogenous household demographic variables influencing consumption and region. The aim is to test for the significance of exogenous variables from the consumption side in the maize output supply function. Target consumption side variables are the numbers of resident males, females and children. A joint test of significance of the demographic variables is performed. Joint significance of these consumption side variables implies that maize consumption and production decisions are made jointly. This would imply nonseparability. Price variables are normalised by the off-farm farm wage rate.

The maize output supply function is modelled as:

$$(3.7)\ y^{OS} = \alpha_0 + \alpha_1 Area92 + \alpha_2 Asset + \alpha_3 w^{F*} + \alpha_4 w^{l*} + \alpha_5 Draft + \alpha_6 w^{fof} + \sum_{i=1}^{4} \delta_i w_i^{off*} + p^{M*} + \sum_{i=1}^{3} \gamma_i h_i + \sum_{i=1}^{4} \lambda_i R_i + u$$

where *Area* is total area cropped during the 1991/92 agricultural season, *Asset* is the value of farm assets while w^{F*}, w^{l*} and w^{off*} are normalised prices of fertiliser, hired casual farm labour and off-farm wage rates respectively. Prices are normalised by the off-farm farm wage rate, w^{fof}. *Draft* is a dummy variable for draught animal ownership. Studies carried out in Zimbabwe have shown that households owning draught animals tend to produce more maize compared to non owners. This increase in production due to draught animal ownership has partly been attributed to timeliness in planting and better land preparation. Lastly *h* and *R* are vectors for household demographics and dummy variables for region respectively. Maize output supply is modelled as a function of all exogenous variables affecting production and consumption. The dependent variable used in the regression analysis is the weight of maize harvested during the drought year. This analysis is restricted to Regions I-III since households in the other two regions experienced poor harvests during the drought year. Two versions of the maize output supply are estimated using Tobit regression analysis for all households and OLS regression analysis for the subset of households harvesting maize during the drought year.

3.4.2.1 Tobit Regression Model

A limited dependent variable regression technique is used since about 50% of the households did not harvest maize during the drought year. Thus, a limited dependent variable problem exists (Tobin) since the dependent variable is limited to non-negative observations for which a Tobit approach is used (Strauss, 1984; Adesina and Zinnah, 1993). The Tobit model is presented in the form:

$$(3.8) \quad y_t = x_t(\beta) + \mu_t; \quad \mu_t \approx NID(0,\sigma^2),$$
$$y_t = y^*_t \; if \; y^*_t > 0; \quad y_t = 0 \; otherwise$$

where y_t^* is a latent variable that is observed only when it is positive (Davidson and Mackinnon, 1993). The dependent variable y_t^* is the probability of harvesting maize in the drought year. Assumptions of adopting the Tobit model are that the error term is independently and normally distributed with zero mean and constant variance. In this study the Tobit model measures the probability that a household will harvest maize. Rather than using a one-zero dependent variable, the actual weight of maize harvested is used. This ensures that variability within the data set is maintained. Regression results of the normalised limited dependent variable regression model are presented below (Table 3.3).

Table 3.3. Maize Output Supply Function, Tobit Regression.
Dependent Variable: Weight of Maize Harvested in 1992 in Kilograms.

	coeff[a].	t-ratio
Intercept	0.67272	1.4962
Total Area Cropped	0.21855***[b]	3.0415
Value of Farm Assets	0.000066	1.1199
Maize Price[c]	0.050161	0.045493
Fertiliser Price	0.027388	0.019866
Casual Labour Cost/day	0.077608	0.57298
Dummy for Draught Animal Ownership	0.35249	1.4037
Off-farm Farm Wage Rate	0.054937	1.5961
Construction Wage Rate	0.11062	1.3396
Government Work Wage Rate	-0.16047*	-1.7506
Private Company Wage Rate	0.038378	0.30948
Other Work Wage Rate	-0.000653	-0.0050364
Number of Resident Adult Males	-0.15378*	-1.7566
Number of Resident Adult Females	-0.038514	-0.43744
Number of Resident Children	0.0037567	0.076949
Dummy for Region II	-1.4732***	-3.0856
Dummy for Region III	-1.0224***	-3.076
Wald Chi-square p-value[d]	0.3031	
R-Squared	0.31866	
Sample Size	142	

[a] Coefficients.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Prices are normalised by the off-farm farm wage rate.
[d] Test for joint significance of demographic variables.

Tobit regression results suggest that the hypothesis of separation is supported since exogenous demographic variables from the consumption function i.e. the numbers of resident males, females and children, are not jointly significant in the maize output supply function. This implies that determinants of maize consumption in the form of demographic variables modelled here do not explain production. It may be inferred that household decision making with respect to maize production is not influenced by maize consumption decisions. The number of resident adult males variable is significant at the 10% level. Results suggest that AHMs are separable.

3.4.2.2 Linear Maize Output Supply Regression Model

A similar test for separation between household production and consumption decisions is carried out using only households which harvested maize during the drought year in Regions I-III. This test uses the maize output supply function. As in the Tobit regression model, the aim is to test whether exogenous variables from the consumption side influence production decisions. A joint test for the significance of household demographic variables influencing consumption is not significant as well (Table 3.4). Tests for significance of these variables individually are insignificant too. These results support the previous finding which suggests that household maize production and consumption decisions are separable. Results also show that the draught animal ownership dummy variable has a significant negative impact on maize output supply. This unexpected result could partly be attributed to effects of the drought on output, i.e. both draught animal owners and nonowners obtained low outputs.

Table 3.4. Maize Output Supply Function, Linear Function.
Dependent Variable: Weight of Maize Harvested in 1992 in Kilograms.

	coeff[a].	t-ratio
Intercept	15.283	0.1259
Total Area Cropped	75.942***[b]	4.075
Value of Farm Assets	0.0094472	0.573
Maize Price[c]	-267.51	-0.7354
Fertiliser Price	301.02	0.4219
Casual Labour Cost/day	50.608	1.487
Dummy for Draught Animal Ownership	-167.82**	-2.472
Off-farm Farm Wage Rate	10.715	1.188
Construction Wage Rate	52.975	2.431
Government Work Wage Rate	-49.716*	-1.913
Private Company Wage Rate	11.741	0.2965
Other Work Wage Rate	39.47	0.9851
Number of Resident Adult Males	28.488	1.025
Number of Resident Adult Females	1.4173	0.06258
Number of Resident Children	-2.4206	-0.1755
Dummy for Region II	-375.31***	-3.353
Dummy for Region III	-41.532	-0.4137
Chi-square test p-value[d]	0.76453	
R-Squared	0.4311	
Sample Size	106	

[a] Coefficients.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Prices are normalised by the off-farm farm wage rate.
[d] Test for joint significance of demographic variables.

3.4.3 Non-nested Hypothesis Tests for Separation

The second test makes use of the maize output supply function to test for separation using substitution possibilities between family labour variables and off-farm wage rates. The rationale for this test is that under separation between consumption and production decisions, family farm and off-farm labour mandays in the maize output supply function can simply be replaced by the off-farm wage rate. This substitution is justified since under separation the opportunity cost of working on your own farm or off-farm are the same. The off-farm wage rate is taken as the exogenous price of labour since it gives a measure of the opportunity cost of household time devoted to farm and off-farm work and is thus used to substitute for the physical production side family labour variables under a separable structure.

The null hypothesis is that of separation. The nonseparable and separable maize output supply models have a common set of variables but differ in additional variables such as family on-farm and off-farm labour mandays in the former model and off-farm wage rates in the latter model. Formulating the models in this way satisfies the requirement for linear regression models that each of the two regression functions contain at least one regressor that is not in the other (Davidson and MacKinnon, 1993). The dependent variable for the separable and nonseparable models is the weight of maize harvested during the drought year. The price of fertiliser is the numeraire. This analysis uses a sub sample of 106 households that harvested maize during the drought year in Regions I-III.

The nonseparable maize output supply is formulated as:

$$(3.9)\ Y_{NS} = \alpha_0 + \alpha_1 Area92 + \alpha_2 Asset + \alpha_3 p^{M*} + \alpha_4 w^F + \alpha_5 w^{l*} + \alpha_6 Draft + \alpha_7 Famlab + \alpha_8 Offlab + \sum_{i=1}^{2} \gamma_i R_i + \mu$$

where *Famlab* and *Offlab* are family labour mandays devoted to on and off-farm work. The separable maize output supply function is depicted as:

$$(3.10)\ Y_S = \alpha_0 + \alpha_1 Area92 + \alpha_2 Asset + \alpha_3 p^{M*} + \alpha_4 w^F + \alpha_5 w^{l*} + \alpha_6 Draft + \sum_{i=1}^{5} \delta_i w_i^{off*} + \sum_{i=1}^{2} \lambda_i R_i + \mu$$

where variables are as defined before. The first step involves running linear regressions and saving predicted values of the dependent variables for the separable and nonseparable maize output supply functions. These predicted values are coded Y_{NS}^P and Y_s^P for the nonseparable and separable maize output supply models respectively. The second step involves adding the predicted values of the dependent variables as explanatory in the alternative functions and running OLS regression. The second set of regressions is set up as:

$$(3.11)\ Y_{NS}^{\prime} = \alpha_0 + \alpha_1 Area92 + \alpha_2 Asset + \alpha_3 p^{M*} + \alpha_4 w^F + \alpha_5 w^{l*} + \alpha_6 Draft + \alpha_7 Famlab + \alpha_8 Offlab + \sum_{i=1}^{3} \delta_i h_i + \sum_{i=1}^{2} \gamma_i R_i + \theta_1 Y_S^P + \mu$$

$$(3.12)\ Y_S^{I} = \alpha_0 + \alpha_1 Area92 + \alpha_2 Asset + \alpha_3 p^{M*} + \alpha_4 w^F + \alpha_5 w^{l*} + \alpha_6 Draft + \sum_{i=1}^{5} \delta_i w_i^{off*} + \sum_{i=1}^{2} \lambda_i R_i + \theta_2 Y_{NS}^{\ P} + \mu$$

The J-test for carrying out non-nested hypothesis tests is implemented by testing for the significance of θ_1 and θ_2. If θ_1 is significant and θ_2 is not, this implies that the separable model is superior to the nonseparable model and vice versa. In this case a clear result is obtained and we are able to identify the preferred model. However results will be ambiguous if θ_1 and θ_2 are both significant or insignificant. Given this scenario, it is impossible to choose between the two model structures. Parameter estimates for regression models incorporating predicted values of the nonseparable and separable maize output supply variables are presented below (Table 3.5 and 3.6). The overall result for the J-test is that the separable model is superior to the nonseparable model. This result holds at the 0.1 level.

Table 3.5. Nonseparable Maize Output Supply Function, J-test Regression. Dependent Variable: Weight of Maize Harvested in Kilograms.

	coeff[a].	t-ratio
Intercept	45.475	0.1762
Total Area Cropped	8.0417	0.2614
Value of Farm Assets	0.000288	0.01676
Maize Price[b]	15.889	0.1955
Fertiliser Price	3.1044	0.01979
Casual Labour Cost/day	0.70361	0.1186
Dummy for Draught Animal Ownership	33.378	0.3175
Family Farm Labour Mandays	-0.52818	-0.4422
Family Off-farm Labour Mandays	-0.14129	-1.222
Dummy for Region II	-49.410	-0.2702
Dummy for Region III	30.302	0.2746
Y_S^P	0.88634*[c]	1.973
R-Squared	0.3270	
Sample Size	106	

[a] Coefficients.
[b] Prices are normalised by that of fertiliser.
[c] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.

Table 3.6. Separable Maize Output Supply Function, J-test Regression. Dependent Variable: Weight of Maize Harvested in 1992 in Kilograms.

	coeff[a].	t-ratio
Intercept	-86.112	-0.2458
Maize Price[b]	0.80686	0.009892
Total Area Cropped	5.0533	0.1385
Value of Farm Assets	0.001108	0.06234
Fertiliser Price	78.848	0.4112
Casual Labour Cost/day	-1.9398	-0.2923
Dummy for Draught Animal Ownership	3.5887	0.02844
Off-farm Farm Wage Rate	9.1125	1.22
Construction Wage Rate	2.4636	0.7797
Government Work Wage Rate	-0.4276	-0.1122
Private Company Wage Rate	4.5173	0.8377
Other Work Wage Rate	-5.9826	-1.044
Dummy for Region II	-93.992	-0.4212
Dummy for Region III	-54.264	-0.4038
Y_{NS}^{P}	0.82175	1.322
R-Squared	0.3278	
Sample Size	106	

[a] Coefficients.
[b] Prices are normalised by that of fertiliser.

