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Modelling agricultural input expenditure in a multi-market modelling framework

by

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Submitted
in partial fulfilment of the requirements
for the degree

DOCTOR OF COMMERCE (Agricultural Economics)

Department of Agricultural Economics, Extension and Rural Development
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DEDICATION

To my parents, Roman Kiflemariam and Fisseha Gebrehiwet

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DECLARATION

I declare that the dissertation, which I hereby submit for the degree of Doctorate in Agricultural Economics at the University of Pretoria, is my own work and has not previously been submitted by me for degree purposes at any other university.

SIGNATURE:……………………………. DATE:…………………………………….

Yemane Fisseha Gebrehiwet

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Yemane Fisseha Gebrehiwet
Pretoria, South Africa
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ABSTRACT

MODELLING AGRICULTURAL INPUT EXPENDITURE IN A MULTI-MARKET MODELLING FRAMEWORK

by

Yemane Fisseha Gebrehiwet

Degree:	DCom (Agricultural Economics)
Department:	Agricultural Economics, Extension and Rural Development
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Agricultural input expenditures have not been widely incorporated in most partial equilibrium models. Thus, investigating the effect of economic policies and other exogenous factors on the agricultural sector will produce only a partial analysis, since the simultaneous impact of these factors on input expenditures is excluded. This study, therefore, extends the existing partial equilibrium multi-market model of the South African agricultural sector (BFAP model) by incorporating agricultural input expenditure. Thus, the analysis of the impact of economic policies on the agricultural sector, which was limited only on the gross income (production, area planted and prices), has now been extended to assess their effects on input expenditures, gross value added and net farming income of the sector. In addition, the analysis is further extended to evaluate the financial and economic position of the agricultural sector by investigating the implications of the policies on the asset and debt values of the sector.

The comparative result obtained from the shocks of a crude oil and world fertiliser price rise shows that due to the inclusion of the recursive effect from the output to input side of the sector and vice versa and endogenising input costs, the effect of the shock on gross value added and net farming income converges slowly and cyclically in the recursively

linked model, compared to the unlinked model, in which the effect abruptly halts after a single year. Thus, the recursively linked integrated model replicates the dynamics experienced by the agricultural sector better than the recursively unlinked integrated model.

In addition, the endogenisation of domestic input costs on the integrated model allows a comprehensive analysis of the effect of macroeconomic variables on the agricultural sector by considering their impact on both outputs and inputs. Thus, using the recursively linked model, a fifty percent devaluation of exchange rate is assessed. The result showed that a depreciation of exchange rate resulted in a net benefit for the sector, as the gain from enhancing agricultural income outweighs the rise in expenditure. Excluding the simultaneous impact on input expenditure would have overestimated the benefit by looking only at its effect on gross income.

The integrated model was also used to project a baseline for the South African agricultural sector's main aggregate variables for the medium term (2010-2015) under the *status quo* of policy assumptions and forecast values of exogenous variables. The baseline projections of the gross income, intermediate input expenditure and gross value added show a modest average annual growth rate during the baseline period. The net farming income, however, depicts a relatively lower growth due to the general modest rise in agricultural gross income compared with total input expenditure. Based on the projected values of main aggregate variables, several financial and economic performance indicators for the agricultural sector are also projected. In general, the economic performance indicators of the sector, measured by the net return on the sector's investment and equity, show good performance when compared with the average cost of borrowing during the baseline period.

Thus, this study shows that integrating input expenditure in a multi-market output model by recursively linking both sides and endogenising domestic input costs would improve the result of the standard partial equilibrium by generating projections for several key aggregate variables, providing the net effect of economic policies on the agricultural

sector and replicating the dynamics of the agricultural sector better than models that have few/no input components or that assess the effects separately and ignore the recursive linkage. Thus, this study provides a powerful modelling tool to be used by policy makers to comprehensively investigate the net effects of economic policies on the agricultural sector and to answer several 'what if' questions.

Key words: Multi-market commodity model, partial equilibrium model, agricultural input expenditure, input costs, general-to-specific methodology, endogenising, recursive link, BFAP, South Africa.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE

INTRODUCTION

1.1 Background

The value added of the agricultural sector is an indicator of the contribution of the sector to the economy and is calculated as the difference between the gross income and intermediate input expenditure of the sector. Similarly, net farming income refers to the profit of agricultural producers after taking into account expenditures on labour, land and capital from the sector's gross value added. Thus, the value added of the sector and net farming income are respectively indicators of the sector's role in the economy and the incentive for producers to remain in the business.

South African agricultural real value added has demonstrated a fluctuating and slightly declining trend during the past three decades. As shown in Figure 1.1, the trend was positive until the early 1980s and fluctuated and depicted a downward trend thereafter. Thus, the performance of the sector in terms of its real contribution to the economy has not been remarkable during the past decades. A similar trend is also observed for the real net farming income of the sector in the past three or four decades. Despite some fluctuations, however, the trend of gross farm income depicts a general growth compared to the gross value added and net farming income.