3.4.4 Test for Separation Between Household Farm Labour Demand and Household Demographics

The third major test for separation considered here is based on Benjamin (1992). Benjamin uses log-linear models in performing a test for separation between farm labour demand (production) and demographic variables (consumption) using a household-farm data set from rural Java, Indonesia. Benjamin's test of separation seeks to find evidence of nonmarket allocations of labour. The null hypothesis is that farm employment is determined according to the neoclassical labour demand model. Thus household composition should have no effect on the mix of labour (family plus hired) used on the farm. A correlation between household demography and the actual farm employment would be attributed to nonseparation. Under separation, the household faces a single labour function thereby implying that hired labour wage rates and off-farm wage rates may be modelled as one. This study uses five off-farm wage rates in addition to the on-farm hired labour wage rate. A household labour demand (L^D) function can be specified as:

$$(3.13) \qquad L^D = L^D(w^l, w^{off}, w^F, p^M, h, K, A, Draft, R)$$

where pM is price of maize, w^l is wage rate for casual farm labour, w^{off} represents off-farm wage rates (construction, government, private company and other work wage rates), w^F is money price of fertilizers in Z$ per kg, A is total area cropped (fixed in short run) and D is a dummy variable for draught animal ownership. K is the value of farm assets and h represents household characteristics i.e. number of resident males, females and children, prime male fraction, prime female fraction, fraction of elderly males and females, age and square of age of household head and a dummy for the education level of the household head. The fraction of the number of resident children is excluded in order to avoid having perfect multicollinearity. Household demographics are treated as exogenous variables. These demographic variables determine labour demand as they are an indicator of the household human resource base. Since the focus is on farm labour demand, demographic variables used relate to resident household members. Lastly R represents dummy variables for region. The approach adopted in this study is to estimate linear and log-linear farm labour demand models based on two versions of the farm labour demand model. The first (or restricted) version of the farm labour demand model does not incorporate fractional demographic variables, a dummy for the education level of the household head and variables representing the age and square of the age of the household head.

The second (unrestricted) version of the farm labour demand model follows the structure adopted by Benjamin (1992) i.e. incorporating fractional demographics, age and square of the age of the household head and a dummy for the education level of the household head. These two model versions are used to implement a test for separation between farm labour demand and household demographics. Price variables in these two forms of farm labour demand are normalised by the off-farm farm wage rate. All households are used in this analysis.

A linear version of the full farm labour demand model can be formulated as:

$$(3.14)\quad L^{D} = \alpha_0 + \alpha_1 w^{l*} + \alpha_2 Draft + \alpha_3 w^{F*} + \alpha_4 Area92 + \alpha_5 Asset + \alpha_6 p^{M*} + \alpha_7 w^{fof} + \sum_{i=1}^{4}\beta_i w^{off*} + \sum_{i=1}^{10}\delta_i h_i + \sum_{i=1}^{5}\gamma_i R_i + \mu$$

where variables are described as in 3.13. By imposing zero restrictions on fractional demographics, age variables and the dummy variable for education, we are able to derive the linear and log-linear restricted farm labour demand models. The full log-linear version of the farm labour demand function is modelled as:

$$(3.15)\quad LogL^{D} = \alpha_0 + \alpha_1 \log w^{l*} + \alpha_2 \log w^{F*} + \alpha_3 logArea92 + \alpha_4 \log Asset + \alpha_5 \log p^{M*} + \alpha_6 Draft + \alpha_7 \log w^{fof} + \sum_{i=1}^{4}\beta_i \log w^{off*} + \sum_{i=1}^{10}\delta_i \log h_i + \sum_{i=1}^{5}\gamma_i R_i + \mu$$

where variables are defined as in 3.13. Following Benjamin (1992), among the demographic variables, only logarithms of the numbers of resident males, females and children are taken. The test for separation boils down to testing whether $\delta_i = 0$ i.e. the null hypothesis for separation. The test is carried out using a joint test for significance of demographic variables. Benjamin (1992) implements the joint test for significance of demographic variables by excluding age and education variables. The same approach is adopted in this study. If the null hypothesis is not rejected, then we may conclude that AHMs are separable. This would suggest that household demographic variables have no effect on farm labour demand decisions. This implies that consumption and production decisions of the household are independent. Failure to reject the null hypothesis implies that demographic variables influence farm labour demand. This implies that AHMs are nonseparable, thus consumption (demographic variables) and production decisions (labour demand variables) are dependent and therefore decisions are made jointly. Whereas the linear regression is easy to run, the log-linear version requires some data manipulations to be undertaken beforehand. The problem with the log-linear version of the model is that logarithms can only be taken for positive values. In order to solve this problem, the approach adopted by Jacoby (1992) and MaCurdy and Pencavel (1986) is applied here. This approach essentially entails accommodating cases with zero input use by adding a constant of one to variables with some zero observations. The choice of the additive constant is arbitrary, except for the presumption that it be 'near' zero, or at least small relative to the average input value (Jacoby, 1992). On taking logarithms, we still get zero effects for cases with ones added. The origin of the labour demand function is transformed by adding a constant to the variables with zero observations. Two linear regression models and their log-linear versions are developed to test the hypothesis that demographic variables have no influence on household labour demand. Parameter estimates for the restricted linear model are presented below (Table 3.7).

Table 3.7. Demand for Farm Labour: Restricted Linear Model. Dependent Variable: Total Number of Man-days Employed on On-farm Work.

	coeff[a].	t-ratio
Intercept	36.144**[b]	2.22
Total Area Cropped	11.469***	5.774
Value of Farm Assets	0.0036992	1.491
Maize Price[c]	-3.4214	-0.07469
Fertiliser Price	-17.014	-0.3834
Casual Labour Cost/day	-3.3297	-0.6771
Dummy for Draught Animal Ownership	14.032*	1.684
Off-farm Farm Wage Rate	-1.7413	-1.255
Construction Wage Rate	-2.5451	-0.8639
Government Work Wage Rate	1.974	0.6969
Private Company Wage Rate	-0.79233	-0.1998
Other Work Wage Rate	1.3869	0.34
Number of Resident Adult Males	-0.69293	-0.2502
Number of Resident Adult Females	-2.3317	-0.7922
Number of Resident Children	2.8777*	1.831
Dummy for Region II	-15.49	-0.8983
Dummy for Region III	-27.107**	-2.139
Dummy for Region IV	-2.2353	-0.09716
Dummy for Region V	31.569**	2.397
R-Squared	0.5631	
Chi-square p-value[d]	0.33771	
Sample Size	215	

[a] Coefficients.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Prices are normalised by the off-farm farm wage rate.
[d] Test for joint significance of demographic variables.

Results suggest that among the household demographic variables, the number of resident children is the only variable which is significant at the 0.1 level (Table 3.7). A joint test for the significance of demographic variables is not significant. Results suggest that household demographics do not influence farm labour demand decisions. This result supports separation between household production and consumption decisions. Regression results for the restricted log-linear model are presented below (Table 3.8).

Results of the restricted log-linear model suggest that none of the demographic variables are significant individually as well as jointly (Table 3.8). As in the linear version above, results suggest that farm labour (production) decisions are independent from household demographics (consumption). This test supports separation. Parameter estimates for the unrestricted linear farm labour demand model are presented next (Table 3.9).

Table 3.8. Demand for Farm Labour: Restricted Log-linear Model. Dependent Variable: Log of Total Number of Man-days Employed on On-farm Work.

	coeff[a].	t-ratio
Intercept	3.7776***[b]	9.594
Log Total Area Cropped	0.6325***	7.291
Log Value of Farm Assets	0.03834*	1.875
Log Maize Price[c]	0.41201**	2.028
Log Fertiliser Price	-0.1031	-0.1876
Log Casual Labour Cost/day	-0.13716	-0.8076
Dummy for Draught Animal Ownership	0.38902***	3.099
Log Off-farm Farm Wage Rate	-0.25479	-1.319
Log Construction Wage Rate	-0.13083	-0.717
Log Government Work Wage Rate	0.23475	1.075
Log Private Company Wage Rate	-0.025755	-0.1119
Log Other Work Wage Rate	0.059498	0.5605
Log Number of Resident Adult Males	-0.058214	-0.6545
Log Number of Resident Adult Females	0.077605	0.5894
Log Number of Resident Children	-0.034076	-0.4284
Dummy for Region II	-1.0999***	-5.026
Dummy for Region III	-0.66203***	-3.184
Dummy for Region IV	-0.53594	-1.563
Dummy for Region V	-0.0049742	-0.0259
R-Squared	0.7055	
Chi-square p-value[d]	0.84659	
Sample Size	215	

[a] Coefficients.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Prices are normalised by the off-farm farm wage rate.
[d] Test for joint significance of demographic variables.

Table 3.9. Demand for Farm Labour, Unrestricted Linear Model. Dependent Variable: Total Number of Man-days Employed on On-farm Work.

	coeff[a].	t-ratio
Intercept	-75.41*[b]	-1.745
Total Area Cropped	11.433***	5.786
Value of Farm Assets	0.0028687	1.123
Maize Price[c]	13.792	0.2901
Fertiliser Price	-16.427	-0.3729
Casual Labour Cost/day	-2.8537	-0.5737
Dummy for Draught Animal Ownership	10.894	1.288
Off-farm Farm Wage Rate	-1.5589	-1.129
Construction Wage Rate	-2.6034	-0.8879
Government Work Wage Rate	2.1161	0.7308
Private Company Wage Rate	-1.4608	-0.3631
Other Work Wage Rate	2.6609	0.6541
Maize Price	13.792	0.2901
Number of Resident Adult Males	1.2061	0.2424
Number of Resident Adult Females	-6.6948	-1.626
Number of Resident Children	4.3482	1.405
Fraction of Prime[d] Males	-21.463	-0.5262
Fraction of Prime Females	33.502	0.9359
Fraction of Elderly Males Over 55 Years	30.671	0.6081
Fraction of Elderly Females Over Over 55 Years	14.04	0.4537
Age of Household Head	3.7223**	2.425
Square of Age of Household Head	-0.032126**	-2.222
Dummy for Level of Education of Household Head	8.9225	0.8166
Dummy for Region II	-14.974	-0.8496
Dummy for Region III	-25.685**	-2.011
Dummy for Region IV	0.67879	0.02947
Dummy for Region V	39.181***	2.954
Wald Chi-square p-value[e]	0.35661	
R-Squared	0.5887	
Sample Size	215	

[a] Coefficients.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Prices are normalised by the off-farm farm wage rate.
[d] Prime refers to the age group 16-55 years.
[e] Test for joint significance of demographic variables.

Joint test results for demographic variables incorporated in the unrestricted linear labour demand model are not significant. This result suggests separation of household farm labour demand from household demographics. The dummy variable for the level of education of the household head is not significant. The two age variables are each significant at the 0.05 level. Lastly, regression results for the unrestricted log-linear model are presented below (Table 3.10).

Regression results for the unrestricted log-linear model incorporating fractional demographics indicate that a joint test for household demographics is not significant (Table 3.10). This suggests separation of farm labour demand (production) from household demographics (consumption). This result supports Benjamin's finding of separation between household demographics and farm labour demand. The two age variables are highly significant and the dummy for the education level of the household is not significant. The next section summarises the three tests which have been used in this study.

Table 3.10. Demand for Farm Labour: Unrestricted Log-linear Model. Dependent Variable: Log of Total Number of Man-days Employed on On-farm Work.

	coeff[a].	t-ratio
Intercept	2.2956***[b]	2.782
Log Total Area Cropped	0.59724***	6.993
Log Value of Farm Assets	0.027652	1.371
Log Maize Price[c]	0.44135**	2.169
Log Fertiliser Price	-0.25574	-0.4767
Log Casual Labour Cost/day	-0.12312	-0.7382
Dummy for Draught Animal Ownership	0.38369***	3.12
Log Off-farm Farm Wage Rate	-0.32931*	-1.733
Log Construction Wage Rate	-0.12389	-0.699
Log Government Work Wage Rate	0.33538	1.542
Log Private Company Wage Rate	-0.13069	-0.5775
Log Other Work Wage Rate	0.071207	0.6936
Log Number of Resident Adult Males	0.20467	0.9211
Log Number of Resident Adult Females	-0.024078	-0.1046
Log Number of Resident Children	-0.21059	-0.6971
Fraction of Prime[d] Males	-1.3641	-1.421
Fraction of Prime Females	-0.27691	-0.3228
Fraction of Elderly Males Over 55 Years	-0.51342	-0.4642
Fraction of Elderly Females Over Over 55 Years	-0.41429	-0.5172
Age of Household Head	0.079572***	3.706
Square of Age of Household Head	-0.00069055***	-3.413
Dummy for Level of Education of Household Head	0.20574	1.377
Dummy for Region II	-1.124***	-5.186
Dummy for Region III	-0.62772***	-3.078
Dummy for Region IV	-0.66524**	-1.972
Dummy for Region V	0.13191	0.6998
R-Squared	0.7357	
Wald Chi-square p-value[e]	0.55114	
Sample Size	215	

[a] Coefficients.
[b] Level of significance: *= 0.1, ** = 0.05 and *** = 0.01 level.
[c] Prices are normalised by the off-farm farm wage rate.
[d] Prime refers to the age group 16-55 years.
[e] Test for joint significance of demographic variables.

3.5 Summary Results of Tests for Separation

The literature presents results supporting both separation and nonseparation. However the focus of studies differ in some respects. Results of the three tests for separation carried out in this study favour separation in all three tests implemented. The result of separation between household demographics and farm labour demand confirm Benjamin's findings. Lopez (1984, 1986) estimated a farm-household model using Canadian data and tested the hypothesis of independence between utility maximization and profit maximization decisions. Results indicated that farm households' utility and profit maximisation decisions are not likely to be independent. Jacoby's study of Peruvian peasants showed that female and male labour are not perfectly substitutable. Thus gender division of peasant farm labour was deemed to be nonseparable. Using UK FES data, Browning and Meghir (1991), rejected separability of male and female labour supply on commodity demands.

Caution has to be taken in making comparisons of different model results. This has to be done against the background of the characteristics of the households investigated such as the level of technological development and land tenure arrangements. Whereas Benjamin uses a household farm data set from rural Java, Lopez uses a Canadian data set of 'households which also own and operate a farm'. Jacoby (1992) performs a test of separation by analysing the productivity of men and women and the gender division of labour in peasant agriculture of the Peruvian Sierra. The study revealed that gender division of labour on the farm implies that female and male labour are not perfectly substitutable. This implies nonseparability in the sexual division of labour on the farm. Jacoby (1992) analyses household behaviour in the absence of labour markets. The Zimbabwean case might differ slightly from those described above. A summary of the results for tests for separation implemented in this study are presented below (Table 3.11). The null hypothesis is that of separation.

Results of three tests implemented all support separation[10] of agricultural household models. There is no evidence to support nonseparation of agricultural household models. Despite the lack of support for nonseparation, the next chapter estimates both separable and nonseparable agricultural household models of maize output supply, yield response to price, acreage demand, consumption demand and marketed surplus supply. Nonseparable models are estimated as well since they are more realistic given the environments in which smallholder farmers operate in. Greater weight will be placed on results derived from the separable models since they are supported by results of the three tests for separation.

[10]Results of a t-test for the null hypothesis of no difference between the local hired farm wage rate and the off-farm farm wage rate show that the means of these two wage categories are not significantly different even at the 0.1 level. The off-farm farm wage rate is a good proxy of the opportunity cost of family and hired labour used on the farm. This result indicates that the two wage rates are similar thereby supporting separation.

Table 3.11. Summary Results for Tests of Separation.

Test Based on:	Key Variables	Model	Null Hypothesis Result
Separation between production and consumption decisions	Number of resident adults and number of resident children	Normalised Tobit regression	Fail to reject
		Normalised OLS regression	Fail to reject
	Predicted value of separable and nonseparable models	Non-nested J-tests, OLS models	Fail to reject
Separation between farm labour demand and household demographic characteristics	Total farm labour demand, household demographics	Restricted normalised linear regression less fractional demographics, age and education variables	Fail to reject
		Restricted normalised log-linear regression less fractional demographics, age and education variables	Fail to reject
		Unrestricted normalised linear full regression model	Fail to reject
		Unrestricted normalised log-linear full regression model	Fail to reject

CHAPTER 4

Empirical Estimation of Agricultural Household Models

4.1 Introduction

This chapter presents empirical estimates of separable and nonseparable agricultural household models. The chapter also presents results of hypothesis tests and possible policy implications of the results obtained. Own price elasticities of the major functions are presented and relevant policy issues are addressed.

4.2 Estimation of Separable and Nonseparable Models

The previous chapter highlighted the major assumptions underlying separation of AHMs. Most studies of separation have focused on the labour market. An implication of separation is that family and hired labour used on the farm are taken to be perfect substitutes in production. Given this scenario, labour use on the farm is modelled using a single labour variable derived from a summation of family and hired labour. Under separation, the wage rate of hired labour may be regarded as the shadow price of family labour used on the farm. In a similar vein, household labour used on and off the farm can be modelled as perfect substitutes implying that household members have no preference for either working on or off the farm. Given this indifference, the off-farm wage rate may be used to value household leisure in the instance where some household members are engaged in off-farm work. Following Benjamin (1992), separation implies that household consumption and production decisions are made independently. Such separation in decision making holds given that households are price takers and have the choice to make up for any shortfalls between production and consumption through market purchases.

Nonseparability entails that household production and consumption decisions are made jointly. Other implications of nonseparation are that family and hired labour are no longer viewed as substitutes in the production process. Under nonseparability, household models are estimated conditional on the amount of family labour used in farming. The labour-leisure trade-off is the link connecting production and consumption decisions. This link has mainly been emphasized as a key source of nonseparability in the literature. The same approach will be adopted in this study. However nonseparability can also arise from other factors such as dynamics, risk and the presence of financial constraints.

Three main approaches are adopted in this study to estimate separable and nonseparable models. Firstly, in the case of maize output supply, yield response and acreage demand functions, the approach adopted is to start off with a general model which is consistent with either separability or nonseparability. The general functions are modelled conditional on the amount of family labour used on the farm. This ensures that we are controlling for the family farm labour-leisure choice connecting production and consumption decisions. Separation or nonseparation is introduced into the general model by estimating it jointly with the relevant separable or nonseparable family farm labour demand function. The main distinguishing characteristic of the nonseparable family farm labour demand function is that it incorporates both production and consumption side variables. Consumption variables used in this study are in the form of three main demographic variables based on the number of resident males, females and children. The nonseparable version of the family farm labour demand function is modelled as:

$$(4.1)\ L^{fd} = \alpha_0 + \alpha_1 p^{M*} + \alpha_2 Area92 + \alpha_3 Asset + \alpha_4 w^{F*} + \alpha_5 w^{l*} + \alpha_6 Draft + \alpha_7 w^{fof} + \sum_{i=1}^{4} w_i^{off*} + \sum_{i=1}^{3} \delta_i h_i + \sum_{i=1}^{2} \gamma_i R_i + u$$

where variables are as defined previously. On the other hand a separable family farm labour demand function is modelled as a function of production side variables only. This function is depicted as:

$$(4.2)\ L^{fd} = \alpha_0 + \alpha_1 p^{M*} + \alpha_2 Area92 + \alpha_3 Asset + \alpha_4 w^{F*} + \alpha_5 w^{l*} + \alpha_6 Draft + \alpha_7 w^{fof} + \sum_{i=1}^{4} \delta_i w^{off*} + \sum_{i=1}^{2} \gamma_i R_i + u$$

The system of equations for estimating the separable or nonseparable maize yield response functions includes equations for family farm labour demand and maize acreage demand. These variables are endogenous in the yield response function. Separable models are estimated as single linear functions by OLS and jointly by seemingly unrelated regression (SUR) procedures. 3SLS can not be used to estimate separable models due to perfect multicollinearity at the second stage regression phase. Perfect collinearity arises because all explanatory variables in the family farm labour demand function are explanatory variables in e.g. the general output supply function. An underlying assumption in using SUR is that all explanatory variables are exogenous. Nonseparable models are estimated jointly by both SUR and 3SLS. The latter regression procedure caters for joint estimation of systems of equations involving endogenous variables.

The second approach of model estimation applies to the maize consumption demand model. This function is not modelled conditional on the amount of family farm labour since this variable has already been incorporated in the production phase. In this case, a general model consistent with either separability or nonseparability is estimated by 2SLS. The amount of income spent on food is an endogenous variable in the maize consumption demand function.

The final approach applies to the maize marketed surplus supply function. As with the consumption function, it is not modelled conditional on the amount of family farm labour. A linear function consistent with separability or nonseparability is estimated directly with the volume of maize sold as the dependent variable. Parameter estimates consistent with a separable or nonseparable maize marketed surplus supply function are derived from a joint estimation of the general maize output supply model, relevant family farm labour demand function and the general maize consumption demand function. Marketed surplus supply is derived as the difference between production (output supply) and consumption demand. As stated above, separation or nonseparation is a function of the nature of the family farm labour demand function. Parameters consistent with a separable marketed surplus supply function are estimated by SUR whilst those for the nonseparable model are estimated by both SUR and 3SLS.

The following sections present separable and nonseparable models of key functions based on the criteria described. Yield response and acreage demand functions are estimated to capture supply response by splitting it into yield and acreage components. This approach has the advantage of possibly attributing output supply response to either yield response or acreage demand. Explanations for the significance of key variables are given for the main functions of interest in cases where models are estimated as a system of equations. Auxiliary regressions were run to detect possible cases of multicollinearity. There are no serious cases of multicollinearity to warrant dropping some variables or incorporating nonsample information in order to improve the explanatory power of the model. Regression models are estimated using appropriate sample sizes. The approach undertaken is to run regressions with the numeraire included. In cases where the numeraire price is significant, a second set of regression models were run with the numeraire excluded. The second scenario imposes homogeneity.

4.3 Maize Output Supply

A general version of the maize output supply function consistent with either separability or nonseparability can be modelled as:

$$
\begin{aligned}
(4.3)\quad y^{OS} = {} & \alpha_0 + \alpha_1 p^{M*} + \alpha_2 Area92 + \alpha_3 Asset + \alpha_4 w^{F*} + \alpha_5 w^{l*} + \alpha_6 Draft \\
& + \alpha_7 Famlab + \alpha_8 w^{fof} + \sum_{i=1}^{4} \lambda_i w_i^{off*} + \sum_{i=1}^{2} \gamma_i R_i + u
\end{aligned}
$$

where variables are as defined previously. The dependent variable is the weight of maize harvested during the drought year. It is apparent that a change in the price of maize simultaneously impacts on both the output supply and the level of family labour devoted to farm work. The analysis of the maize output supply function is based on a sub sample of households who harvested maize during the drought year in Regions I-III during the 1991/92 agricultural season. The sub sample consists of 106 households.

4.3.1 Separable Maize Output Supply

The linear separable maize output supply is estimated as 4.3 under the assumption that the family farm labour variable is predetermined. Parameter estimates for this model are presented below (Table 4.1). Results suggest that maize and fertiliser prices are not significant. The numeraire price is significant at the 0.1 level. Significance of the numeraire price implies that maize output supply increases as all prices are increased equiproportionally. Estimation of this model with the numeraire price dropped does not improve the statistical significance of maize and fertiliser prices.

Table 4.1. Linear Separable Maize Output Supply Function. Dependent Variable: Weight of Maize Harvested in Kilograms.

	coeff[a].	t-ratio
Intercept	74.698	0.4102
Total Area Cropped	48.323**[b]	2.204
Value of Farm Assets	0.00073537	0.4295
Maize Price[c]	187.29	0.5587
Fertiliser Price	-345.81	-0.7868
Casual Labour Cost/day	6.9939	0.1604
Dummy for Draught Animal Ownership	153.51*	1.886
Family Farm Labour Mandays	-0.21713	-0.1808
Off-farm Farm Wage Rate	19.563*	1.768
Construction Wage Rate	30.122	1.212
Government Work Wage Rate	4.1947	0.1234
Private Company Wage Rate	28.967	0.701
Other Work Wage Rate	-24.853	-0.6067
Dummy for Region II	-395.17**	-2.574
Dummy for Region III	-139.22	-1.324
R-Squared	0.3242	
Sample Size	106	

[a] Coefficients.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Prices are normalised by the off-farm farm wage rate.

Joint estimation of 4.2 and 4.3 by SUR enables us to derive parameter estimates for the second version of the separable maize output supply. The assumption that the family farm labour variable is exogenous holds. Parameter estimates for this system of equations are presented below (Tables 4.2 and 4.3). Results suggest that maize and fertiliser prices are not significant individually in both the maize output supply and family farm labour demand functions. The marginal significance of the numeraire price in both functions suggests that maize output supply and family farm labour demand increase as all prices are increased in equal proportion. Estimation of this system of equations with the numeraire price dropped does not improve the statistical significance of maize and fertiliser price variables. These results are not reported.