Moreover, Figure 1.1 shows that the gap between gross income and the other variables (gross value added and net farming income) has been growing, particularly since early 1990s. As intermediate inputs are factored into the calculations of the gross value added and net farming income, their steady growth since early 1990s has largely contributed to the widening gap. Thus, intermediate inputs expenditure has played a role in squeezing the value added and net farming income of the sector, as its high growth rate precludes the growth of the gross income from reflecting similar growth in the gross value added and net farming income.

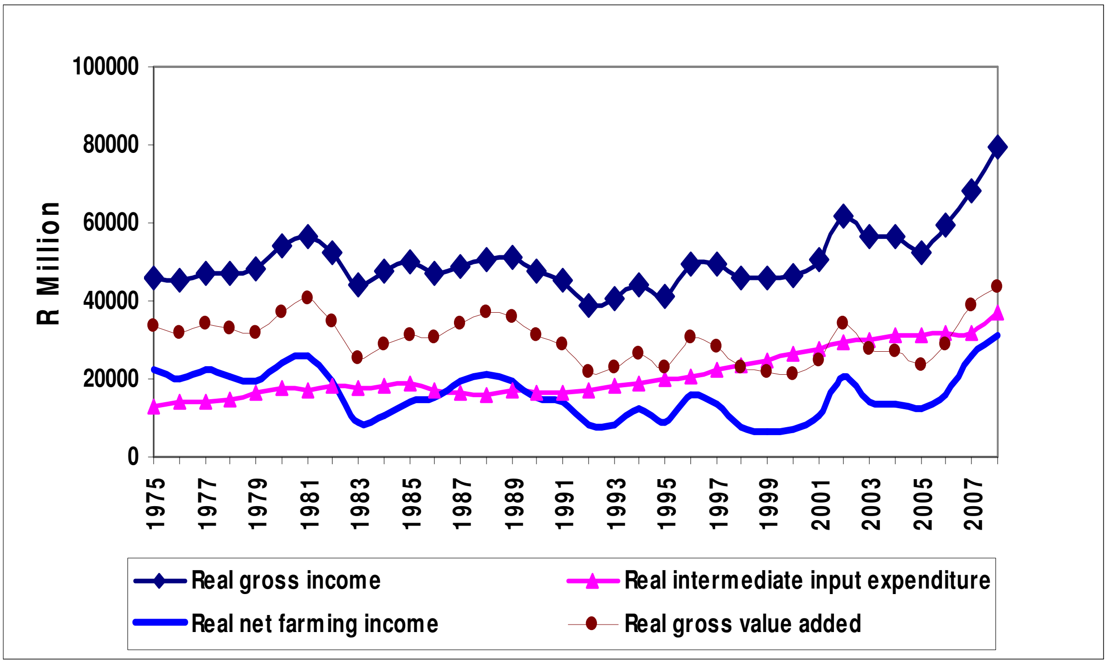


Figure 1.1: Agricultural gross income, value added, intermediate input expenditure and net farming income at constant 2000 prices.
Source: Adapted from DAFF (2009)

Since the growth of the gross value added and net farming income do not exactly match the growth of the gross income due to the incorporation of input expenditures, economic and sectoral policy analyses that are based only on the gross farm income could reach a misleading conclusion. Thus, a comprehensive policy analyses on the agricultural sector should assess the simultaneous implications of policies on all input expenditures to unearth their net effect on the sector.

To analyse the implication of policies on the agricultural sector, partial equilibrium models are widely applied. These models treat the agricultural sector as a closed system with limited influence on the rest of the economy and they capture the impact of domestic economy and the rest of the world on the sector by changing parameters and exogenous variables. Partial equilibrium models have an advantage in being able to provide detailed product coverage (Van Tongeren *et al.,* 2001) and present agricultural policy makers with considerable detail at the local, national and international level (Binfield *et al.,* 1999).

The first partial equilibrium multi-market commodity model for the South African agricultural sector has been developed and maintained by the Bureau for Food and Agricultural Policy (BFAP). The system of models used by BFAP is composed of three levels, which are the international, sectoral and farm levels (see Figure 1.2). These tiers are important in analysing the impact of any major policy or market changes at the international and sectoral level on the gross market of producers.

At the international level, the model is linked to the Food and Agricultural Policy Research Institute's (FAPRI) global model, which generates projections for a range of agricultural commodities for many countries across the world. The BFAP model incorporates the FAPRI world price projections into the South African system of equations to generate medium to long-term projections for the South African market. The BFAP model also links to the computable general equilibrium (CGE) model developed by the Provincial Decision-Making Enabling Project (PROVIDE) when agricultural shocks or policies are to be evaluated for the overall South African economy. Since the PROVIDE model is a static one and the BFAP sector model is a dynamic time series model, there is no direct link between these two models and the output of each model has to be adapted and interpreted before it can be incorporated into the other level.

At the sectoral level, the BFAP model incorporates domestic macro-economic variables such as the exchange rate and GDP growth. In addition, it takes into account the impacts of population dynamics, consumer trends and weather on the South African grain and livestock sectors. Table 1.1 illustrates the primary commodities and other products included in the BFAP sectoral model. These commodities encompass around 70 % of the primary commodities of the agricultural sector.