Table 4.2. SUR Separable Maize Output Supply Function.
Dependent Variable: Weight of Maize Harvested in Kilograms.

	coeff[a].	t-ratio
Intercept	74.698	0.4114
Total Area Cropped	48.323**[b]	2.211
Value of Farm Assets	0.0073537	0.4307
Maize Price[c]	187.29	0.5603
Fertiliser Price	-345.81	-0.789
Casual Labour Cost/day	6.9939	0.1608
Dummy for Draught Animal Ownership	153.51*	1.891
Family Farm Labour Mandays	-0.21713	-0.1813
Off-farm Farm Wage Rate	19.563*	1.773
Construction Wage Rate	30.122	1.215
Government Work Wage Rate	4.1947	0.1237
Private Company Wage Rate	28.967	0.7029
Other Work Wage Rate	-24.853	-0.6084
Dummy for Region II	-395.17**	-2.581
Dummy for Region III	-139.22	-1.327
R-Squared	0.3242	
Sample Size	106	

[a] Coefficients.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Prices are normalised by the off-farm farm wage rate.

Table 4.3. SUR Separable Family Farm Labour Demand Function - Output Supply Regression System.
Dependent Variable: Family Farm Labour Mandays.

	coeff[a].	t-ratio
Intercept	44.902***[b]	2.965
Total Area Cropped	7.1891	4.098
Value of Farm Assets	-0.0011247	-0.7568
Maize Price[c]	15.407	0.5287
Fertiliser Price	-11.3	-0.2954
Casual Labour Cost/day	-4.1421	-1.098
Dummy for Draught Animal Ownership	7.2857	1.034
Off-farm Farm Wage Rate	-1.5866*	-1.672
Construction Wage Rate	0.93744	0.4336
Government Work Wage Rate	-0.44572	-0.1506
Private Company Wage Rate	0.39443	0.1096
Other Work Wage Rate	-0.017722	-0.004969
Dummy for Region II	-24.566*	-1.873
Dummy for Region III	-13.31	-1.47
R-Squared	0.4113	
Sample Size	106	

[a] Coefficients.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Prices are normalised by the off-farm farm wage rate.

4.3.2 Nonseparable Maize Output Supply

Joint estimation of 4.1 and 4.3 by 3SLS gives parameter estimates consistent with a nonseparable maize output supply. Parameter estimates for this system of equations are presented below (Table 4.4 and 4.5). Results suggest that none of the variables in the nonseparable maize output supply function are statistically significant. Results also suggest that maize and fertiliser prices are not statistically significant in the family labour demand function (Table 4.5). There is no evidence of multicollinearity in this system of equations.

Table 4.4. 3SLS Nonseparable Maize Output Supply Function. Dependent Variable: Weight of Maize Harvested in Kilograms.

	coeff[a].	t-ratio
Intercept	40.686	0.1028
Total Area Cropped	42.878	0.7108
Value of Farm Assets	0.0082056	0.4239
Maize Price[b]	175.62	0.4898
Fertiliser Price	-337.25	-0.7468
Casual Labour Cost/day	10.131	0.1857
Family Farm Labour Mandays	0.54033	0.06838
Dummy for Draught Animal Ownership	147.99	1.482
Off-farm Farm Wage Rate	20.765	1.246
Construction Wage Rate	29.412	1.127
Government Work Wage Rate	4.5323	0.1316
Private Company Wage Rate	28.668	0.6866
Other Work Wage Rate	-24.839	-0.6017
Dummy for Region II	-376.56	-1.528
Dummy for Region III	-129.13	-0.8699
R-Squared	0.3212	
Sample Size	106	

[a] Coefficients.
[b] Prices are normalised by the off-farm farm wage rate.

Table 4.5. 3SLS Nonseparable Family Farm Labour Demand Function - Output Supply Regression System.
Dependent Variable: Family Farm Labour Mandays.

	coeff[a].	t-ratio
Intercept	49.681***[b]	3.082
Total Area Cropped	8.0079***	4.124
Value of Farm Assets	-0.0014209	-0.9427
Maize Price[c]	24.473	0.8244
Fertiliser Price	-10.489	-0.2673
Casual Labour Cost/day	-4.2808	-1.138
Dummy for Draught Animal Ownership	6.5334	0.9146
Number of Resident Males	2.6088	0.9991
Number of Resident Females	-2.1294	-0.8786
Number of Resident Children	-0.71165	-0.5222
Off-farm Farm Wage Rate	-1.8276*	-1.894
Construction Wage Rate	0.93723	0.4285
Government Work Wage Rate	-0.49795	-0.1649
Private Company Wage Rate	0.12772	0.03551
Other Work Wage Rate	-0.71819	-0.1996
Dummy for Region II	-25.523*	-1.938
Dummy for Region III	-14.102	-1.514
R-Squared	0.4251	
Sample Size	106	

[a] Coefficients.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Prices are normalised by the off-farm farm wage rate.

SUR parameter estimates for the maize output supply under nonseparation are presented below (Tables 4.6 and 4.7). As with the separable models, coefficients for maize and fertiliser prices are not statistically significant individually. This result holds for the family farm labour demand function as well. The marginal significance of the numeraire price in these two functions suggests that maize output supply and family farm labour demand increase as all prices are increased in equal proportion. Estimation of this system of equations with the numeraire price dropped does not improve the statistical significance of maize and fertiliser price variables. These results are not reported.

Table 4.6. SUR Nonseparable Maize Output Supply Function. Dependent Variable: Weight of Maize Harvested in Kilograms.

	coeff[a].	t-ratio
Intercept	73.901	0.4036
Total Area Cropped	48.196**[b]	2.187
Value of Farm Assets	0.0073737	0.4283
Maize Price[c]	187.02	0.5549
Fertiliser Price	-345.61	-0.782
Casual Labour Cost/day	7.0675	0.1612
Family Farm Labour Mandays	-0.19937	-0.1651
Dummy for Draught Animal Ownership	153.38*	1.874
Off-farm Farm Wage Rate	19.591*	1.761
Construction Wage Rate	30.105	1.205
Government Work Wage Rate	4.2026	0.1229
Private Company Wage Rate	28.96	0.697
Other Work Wage Rate	-24.852	-0.6033
Dummy for Region II	-394.73**	-2.557
Dummy for Region III	-138.98	-1.314
R-Squared	0.3242	
Sample Size	106	

[a] Coefficients.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Prices are normalised by the off-farm farm wage rate.

Table 4.7. SUR Nonseparable Family Farm Labour Demand Function - Output Supply Regression System.
Dependent Variable: Family Farm Labour Mandays.

	coeff[a].	t-ratio
Intercept	49.714***[b]	3.084
Total Area Cropped	8.0113	4.125
Value of Farm Assets	-0.0014224	-0.9436
Maize Price[c]	24.472	0.8244
Fertiliser Price	-10.435	-0.2659
Casual Labour Cost/day	-4.2812	-1.138
Dummy for Draught Animal Ownership	6.5292	0.9139
Number of Resident Males	2.6009	0.9949
Number of Resident Females	-2.1185	-0.8729
Number of Resident Children	-0.72398	-0.5302
Off-farm Farm Wage Rate	-1.8282*	-1.894
Construction Wage Rate	0.94066	0.43
Government Work Wage Rate	-0.50378	-0.1668
Private Company Wage Rate	0.12676	0.03524
Other Work Wage Rate	-0.71648	-0.1991
Dummy for Region II	-25.538*	-1.94
Dummy for Region III	-14.101	-1.514
R-Squared	0.4251	
Sample Size	106	

[a] Coefficients.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Prices are normalised by the off-farm farm wage rate.

4.4 Maize Marketed Surplus Supply Function

A marketed surplus supply function gives information pertaining to the response of the volume of sales to changes in variables influencing both production and consumption. Peasant farmers consume a significant proportion of their production and market some surplus. It is therefore important to estimate a marketed surplus supply function for maize since it is a key food and cash crop. The maize marketed surplus supply function is derived as the difference between the maize output supply (production) and maize consumption demand function (Strauss, 1984; Lau *et al*, 1978). Thus the volume of maize sales is modelled as a function of all the variables influencing production and consumption. In this study, direct maize sales figures are used to estimate a maize marketed surplus supply function. This arises from the fact that data collection captured actual sales volumes. Strauss (1984) defines a general reduced form version of marketed surplus as:

$$(4.4) \quad y^{MS} = y^{MS}(p,\eta,m,z,k,A)$$

where p is an N vector of grain sales prices, η is household characteristics affecting taste, m is household characteristics determining time available to the household for work and leisure, z is a vector of farm characteristics including fixed inputs, k is a vector of production technology parameters and A is exogenous income. Off-farm wage rates are used as a measure of the household's level of exogenous income.

A general linear version of the maize marketed surplus supply function consistent with either separation or nonseparation is modelled as:

$$(4.5)\ y^{MS} = \alpha_0 + \alpha_1 p^{M*} + \alpha_2 Area92 + \alpha_3 Asset + \alpha_4 w^{F*} + \alpha_5 w^{l*} + \alpha_6 Draft + \alpha_7 w^{fof} + \sum_{i=1}^{4} w^{off*} + \sum_{i=1}^{3} \delta_i h_i + \sum_{i=1}^{2} \gamma_i R_i + u$$

where variables are defined as in previous equations. This function is not modelled conditional on the level of family labour devoted to farming since this variable has already been incorporated in the production function. The impact of changes in the price of maize on its marketed surplus is derived as the difference between the impact of maize price on maize production and on maize consumption. The analysis of maize marketed surplus is restricted to Regions I-III only. These are the regions where maize is mainly grown and a significant proportion of the households sold maize. All households in the three regions are used in this analysis since selling maize is a choice variable. Parameter estimates for a separable or nonseparable maize marketed surplus supply function are derived from joint estimation of the general maize output supply, relevant family farm labour demand and the general maize consumption demand functions. Parameter estimates for these systems of equations are not presented in this study. Marketed surplus is derived as the difference between production and consumption. Parameter estimates for the linear maize marketed surplus supply function which is consistent with separation or nonseparation is estimated by OLS using the model structure of 4.5. Regression results for the linear model are presented below (Table 4.8). Results show that maize and fertiliser prices do not have significant impacts individually. The significance of the numeraire price suggests that maize marketed surplus supply increases if all prices increase in equal proportion. Estimation of the above model with the numeraire price excluded does not improve the statistical significance of maize and fertiliser prices. These results are not reported.

Table 4.8. General Linear Maize Marketed Surplus Supply Function. Dependent Variable: Weight of Maize Sold in Kilograms.

	coeff[a].	t-ratio
Intercept	-1532.1**[b]	-3.532
Total Area Cropped	116.44	1.622
Value of Farm Assets	0.04957	0.8086
Maize Price[c]	-795.78	-0.7045
Fertiliser Price	-1768	-1.274
Casual Labour Cost/day	128.37	0.9581
Dummy for Draught Animal Ownership	337.73	1.367
Off-farm Farm Wage Rate	211.62***	6.074
Construction Wage Rate	283.29***	3.455
Government Work Wage Rate	-35.25	-0.4556
Private Company Wage Rate	38.228	0.3103
Other Work Wage Rate	-24.616	-0.1908
Number of Resident Males	-105.3	-1.227
Number of Resident Females	-176.40**	-1.987
Number of Resident Children	20.758	0.4232
Dummy for Region II	-892.30*	-1.925
Dummy for Region III	-382.61	1.155
R-Squared	0.4595	
Sample Size	142	

[a] Coefficients.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Prices are normalised by the off-farm farm wage rate.

4.5 Models of Maize Supply Response

Supply response functions for maize are derived using yield response and acreage demand functions. Yield response and acreage demand equations can be viewed as a structural model underlying a reduced form output supply equation. These reduced form equations involve different time frames in terms of decision making. Earlier studies of supply response modelled it with output as the dependent variable. A major problem with reduced form models is that they are prone to multicollinearity problems compared to the estimation of structural equations. Using yield and acreage as dependent variables has the advantage of incorporating economic variables which influence supply response (Mundang, 1996). There are substantial gains in efficiency and understanding when the acreage and yield components are estimated directly rather than as reduced form output supplies (Mundang, 1996). Estimating acreage demands has the advantage that acreage planted is unaffected by subsequent weather and hence may proxy planned output more closely than does observed output (Mundang, 1996). The analysis will focus on deriving a maize supply response functions for households in Regions I-III since the other two regions experienced near total maize crop failures. The emphasis is on risk neutral models of supply response since data is cross-sectional. Supply response models for Manitoba agriculture have been estimated by Mundang (1996), Coyle and Mundang (1997) and Coyle (1993). Supply response functions are normalized by the wage rate for hired casual farm labour. This study does not incorporate measures of risk aversion since cross sectional data for one agricultural season is used. However other studies of crop supply response such as Mundang (1996) and Coyle and Mundang (1997) have used models which include measures of risk aversion. The models adopted in this study are risk neutral and static as opposed to dynamic.

4.5.1 Models of Crop Yield Response to Price

A yield response function has one major weakness with regard to this study. A major drought was experienced during the survey period. Crop yields were therefore affected by the drought. The implication is that the estimated yield response function is specific to the drought year under consideration. Results do not apply to normal seasons. Under nonseparability between production and consumption decisions, the maize yield response function depends on all the exogenous variables influencing production and consumption. A general maize yield response function conditional on the level of family labour and consistent with either separability or nonseparability can be depicted as:

$$(4.6)\ y^{ld} = \alpha_0 + \alpha_1 p^{M*} + \alpha_3 Asset_a + \alpha_4 MzArea + \alpha_5 w^{F*} + \alpha_6 w^l + \alpha_7 Draft + \alpha_8 Famlab_a + \sum_{i=1}^{5} \lambda_i w_i^{off*} + \sum_{i=1}^{2} \gamma_i R_i + u$$

where *MzArea* is maize acreage in the 1991/92 agricultural season, $Asset_a$ and $Famlab_a$ are the value of farm assets per acre and family farm labour mandays per acre respectively and other variables are as defined before. There are two endogenous variables in this function i.e. the amount of family farm labour mandays used on the farm and acreage under maize. It is apparent that variations in maize price influence maize yield , family farm labour demand and maize acreage. The effect of maize price on yield is indirect i.e. via the influence on area planted and level of input application.

A general maize acreage demand function conditional on the amount of family labour used on the farm can be depicted as:

$$(4.7)\ y^{ad} = \alpha_0 + \alpha_1 p^{M*} + \alpha_2 Area91 + \alpha_3 Area92 + \alpha_4 Asset_a + \alpha_5 w^{F*} + \alpha_6 w^{l} + \alpha_7 Draft + \alpha_8 Famlab_a + \sum_{i=1}^{5} \lambda_i w_i^{off*} + \sum_{i=1}^{2} \gamma_i R_i + u$$

where Area91 is total area cropped during the 1990/91 agricultural season and other variables are as defined before. The next two sections present yield response and acreage demand models in that order. The analysis on supply response is restricted to the sub sample of households that harvested maize during 1991/92 agricultural season. This analysis thus uses positive yields only. Zero yields are excluded since failure to harvest maize can be attributed to the drought and does not represent a choice variable.

4.5.1.1 Separable Model of Maize Yield Response to Price

A linear maize yield response function given that family farm labour demand is exogenous is modelled as 4.6. Parameter estimates for this model are presented below (Table 4.9). Results suggest that maize and fertiliser prices do not have significant individual effects on maize yield. The numeraire price is not statistically significant. There is no evidence of multicollinearity in this function.

Table 4.9. Linear Separable Maize Yield Response Function. Dependent Variable: Maize Yield in Kilograms/acre.

	coeff[a].	t-ratio
Intercept	198.17	1.638
Maize Price[b]	144.91	0.528
Value of Farm Assets per Acre	0.0057577	0.2076
Maize Acreage	-53.051**[c]	-2.582
Fertiliser Price	-689.19	-1.162
Casual Labour Cost/day	6.2949	1.039
Draught Animal Ownership Dummy	84.11*	1.897
Family Farm Labour Mandays per Acre	1.5254	0.8452
Off-farm Farm Wage Rate	35.54	1.005
Construction Wage Rate	39.777	1.582
Government Work Wage Rate	16.533	0.7395
Private Company Wage Rate	10.245	0.3764
Other Work Wage Rate	-32.386	-1.352
Dummy for Region II	-199.49**	-2.368
Dummy for Region III	-73.904	-1.213
R-Squared	0.2239	
Sample Size	106	

[a] Coefficients.

[b] Prices are normalised by the daily wage rate of casual farm labour.

[c] Prices are normalised by the daily wage rate of casual farm labour.

Joint estimation by SUR of 4.2, 4.6 and 4.7 gives parameter estimates for a yield response function consistent with separation. Parameter estimates for this system of three equations are presented below (Tables 4.10, 4.11 and 4.12). Results of the separable maize yield response function suggest that maize acreage has a negative significant effect on yield. This result can be attributed to the fact that an increase in maize area spreads out input use leading to lower yields or that average quality of land in maize production decreases as maize area increases. The dummy variable for draught animal ownership has a significant positive impact on maize yield. This effect could be attributed to timeliness in planting and better land preparation. Results show that maize and fertiliser variables are not significant in each of the three equations forming this system. However maize and fertiliser prices have somewhat high though insignificant t-ratios in the family farm labour demand function (Table 4.11). The numeraire price is not significant in all three equations.

Table 4.10. SUR Separable Maize Yield Response Function. Dependent Variable: Maize Yield in Kilograms per Acre.

	coeff[a].	t-ratio
Intercept	207.41*[b]	1.715
Maize Price[c]	144.44	0.5263
Value of Farm Assets per Acre	0.0062686	0.226
Maize Acreage	-59.30***	-2.889
Fertiliser Price	-723.15	-1.219
Casual Labour Cost/day	6.6329	1.095
Draught Animal Ownership Dummy	90.804**	2.049
Family Farm Labour Mandays per Acre	1.5206	0.8428
Off-farm Farm Wage Rate	37.707	1.066
Construction Wage Rate	40.824	1.623
Government Work Wage Rate	17.308	0.7742
Private Company Wage Rate	9.4607	0.3476
Other Work Wage Rate	-33.03	-1.379
Dummy for Region II	-209.97**	-2.493
Dummy for Region III	-80.469	-1.321
R-Squared	0.2229	
Sample Size	106	

[a] Coefficients.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Prices are normalised by the daily wage rate of casual farm labour.

Table 4.11. SUR Separable Family Farm Labour Demand Function - Maize Yield Response Regression System.
Dependent Variable: Family Farm Labour Mandays per Acre.

	coeff[a].	t-ratio
Intercept	32.124***[b]	5.595
Total Area Cropped	-3.2372***	-5.222
Value of Farm Assets per Acre	-0.0018372	-1.172
Maize Price[c]	25.193	1.644
Fertiliser Price	-46.288	-1.4
Casual Labour Cost/day	-0.24465	-0.7129
Draught Animal Ownership Dummy	3.2409	1.337
Off-farm Farm Wage Rate	-1.7327	-0.8709
Construction Wage Rate	3.03973**	2.226
Government Work Wage Rate	0.25721	0.2027
Private Company Wage Rate	-1.0673	-0.6956
Other Work Wage Rate	0.00882	0.006511
Dummy for Region II	-13.652***	-3.138
Dummy for Region III	-4.0579	-1.251
R-Squared	0.4711	
Sample Size	106	

[a] Coefficients.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Prices are normalised by the daily wage rate of casual farm labour.

Table 4.12. SUR Separable Maize Acreage Demand Function - Maize Yield Response Regression System.
Dependent Variable: Maize Acreage in 1991/92 Agricultural Season.

	coeff[a].	t-ratio
Intercept	0.96202**[b]	2.41
Maize Price[c]	0.62166	0.668
Total Area 1990/91	-0.054706	-0.8968
Total Area 1991/92	0.49186***	7.893
Value of Farm Assets per Acre	0.0000899	0.9485
Fertiliser Price	-2.4888	-1.245
Casual Labour Cost/day	0.010427	0.4983
Dummy for Draught Animal Ownership	0.35107**	2.394
Family Farm Labour Per Acre	-0.0073533	-1.163
Off-farm Farm Wage Rate	0.11363	0.9458
Construction Wage Rate	0.06869	0.7998
Government Work Wage Rate	0.02497	0.328
Private Company Wage Rate	-0.073284	-0.7825
Other Work Wage Rate	-0.10596	-1.305
Dummy for Region II	-0.80668***	-2.941
Dummy for Region III	-0.64001***	-3.079
R-Squared	0.7598	
Sample Size	106	

[a] Coefficients.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Prices are normalised by the daily wage rate of casual farm labour.

4.5.1.2 Nonseparable Model of Maize Yield Response to Price

Joint estimation of 4.1, 4.6 and 4.7 by 3SLS give parameter estimates for the nonseparable version of the maize yield response function. Parameter estimates for this system of three equations are given below (Tables 4.13 - 4.15). Results of the nonseparable maize yield response function are almost similar to those of the separable version and the same interpretations hold with respect to the significance of maize and fertiliser price variables. The coefficient for fertiliser is somewhat high though insignificant. Maize price also has a somewhat high but insignificant effect on the family farm labour demand function. On the other hand fertiliser price has a significant negative impact on the family farm labour demand function. The numeraire price is insignificant in all three functions.

Table 4.13. 3SLS Nonseparable Maize Yield Response Function. Dependent Variable: Maize Yield in Kilograms per Acre.

	coeff[a].	t-ratio
Intercept	390.6	1.517
Maize Price[b]	282.39	0.8542
Value of Farm Assets per Acre	0.001037	0.03541
Maize Acreage	-93.505**[c]	-2.006
Fertiliser Price	-1026.3	-1.443
Casual Labour Cost/day	5.783	0.9067
Draught Animal Ownership Dummy	118.7**	2.084
Family Farm Labour Mandays per Acre	-3.3414	-0.5244
Off-farm Farm Wage Rate	34.111	0.9214
Construction Wage Rate	57.394*	1.748
Government Work Wage Rate	19.596	0.8476
Private Company Wage Rate	1.4425	0.04877
Other Work Wage Rate	-36.727	-1.47
Dummy for Region II	-301.33**	-2.142
Dummy for Region III	-123.63	-1.516
R-Squared	0.1554	
Sample Size	106	

[a] Coefficients.
[b] Prices are normalised by the daily wage rate of casual farm labour.
[c] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.

Table 4.14. 3SLS Nonseparable Family Farm Labour Demand Function - Maize Yield Response Regression System.
Dependent Variable: Family Farm Labour Mandays per Acre.

	coeff[a].	t-ratio
Intercept	29.602***[b]	4.99
Total Area Cropped	-3.7133***	-5.409
Maize Price[c]	23.961	1.555
Value of Farm Assets per Acre	-0.0019687	-1.249
Fertiliser Price	-59.393*	-1.766
Casual Labour Cost/day	-0.18499	-0.5406
Draught Animal Ownership Dummy	2.8329	1.162
Number of Resident Males	0.87147	0.9966
Number of Resident Females	0.95375	1.168
Number of Resident Children	0.023488	0.05145
Off-farm Farm Wage Rate	-2.1718	-1.08
Construction Wage Rate	3.3312**	2.367
Government Work Wage Rate	0.63112	0.4859
Private Company Wage Rate	-0.86845	-0.5699
Other Work Wage Rate	0.19546	0.145
Dummy for Region II	-13.667***	-3.15
Dummy for Region III	-2.9973	-0.9125
R-Squared	0.4836	
Sample Size	106	

[a] Coefficients.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Prices are normalised by the daily wage rate of casual farm labour.

Table 4.15. 3SLS Nonseparable Maize Acreage Demand Function - Maize Yield Response Regression System.
Dependent Variable: Maize Acreage in 1991/92 Agricultural Season.

	coeff.[a]	t-ratio
Intercept	0.22696	0.2157
Maize Price[b]	0.046381	0.03719
Total Area Cropped 1990/91	-0.067946	-0.9407
Total Area Cropped 1991/92	0.57522***[c]	6.055
Value of Farm Assets per Acre	0.00013	1.105
Fertiliser Price	-1.4333	-0.5636
Casual Labour Cost/day	0.016793	0.7366
Dummy for Draught Animal Ownership	0.27607	1.515
Family Farm Labour Per Acre	0.015186	0.4792
Off-farm Farm Wage Rate	0.15049	1.066
Construction Wage Rate	0.00010645	0.0007888
Government Work Wage Rate	0.018046	0.2227
Private Company Wage Rate	-0.045327	-0.4455
Other Work Wage Rate	-0.10531	-1.22
Dummy for Region II	-0.49935	-0.9714
Dummy for Region III	-0.53283**	-2.279
R-Squared	0.7249	
Sample Size	106	

[a] Coefficients.
[b] Prices are normalised by the daily wage rate of casual farm labour.
[c] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.

Joint estimation of 4.1, 4.6 and 4.7 by SUR gives parameter estimates for the second nonseparable version of the maize yield response function. These results are presented below (Tables 4.16-4.18). Maize and fertiliser price variables are insignificant individually in the maize yield response and acreage demand functions. Maize and fertiliser prices have significant positive and negative impacts respectively on the nonseparable family farm labour demand function. These two price variables are both significant at the 0.1 level. The numeraire price is not significant in all three equations.

Table 4.16. SUR Nonseparable Maize Yield Response Function. Dependent Variable: Maize Yield in Kilograms per Acre.

	coeff[a].	t-ratio
Intercept	198.62	1.634
Maize Price[b]	136.98	0.4964
Value of Farm Assets per Acre	0.0066074	0.2369
Maize Acreage	-58.171***[c]	-2.819
Fertiliser Price	-710.72	-1.192
Casual Labour Cost/day	6.7168	1.103
Draught Animal Ownership Dummy	90.064**	2.021
Family Farm Labour Mandays per Acre	1.7811	0.9821
Off-farm Farm Wage Rate	38.146	1.072
Construction Wage Rate	40.052	1.584
Government Work Wage Rate	17.273	0.7684
Private Company Wage Rate	9.8024	0.3582
Other Work Wage Rate	-32.904	-1.366
Dummy for Region II	-206.25**	-2.436
Dummy for Region III	-78.896	-1.288
R-Squared	0.2227	
Sample Size	106	

[a] Coefficients.
[b] Prices are normalised by the daily wage rate of casual farm labour.
[c] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.

Table 4.17. SUR Nonseparable Family Farm Labour Demand Function - Maize Yield Response Function.
Dependent Variable: Family Farm Labour Mandays per Acre.

	coeff[a].	t-ratio
Intercept	30.077***[b]	5.052
Total Area Cropped	-3.5513***	-5.122
Maize Price[c]	25.851*	1.674
Value of Farm Assets per Acre	-0.0021777	-1.38
Fertiliser Price	-57.847*	-1.717
Casual Labour Cost/day	-0.18231	-0.5325
Draught Animal Ownership Dummy	2.575	1.055
Number of Resident Males	1.1791	1.294
Number of Resident Females	0.90148	1.067
Number of Resident Children	-0.31672	-0.6549
Off-farm Farm Wage Rate	-2.3872	-1.186
Construction Wage Rate	3.5079**	2.49
Government Work Wage Rate	0.54584	0.4186
Private Company Wage Rate	-0.92283	-0.6054
Other Work Wage Rate	0.14437	0.107
Dummy for Region II	-14.065***	-3.239
Dummy for Region III	-2.8949	-0.8811
R-Squared	0.4875	
Sample Size	106	

[a] Coefficients.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Prices are normalised by the daily wage rate of casual farm labour.

Table 4.18. SUR Nonseparable Maize Acreage Demand Function - Maize Yield Response Regression System.
Dependent Variable: Maize Acreage in 1991/92 Agricultural Season.

	coeff[a].	t-ratio
Intercept	0.94244**[b]	2.348
Maize Price[c]	0.60619	0.6478
Total Area Cropped 1990/91	-0.054898	-0.895
Total Area Cropped 1991/92	0.49392***	7.883
Value of Farm Assets per Acre	0.000091	0.9547
Fertiliser Price	-2.461	-1.224
Casual Labour Cost/day	0.010593	0.5034
Dummy for Draught Animal Ownership	0.34916**	2.368
Family Farm Labour Per Acre	-0.0067461	-1.062
Off-farm Farm Wage Rate	0.11468	0.9493
Construction Wage Rate	0.066843	0.774
Government Work Wage Rate	0.024809	0.3241
Private Company Wage Rate	-0.072585	-0.7707
Other Work Wage Rate	-0.10595	-1.298
Dummy for Region II	-0.79852***	-2.895
Dummy for Region III	-0.63736***	-3.05
R-Squared	0.7597	
Sample Size	106	

[a] Coefficients.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Prices are normalised by the daily wage rate of casual farm labour.

4.5.2 Maize Acreage Demand Function

A general version of the maize acreage demand function conditional on the amount of family farm labour and consistent with either separability or nonseparability can be modelled as 4.7.

4.5.2.1 Separable Maize Acreage Demand Function

A linear separable version of the maize acreage demand function assuming family farm labour is exogenous is modelled as 4.7. Parameter estimates for the linear separable maize acreage demand function are presented below (Table 4.19). Results further suggest that maize and fertiliser prices are not significant. The numeraire price is not significant too.

Table 4.19. Linear Separable Maize Acreage Demand Function. Dependent Variable: Maize Acreage in 1991/92 Agricultural Season.

	coeff[a].	t-ratio
Intercept	0.96526**[b]	2.404
Maize Price[c]	0.62332	0.6661
Total Area Cropped 1990/91	-0.048037	-0.7818
Total Area Cropped 1991/92	0.48676***	7.759
Value of Farm Assets per Acre	0.0000907	0.9516
Fertiliser Price	-2.4922	-1.24
Casual Labour Cost/day	0.010029	0.4766
Dummy for Draught Animal Ownership	0.35199**	2.387
Family Farm Labour Mandays	-0.0072759	-1.145
Off-farm Farm Wage Rate	0.11493	0.9513
Construction Wage Rate	0.067865	0.7858
Government Work Wage Rate	0.025542	0.3337
Private Company Wage Rate	-0.075178	-0.7982
Other Work Wage Rate	-0.10639	-1.304
Dummy for Region II	-0.80569***	-2.921
Dummy for Region III	-0.6477***	-3.098
R-Squared	0.7598	
Sample Size	106	

[a] Coefficients.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Prices are normalised by the daily wage rate of casual farm labour.

Joint estimation of 4.2 and 4.7 by SUR gives parameter estimates for the separable maize acreage demand function when the acreage demand and family farm labour models are estimated as a system. Parameters derived from this system of two equations are presented below (Tables 4.20 and 4.21). Results of the maize acreage demand function suggest that total acreage during the current season (1991/92) is an important determinant of maize acreage demand. This variable is highly significant (0.01 level). Neither maize nor fertiliser price is statistically significant in the two functions. Maize and fertiliser prices have somewhat high but insignificant t-ratios in the family farm labour demand function (Table 4.21). The numeraire price is not significant in all two functions. There is no evidence of multicollinearity in these functions.

Table 4.20. SUR Separable Maize Acreage Demand Function.
Dependent Variable: Maize Acreage in 1991/92 Agricultural Season.

	coeff[a].	t-ratio
Intercept	0.96526**[b]	2.418
Maize Price[c]	0.62332	0.6697
Total Area Cropped 1990/91	-0.048037	-0.7862
Total Area Cropped 1991/92	0.48676***	7.802
Value of Farm Assets per Acre	0.0000907	0.9569
Fertiliser Price	-2.4922	-1.246
Casual Labour Cost/day	0.010029	0.4792
Dummy for Draught Animal Ownership	0.35199**	2.4
Family Farm Labour Mandays	-0.0072759	-1.151
Off-farm Farm Wage Rate	0.11493	0.9566
Construction Wage Rate	0.067865	0.7901
Government Work Wage Rate	0.025542	0.3355
Private Company Wage Rate	-0.075178	-0.8026
Other Work Wage Rate	-0.10639	-1.311
Dummy for Region II	-0.80569***	-2.937
Dummy for Region III	-0.6477***	-3.116
R-Squared	0.7598	
Sample Size	106	

[a] Coefficients.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Prices are normalised by the daily wage rate of casual farm labour.

Table 4.21. SUR Separable Family Farm Labour Demand Function - Maize Acreage Demand Regression System.
Dependent Variable: Family Farm Labour Mandays per Acre.

	coeff[a].	t-ratio
Intercept	32.124***[b]	5.595
Total Area Cropped	-3.2369***	-5.221
Value of Farm Assets per Acre	-0.0018371	-1.172
Maize Price[c]	25.194	1.644
Fertiliser Price	-46.285	-1.4
Casual Labour Cost/day	-0.24469	-0.713
Dummy for Draught Animal Ownership	3.2403	1.337
Off-farm Farm Wage Rate	-1.7329	-0.871
Construction Wage Rate	3.0972**	2.226
Government Work Wage Rate	0.25713	0.2026
Private Company Wage Rate	-1.0672	-0.6956
Other Work Wage Rate	0.0088145	0.006507
Dummy for Region II	-13.652***	-3.138
Dummy for Region III	-4.0576	-1.251
R-Squared	0.4711	
Sample Size	106	

[a] Coefficients.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Prices are normalised by the daily wage rate of casual farm labour.

4.5.2.2 Nonseparable Maize Acreage Demand Function

Parameter estimates consistent with a nonseparable maize acreage demand function are obtained by estimating 4.1 and 4.7 jointly. 3SLS regression results for this system are given below (Tables 4.22 and 4.23). As in previous models, maize and fertiliser prices are insignificant in the maize acreage demand function. Maize price has a somewhat high but insignificant t-ratio in the family farm labour demand function (Table 4.23). However fertiliser price has a significant negative impact on the nonseparable family farm labour demand function. This result holds at the 0.1 level. The numeraire price is not significant in these two functions.

Table 4.22. 3SLS Nonseparable Maize Acreage Demand Function. Dependent Variable: Maize Acreage in 1991/92 Agricultural Season.

	coeff[a].	t-ratio
Intercept	0.16614	0.1573
Maize Price[b]	-0.003	-0.002399
Total Area Cropped 1990/91	-0.051878	-0.7118
Total Area Cropped 1991/92	0.56999***[c]	5.975
Value of Farm Assets per Acre	0.00013588	1.151
Fertiliser Price	-1.3418	-0.5259
Casual Labour Cost/day	0.016335	0.7145
Dummy for Draught Animal Ownership	0.2711	1.483
Family Farm Labour Mandays per Acre	0.0175	0.5499
Off-farm Farm Wage Rate	0.15721	1.111
Construction Wage Rate	-0.0085224	-0.06292
Government Work Wage Rate	0.01884	0.2318
Private Company Wage Rate	-0.047602	-0.4665
Other Work Wage Rate	-0.10636	-1.229
Dummy for Region II	-0.46752	-0.906
Dummy for Region III	-0.54259**	-2.314
R-Squared	0.7185	
Sample Size	106	

[a] Coefficients.
[b] Prices are normalised by the daily wage rate of casual farm labour.
[c] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.

Table 4.23. 3SLS Nonseparable Family Farm Labour Demand Function - Maize Acreage Demand Regression System.
Dependent Variable: Family Farm Labour Mandays per Acre.

	coeff[a].	t-ratio
Intercept	29.386***[b]	4.937
Total Area Cropped	-3.7598***	-5.447
Maize Price[c]	23.839	1.542
Value of Farm Assets per Acre	-0.001995	-1.262
Fertiliser Price	-60.698*	-1.799
Casual Labour Cost/day	-0.17919	-0.5221
Draught Animal Ownership Dummy	2.7763	1.135
Number of Resident Males	0.95784	1.08
Number of Resident Females	1.0886	1.317
Number of Resident Children	-0.0030852	-0.00665
Off-farm Farm Wage Rate	-2.2301	-1.105
Construction Wage Rate	3.3708**	2.388
Government Work Wage Rate	0.65585	0.5032
Private Company Wage Rate	-0.84755	-0.5546
Other Work Wage Rate	0.21777	0.1611
Dummy for Region II	-13.701***	-3.148
Dummy for Region III	-2.8657	-0.8698
R-Squared	0.4833	
Sample Size	106	

[a] Coefficients.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Prices are normalised by the daily wage rate of casual farm labour.

Joint estimation of 4.1 and 4.7 by SUR gives parameter estimates for the second version of the nonseparable maize acreage demand function. These parameter estimates are presented below (Tables 4.24 and 4.25). Results suggest that maize and fertiliser prices are not significant explanatory variables in the SUR estimated maize acreage demand function. Maize and fertiliser prices have marginally significant positive and negative effects respectively on the family farm labour demand function (Table 4.25). The numeraire price is not significant in both functions.

Table 4.24. SUR Nonseparable Maize Acreage Demand Function. Dependent Variable: Maize Acreage in 1991/92 Agricultural Season.

	coeff[a].	t-ratio
Intercept	0.94537**[b]	2.348
Maize Price[c]	0.60775	0.6476
Total Area Cropped 1990/91	-0.048298	-0.7839
Total Area Cropped 1991/92	0.48895***	7.773
Value of Farm Assets per Acre	0.0000918	0.9605
Fertiliser Price	-2.4636	-1.222
Casual Labour Cost/day	0.010195	0.4831
Dummy for Draught Animal Ownership	0.34996**	2.366
Family Farm Labour Mandays per Acre	-0.0066637	-1.045
Off-farm Farm Wage Rate	0.11595	0.9571
Construction Wage Rate	0.065992	0.762
Government Work Wage Rate	0.025362	0.3304
Private Company Wage Rate	-0.074447	-0.7882
Other Work Wage Rate	-0.10638	-1.3
Dummy for Region II	-0.79733***	-2.883
Dummy for Region III	-0.64491***	-3.076
R-Squared	0.7598	
Sample Size	106	

[a] Coefficients.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Prices are normalised by the daily wage rate of casual farm labour.

Table 4.25. SUR Nonseparable Family Farm Labour Demand Function - Maize Acreage Demand Regression System.
Dependent Variable: Family Farm Labour Mandays per Acre.

	coeff[a].	t-ratio
Intercept	30.099***[b]	5.042
Total Area Cropped	-3.5451***	-5.097
Maize Price[c]	25.869*	1.67
Value of Farm Assets per Acre	-0.0021724	-1.372
Fertiliser Price	-57.677*	-1.708
Casual Labour Cost/day	-0.18305	-0.5332
Draught Animal Ownership Dummy	2.5841	1.056
Number of Resident Males	1.1685	1.278
Number of Resident Females	0.87797	1.035
Number of Resident Children	-0.30925	-0.6374
Off-farm Farm Wage Rate	-2.3778	-1.178
Construction Wage Rate	3.5005**	2.478
Government Work Wage Rate	0.54448	0.4164
Private Company Wage Rate	-0.92573	-0.6056
Other Work Wage Rate	0.14078	0.1042
Dummy for Region II	-14.055***	-3.228
Dummy for Region III	-2.9154	-0.8849
R-Squared	0.4875	
Sample Size	106	

[a] Coefficients.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Prices are normalised by the daily wage rate of casual farm labour.

4.6 Maize Consumption Function

A maize consumption function consistent with either separation or nonseparation is formulated as:

$$(4.8) \quad y^{Cons} = \alpha_0 + \alpha_1 p^{M*} + \alpha_2 Fexp + \sum_{i=1}^{3} \delta_i h_i + \sum_{i=1}^{5} \gamma_i R_i + \mu$$

where *Fexp* is the amount of income spent on food purchases and other variables are as defined before. Food expenditure is used as the numeraire price for this function. An expenditure variable is chosen over full household income or exogenous income since it excludes fewer variables compared to the other two alternatives. Leisure is not explicitly modelled in the consumer demand function. The assumption is that leisure is weakly separable from the utility function of the household. Since the amount of income spent on food is endogenous, 2SLS procedures are used to estimate the maize consumer demand function. Parameter estimates for this system are presented below (4.26). Maize price is not statistically significant. Results suggest that the amount of income spent on food, which is the numeraire price, is significant at the 0.05 level. Among the demographic variables, maize price has a marginally significant positive impact on maize consumption. Significance of the numeraire price implies that maize consumption demand increases if all prices are increased by an equal proportion. The dummy variable for region III has a significant positive impact on maize consumption suggesting that a move from region I to region III is characterised by an increase in maize consumption.

Table 4.26. 2SLS Maize Consumption Function.
Dependent Variable: Weight of Maize Consumed in Kilograms.

	coeff[a].	t-ratio
Intercept	175.21	0.4219
Maize Price[b]	-362360.0	-0.6282
Expenditure on Food	0.2217**[c]	2.046
Number of Resident Males	-58.673	-1.264
Number of Resident Females	105.80*	1.855
Number of Resident Children	-10.639	-0.363
Dummy for Region II	329.14	1.639
Dummy for Region III	819.91***	4.657
Dummy for Region IV	-6.8399	-0.02476
Dummy for Region V	-229.36	-0.9753
R-Squared	0.4135	
Sample Size	215	

[a] Coefficients.
[b] Prices are normalised by the amount of income spent on purchasing food.
[c] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.

A second maize consumption demand is estimated excluding the numeraire price. A linear model is used since all explanatory variables are now exogenous. Parameter estimates for this model are presented below (Table 4.27). Results suggest that the normalised maize price is now highly significant. This variable has the expected negative sign, suggesting that an increase in maize price leads to a decrease in the volume of maize consumed. Due to the nature of normalisation done, we get a large maize coefficient. Elimination of the numeraire price thus improves the statistical significance of the maize price in the maize consumer demand function.

Table 4.27. Linear Maize Consumption Function. Dependent Variable: Weight of Maize Consumed in Kilograms.

	coeff[a].	t-ratio
Intercept	940.88***[b]	4.951
Maize Price[c]	-1253200.0***	-3.138
Number of Resident Males	-39.396	-0.8211
Number of Resident Females	168.77***	3.327
Number of Resident Children	16.656	0.6044
Dummy for Region II	73.937	0.4449
Dummy for Region III	674.08***	3.966
Dummy for Region IV	-420.94**	-2.121
Dummy for Region V	-593.02***	-3.648
R-Squared	0.3430	
Sample Size	215	

[a] Coefficients.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Prices are normalised by the amount of income spent on purchasing food.

4.7 Tests of Hypotheses

This section presents a discussion of some hypothesis tests carried out in this study. Test results are summarised and discussed below. The first hypothesis postulates that only relative prices matter in the separable and nonseparable models estimated in this chapter. The theory is that if homogeneity conditions hold, the coefficient of the numeraire price should be zero. Since the regression equation includes relative prices as separate variables, a significant coefficient for the separate numeraire price implies that an equiproportional increase in all prices leads to a change in the dependent variable (violating homogeneity). Rejection of the null hypothesis implies that the notion that only relative prices matter does not hold. The test for the significance of the numeraire price uses the t-test. Wage rates are treated as prices since they represent a reward to labour.

The second hypothesis investigates the nature of the impact of maize price on the dependent variables of the separable and nonseparable models estimated above. This test is restricted to the price of maize only since prices of substitute grains are not available due to very little to insignificant sales of these substitutes. This test is important since maize is a staple crop in Zimbabwe and household food security is viewed as a function of maize availability via production and access to maize using various sources of income.

The third hypothesis examines whether changes in fertiliser price have significant effects on the dependent variables of the production related functions. Chemical fertiliser is a key input in smallholder agriculture and possibly accounts for the largest share of the variable input costs in an agricultural season. Changes in the price of fertiliser impact on both the dependent variable and on the amount of family labour devoted to farming.

4.7.1 Interpretation of Test Results for Homogeneity

Results for the tests of significance of the numeraire price in both separable and nonseparable versions of the models are presented below (Table 4.28). This information is extracted from the relevant regression models.

Table 4.28. Results of Testing for Homogeneity.

	Separable Model p-value		Nonseparable Model p-value	
Function	Linear	SUR	3SLS	SUR
Maize Output Supply[a]	0.080*[b]	0.080*	0.216	0.082*
Maize Yield Response[c]	0.301	0.276	0.367	0.273
Maize Acreage Demand[c]	0.635	0.633	0.477	0.63
Maize Consumption Function[ad]	0.042**			
Maize Marketed Surplus[ae]	0.0000***			

[a] Numeraire price is off-farm farm wage rate.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Numeraire price is casual labour wage rate.
[d] Model estimated by 2SLS, consistent with separability or nonseparability.
[e] Model consistent with separability or nonseparability.

Results suggest that homogeneity holds for all separable and nonseparable models of maize yield response and acreage demand functions. Among the separable models, homogeneity does not hold for the maize output supply and consumption demand functions. The numeraire price for the linear maize marketed surplus supply and consumption function is statistically significant, suggesting the theory that only relative prices matter does not hold. This theory is also violated in all models of the maize output supply apart from the one estimated by 3SLS. Thus results of this test are mixed. However three of the four cases where homogeneity does not hold occur at a marginal significance level (0.1).

4.7.2 Testing for Significance of the Impact of Changes in Maize Price on Dependent Variables of Major Functions

This section presents test results for the null hypothesis that the impact of maize price on the dependent variable of maize output supply, marketed surplus supply, yield response to price, acreage demand and consumption demand is zero for the individual functions. The hypothesis is tested by checking whether a change in maize price has a significant effect on changes in the dependent variable. A direct examination of the statistical significance of maize price coefficients in the linear functions is adequate to implement this test. The null hypothesis of no effect of a change in maize price on the dependent variable of the linear functions which are consistent with separation or nonseparation is set as:

$$(4.9)\quad H_0\!:\frac{\partial Y}{\partial p^{M}} = 0$$
$$H_1\!:\frac{\partial Y}{\partial p^{M}} \neq 0$$

where Y is the dependent variable and p^M is the price of maize.

The approach for deriving total impacts of a change in maize price are slightly complex for models estimated by SUR or 3SLS. In the case of maize output supply and acreage demand functions, output is a function of maize price, family labour devoted to farming and other variables. The level of family labour devoted to farming is in turn a function of the price of maize. Thus the total impact of maize price on these functions is obtained by summing the partial impacts of maize price on both the dependent variable and on the family farm labour function. The latter effect is obtained as the product of the partial impacts of family farm labour on the dependent variable and that of maize price on family farm labour. The mechanics of deriving the total impact of a change in maize price on models estimated by SUR and 3SLS are illustrated below:

$$(4.10)\quad Y = f(p^M, x^l, ..),\ x^l = g(p^M, ...)$$
$$\frac{dY}{dp^M} = \frac{\partial f}{\partial p^M} + \frac{\partial f}{\partial x^l} * \frac{\partial x^l}{\partial p^M}$$

where x^l is the family farm labour mandays and p^M is the price of maize.

In the case of maize supply response to price, three equations incorporating two endogenous variables i.e. family farm labour mandays per acre and maize acreage are used. Changes in the price of maize impact on changes in maize yield via indirect effects on inputs and also influences on area allocated to maize. The impact of maize price on maize yield response is derived as:

$$(4.11)\quad y^{ld} = f(p^M, x^l, y^{ad} ..),\ \ x^l = g(p^M, ...),\ \ y^{ad} = h(x^l, p^M)$$
$$\frac{dy^{ld}}{dp^M} = \frac{\partial f}{\partial p^M} + \frac{\partial f}{\partial x^l} * \frac{\partial x^l}{\partial p^M} + \frac{\partial f}{\partial y^{ad}} * \left(\frac{\partial y^{ad}}{\partial x^l} * \frac{\partial x^l}{\partial p^M} + \frac{\partial y^{ad}}{\partial p^M}\right)$$

where y^{ad} is the acreage under maize.

The last case pertains to identifying the impact of maize price on parameter estimates consistent with the separable and nonseparable maize marketed surplus supply functions. These impacts are derived taking into account the fact that marketed surplus is derived as the difference between production and consumption. The total impact of maize price on maize marketed surplus supply is derived indirectly from parameter estimates derived by the joint estimation of the general maize output supply, the relevant family farm labour demand and the general maize consumption demand functions. The impact of maize price on maize marketed surplus is derived as:

$$(4.12)\quad \frac{dy^{MS}}{dp^{M}} = \frac{dy^{OS}}{dp^{M}} - \frac{dy^{Cons}}{dp^{M}}$$

$$\frac{dy^{MS}}{dp^{M}} = \frac{\partial y^{OS}}{\partial p^{M}} + \frac{\partial y^{OS}}{\partial x^{l}} * \frac{\partial x^{l}}{\partial p^{M}} - \frac{\partial y^{Cons}}{\partial p^{M}}$$

where y^{MS}, y^{OS} and y^{Cons} are maize marketed surplus, output supply and consumption demand respectively. T-test results for the impact of maize price on the dependent variables for the models estimated above are presented below (Table 4.29).

Table 4.29. Results of Testing for the Marginal Impact of a Change in Maize Price on Dependent Variables.

Function	Dependent Variable	Separable Model p-value		Nonseparable Model p-value	
		Linear	SUR	3SLS	SUR
Maize Output Supply	Quantity of Maize Harvested	0.578	0.5823	0.58382	0.5893
Maize Yield Response	Maize Yield	0.599	0.47393	0.55738	0.4773
Maize Acreage Demand	Maize Acreage	0.507	0.63465	0.65596	0.64103
Maize Marketed Surplus[a]	Quantity of Maize Sold	0.482	0.04117**[b]	0.04082**	0.043**
Maize Consumption Function[c]	Quantity of Maize Consumed	0.531			
Maize Consumption Function[d]	Quantity of Maize Consumed	0.002***			

[a] Model consistent with separability or nonseparability.
[b] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[c] Estimated by 2SLS, consistent with separability or nonseparability.
[d] Estimated by OLS, consistent with separability or nonseparability, excludes numeraire.

Results suggest that maize price has no significant effect on both separable and nonseparable models of output supply, yield response and acreage demand. The same result also holds for the linear consumption demand and marketed surplus functions. Excluding the numeraire price in the consumption function gives a highly significant maize price. Maize price does have significant impacts on the SUR separable and both nonseparable models of maize marketed surplus supply (Table 4.29). Maize price also has significant positive impacts on nonseparable SUR family farm labour demand functions of maize yield response and acreage demand functions (Tables 4.17 and 4.25). Significance of maize price in both cases holds at the 0.1 level. Maize price also has somewhat high but insignificant impacts on the separable SUR and 3SLS nonseparable models of maize yield response and acreage demand (Tables 4.11, 4.14, 4.21 and 4.23) respectively.

In the case of the maize output supply (except the 3SLS model), consumption function and marketed surplus, significance of the numeraire price (Table 4.28) suggests that an equiproportional increase in all prices leads to an increase in the respective dependent variables. This is an indication of some degree of sensitivity to maize price changes. Results suggest that effects of changes in maize price are likely to affect household marketing decisions in the case of SUR and 3SLS models. Maize price also has significant effects in the consumption function which has homogeneity imposed. The result of insignificant prices has been reported in other studies. Mundang (1996) noted that prices were insignificant in simple risk-neutral static (one period) models of Manitoba crop yields, although prices were significant in distributed lag models of yield response. Unfortunately distributed lag models of crop supply response can not be considered using the cross section data set of this study. Insignificant price effects may be due to errors in data or model specification. Immediately after independence in 1980, the government increased the price of maize and then peasant households produced and sold record levels of maize. This suggests that farmers may well be responsive to price.

A possible explanation for the apparent insensitivity of maize production to changes in own price is that maize is a staple crop and is primarily produced for household consumption. This however does not underscore the fact that maize is also a cash crop and results here suggest that maize price has significant effects on the volume of sales given separable and nonseparable model structures. Changes in the price of maize have no impact on the level of household maize consumption when the numeraire price is included. This again can be attributed to the fact that maize is a staple crop and so changes in maize price are unlikely to influence the level of maize consumption. However dropping the numeraire in estimation of the maize consumption function results in a highly significant impact of maize price. Results indicate that there is no marked difference in the marginal impact of maize price on either the separable or nonseparable models of maize output supply, yield response and acreage demand.

4.7.3 Testing for Significance of the Impact Fertiliser Price on Dependent Variables

This section presents results for testing the null hypothesis that changes in fertiliser price have no significant effect on maize output supply, yield response, acreage demand and marketed surplus. The mechanics for carrying out this test are similar to those illustrated above for the respective functions. Results of this test are presented below (Table 4.30).

Table 4.30. Results of Testing for the Marginal Impact of Fertiliser Price on Dependent Variables.

Function	Dependent Variable	Separable Model p-value		Nonseparable Model p-value	
		Linear	SUR	3SLS	SUR
Maize Output Supply[a]	Quantity of Maize Harvested	0.433	0.43429	0.43874	0.43786
Maize Yield Response[b]	Maize Yield	0.248	0.16763	0.23468	0.15836
Maize Acreage Demand[b]	Maize Acreage	0.218	0.28104	0.24355	0.3028
Maize Marketed Surplus[ad]	Quantity of Maize Sold	0.205	0.43429	0.43874	0.43786

[a] Numeraire price is off-farm farm wage rate.
[b] Numeraire price is casual labour wage rate.
[c] Level of significance: * = 0.1, ** = 0.05 and *** = 0.01 level.
[d] Consistent with separability or nonseparability.

Results suggest that changes in fertilizer price have no significant effect on the above AHMs. This result holds for both separable and nonseparable models. Results suggest that fertiliser price has a somewhat high but insignificant effect on the nonseparable 3SLS maize yield response function (Table 4.13) and on the separable SUR family farm labour demand functions for both maize yield response and acreage demand (Tables 4.11 and 4.21). Fertiliser price does have a significant impact on SUR and 3SLS nonseparable family farm labour demand functions for both maize yield response and acreage demand (Tables 4.17 and 4.23). Results suggest that fertiliser price has significant negative impacts on some family farm labour demand functions but does not have statistically significant effects on dependent variables of the key functions.

4.8 Determination of Own Price Elasticities

This section presents own price elasticities for separable and nonseparable models estimated in this chapter. The own price elasticities are calculated at the mean of the dependent variable and its price. The own price elasticity of demand (supply) is a measure of the percentage change in the quantity demanded (supplied) arising from a one percentage change in own price and normally has a negative (positive) sign. The own price elasticity is an important instrument since it is an indicator of the degree of responsiveness of the dependent variable to changes in its own price. It can therefore be used to assess the impact of micro policy actions. Due to lack of prices of substitute grains, cross price elasticities are not calculated in this study. The cross price elasticity measures the percentage change in the dependent variable induced by a percentage change in the price of a substitute or complement.

The own price elasticity derived at the mean for a function derived by OLS or 2SLS with Y as dependent variable and P as its price is computed as:

$$(4.13) \quad \epsilon = \frac{\partial Y}{\partial P} * \frac{\overline{P}}{\overline{Y}}$$

In the case where a system of two equations is estimated jointly by SUR or 3SLS, the derivation of elasticities is slightly complex. This applies to the maize output supply and acreage demand functions which are estimated jointly with the family farm labour demand function.

The own price elasticity for each of these two functions is calculated as:

$$(4.14)\quad \epsilon = \frac{dy}{dp^M}*\frac{\overline{p^M}}{\bar{y}} = (\frac{\partial y}{\partial p^M}+\frac{\partial y}{\partial x^l}*\frac{\partial x^l}{\partial p^M})*\frac{\overline{p^M}}{\bar{y}}$$

where y is either maize output supply in kilograms or maize acreage, p^M is the price per kilogram of maize and x^l is the amount of family labour used on the farm in mandays. The maize yield response function is estimated jointly as a system with the family farm labour demand function and the maize acreage demand function. The own price elasticity of the yield response function derived at the mean is computed as:

$$(4.15)\quad \epsilon = \frac{dy^{ld}}{dp^M}*\frac{\overline{p^M}}{\overline{y^{ld}}} = [\frac{\partial y^{ld}}{\partial p^M}+\frac{\partial y^{ld}}{\partial x^l}*\frac{\partial x^l}{\partial p^M}+\frac{\partial y^{ld}}{\partial y^{ad}}*(\frac{\partial y^{ad}}{\partial x^l}*\frac{\partial x^l}{\partial p^M}+\frac{\partial y^{ad}}{\partial p^M})]*\frac{\overline{p^M}}{\bar{y}}$$

where y^{ld} is maize yield in kilograms per acre and y^{ad} is the acreage under maize. The own price elasticity for the maize marketed surplus supply function is computed as:

$$(4.16)\quad \epsilon = \frac{dy^{MS}}{dp^M}*\frac{\overline{p^M}}{\overline{y^{MS}}} = (\frac{\partial y^{MS}}{\partial p^M}+\frac{\partial y^{MS}}{\partial x^l}*\frac{\partial x^l}{\partial p^M}-\frac{\partial y^{Cons}}{\partial p^M})*\frac{\overline{p^M}}{\overline{y^{MS}}}$$

where y^{MS} is the volume of maize marketed in kilograms and derived as the difference between production and consumption and y^{Cons} is the amount of maize consumed in kilograms. Own price elasticities[11] computed for the models estimated are presented

[11]Elasticity categories are inelastic ($\epsilon < 1$), unitary ($\epsilon = 1$), elastic ($\epsilon > 1$), perfectly inelastic ($\epsilon = 0$) and perfectly elastic ($\epsilon = \infty$).

below (Table 4.31).

Table 4.31. Computed Own-Price Elasticities for Major Functions.

Function	Separable Model		Nonseparable Model	
	Linear	SUR	3SLS	SUR
Maize Output Supply	0.038	0.037609	0.03861	0.03724
Maize Yield Response	0.036	0.068315	0.059174	0.068111
Maize Acreage Demand	0.02	0.019609	0.018457	0.019402
Maize Marketed Surplus[a]	-0.103	-0.51212	-0.55141	-0.50789
Maize Consumption Function[b]	-0.0637			

[a] Consistent with separability or nonseparability.
[b] Estimated by 2SLS and is consistent with separability or nonseparability.

It is apparent that all own price elasticities are inelastic. All own price elasticities have expected signs apart from the own price elasticity for marketed surplus which has a negative sign. *A priori* reasoning would suggest that a percentage increase in maize price will result in an increase in the volume of maize marketed. The negative sign is however consistent with Renkow (1990) who found positive long-run marketed surplus response and negative short-run marketed surplus elasticities in a study of semi-subsistence agriculture using an agricultural household model. The own price elasticities for maize output supply derived in this study are lower than the one derived by Jayne *et al* (1994) who computed an own price elasticity for maize which was 0.76. Results imply that a one percentage change in maize price leads to a less than one percentage change in the dependent variables of the respective functions. This may suggest that the use of maize price policy with regard to the dependent variables of the functions under investigation is not likely to be effective since household response to changes in maize price is low. In the case of maize consumption, inelastic response is expected since maize is a staple crop and variations in maize price are not likely to be followed by any significant changes in the consumption behaviour of households. Results suggest that own price elasticities are inelastic for both separable and nonseparable models of the functions investigated and maize price policies are not likely to be effective in influencing changes in dependent variables of the AHMs modelled in this study.

4.9 Summary on Empirical Results

Results suggest that maize price does not have a significant marginal impact on maize output supply, yield response, acreage demand and consumption demand functions. Maize price does have a significant impact on SUR and 3SLS models of maize marketed surplus supply as well as on the maize consumption function which excludes the numeraire. Maize price also has significant effects on SUR nonseparable family farm labour demand functions for maize yield response and acreage demand. Fertiliser price does not have a significant impact on the major production related functions investigated. However fertiliser price does have some significant effects on some family farm labour demand functions. Results of the tests carried out suggest that own price elasticities for maize output supply, yield response, acreage demand, consumption demand and marketed surplus are inelastic. Homogeneity conditions hold for all separable and nonseparable models of acreage demand and yield response functions. Significance of the numeraire price in the maize output supply (except the 3SLS model), marketed surplus supply and consumption functions suggest that an equiproportional increase in all prices results in an increase in the respective dependent variables. Results do not show any marked differences in household response to maize price given separable and nonseparable AHMs.

CHAPTER 5

Summary

5.1 Summary

This study has presented some tests for separation of agricultural household models using a cross-sectional household data set of smallholder farmers located in four communal areas of Zimbabwe. This data set provides a wide coverage since it consists of households drawn from all five natural regions of Zimbabwe. All three tests for separation suggest that AHMs in Zimbabwe are separable. An implication of separation is that household production and consumption decisions are made independently. Despite the lack of support for nonseparation, nonseparable models are estimated as well since they are more relevant to developing economies where agricultural households generally produce and consume part of the produce as well.

Results suggest that changes in maize price do not have significant effects on maize output supply, yield response to price, acreage demand and consumption. Hypothesis tests implemented and own price elasticity measures calculated suggest that maize price policies are likely to have limited roles in influencing household production decisions. This result holds for both separable and nonseparable models of production related models. Changes in maize price however have significant marginal impacts on SUR and 3SLS models of the maize marketed surplus supply function and on the maize consumption function which does not incorporate the numeraire. However these significant impacts still result in an inelastic own price response. Immediately after independence, peasant farmers increased maize sales to the GMB. This increase was largely attributed to price incentives, availability of agricultural credit, improved agricultural marketing infrastructure and a cessation of the war. Jayne *et al* (1994) concluded that total cropped area in the smallholder lands has decreased slightly since the mid 1980s, as real producer prices have gradually declined, government buying stations have been closed, and government credit supply has been contracted. The importance of credit as a prime mover of agricultural production has been highlighted in other studies of smallholder agriculture (see Wolgin, 1975). The inelastic own price response may be attributed to the cross sectional nature of the data set. The same inelastic response pattern holds with respect to fertilizer price effects on production related models. The theory that only relative prices matter holds for all separable and nonseparable models of maize yield response and acreage demand. The apparent insensitivity of maize and fertiliser prices of major functions may be attributed to among other things errors in data and/or model specification. Results do not show marked differences in household behaviour given separable or nonseparable AHMs.

5.2 Caveats and Suggestions for Further Research

This study is mainly based on a data set collected during a drought year. Results obtained are therefore atypical of a normal season and have to be interpreted accordingly. The study has also focused entirely on the maize enterprise. This is justified since maize is a key staple crop. In terms of prices, there is insufficient data on the minor grains to provide enough information to incorporate prices of substitutes in modelling AHMs. Thus marginal impacts of substitute crops on household production, consumption and sales choices are not captured. A further weakness is that static, risk neutral models are used in estimating maize supply response. Models incorporating risk aversion and price uncertainty are more appropriate to peasant households given that their production and marketing decisions are conditioned by risk aversion strategies. Wolgin (1975) has emphasized the importance of taking risk into account in analyses of Kenyan smallholder agriculture since uncertainty arises with respect to weather conditions leading to difficulties in resource allocation decisions.

Future research should attempt to model household production and consumption decisions within the framework of a normal season. This will help to compare the microeconomic behavior of households in a normal and drought season. Models of crop supply response incorporating risk and dynamics are more appropriate and should thus be estimated in future research using time series household level data (panel data).

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APPENDICES

APPENDIX 1

Table A3.1. WHO Daily Kilocalorie Allowance.

	Kilocalorie Allowance	Adult Equivalent Unit
Male over 17 years	3 000	1.00
Female over 17 years	2 200	0.73
Male 6 - 16 years	2 318	0.77
Female 6 - 16 years	1 972	0.66
Pre-school child under 6 years	1 415	0.47

Source: WHO (1985) quoted in Stanning, 1989