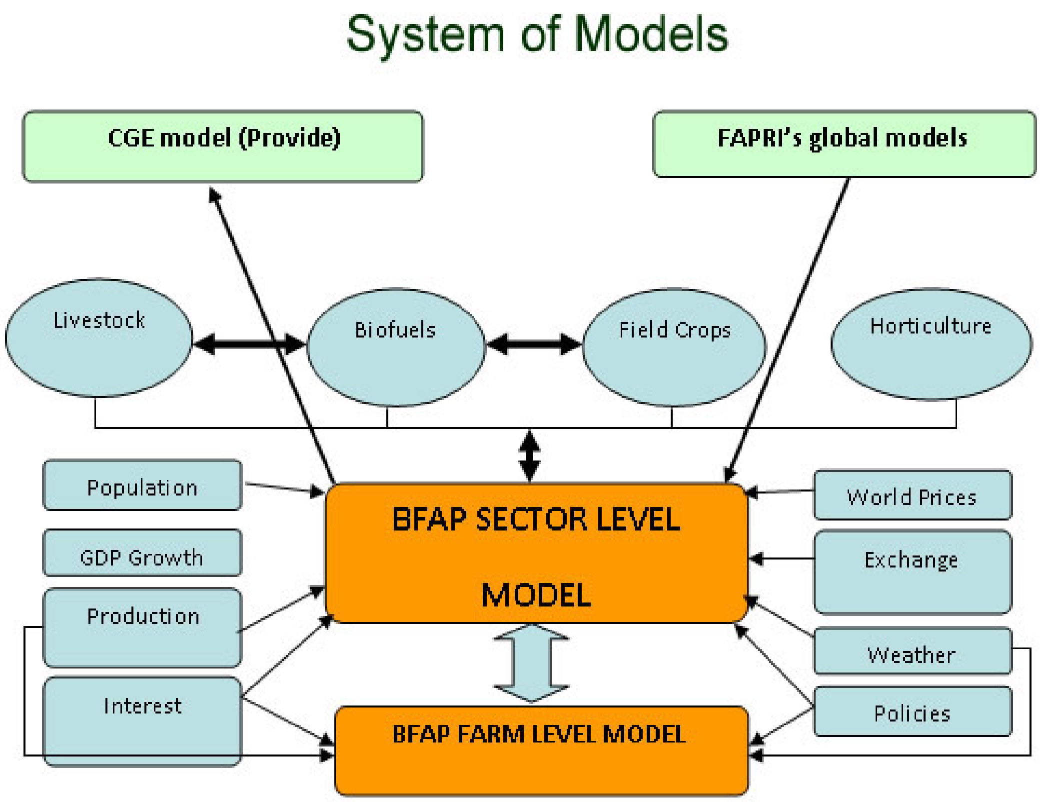


Figure 1.2: Basic structure of the BFAP system of models.
Source: BFAP (2010).

Table 1.1: Products included in the BFAP econometric system of equations

Field crops	Animal products	Horticulture	Other
White Maize	Pork	Wine	Ethanol
Yellow Maize	Chicken	Apples	Biodiesel
Wheat	Beef	Potatoes	DDGs
Sorghum	Mutton	Table grapes	
Barley	Eggs		
Sunflowers	Dairy		
Soybeans			
Canola			
Sugarcane			

Source: BFAP (2010)

The BFAP model utilises historical information about the commodity and livestock markets to develop a system of demand and supply equations. Among others, yield, area devoted for production, imports, exports, human consumption and ending stock are estimated for each commodity.

A farm-level model named FinSim has also been developed to simulate the likely impact of changes in policies and markets on the financial viability of individual farms. Changes in the international and sector-level models feed through to the farm-level model, quantifying the impact of the change in terms of rands and cents on a representative farm. The model incorporates information on different economic variables, market variables, taxes, government policies as well as climate and other risk factors as they occur in agricultural production. Data for the farm level model is collected from surveys and producer panels.

This large scale multi-market partial equilibrium model, which is also called the BFAP sectoral (output) model, has been used to produce an annual baseline outlook for the South African agricultural sector since 2005. However, it is largely limited to producing projections and analysing policies only on the gross income side of the agricultural sector.

1.2 Problem Statement

Since the existing BFAP model evaluates the effect of policies only on the gross income of the agricultural sector and as policy makers are using the growth of the agricultural GDP as a main target to attain a sectoral economic growth rate of at least 6% by 2014 to achieve the Accelerated and Shared Growth in South Africa (ASGISA) goals, economic models that are useful to evaluate the effect of policies and sectoral strategies on the growth of the sector are important. Assessing the impact of domestic policies on the agricultural GDP (the sector's contribution to the economy) will also evaluate the net impact of policies that simultaneous affect agricultural gross income and intermediate input expenditure. In addition, extending the effect of these policies by analysing their impact on the expenditures on capital, labour, land and allowance for depreciation on net farming income provides more insight on the effect of the policies on the profitability of the sector.

Evaluating economic policies on the agricultural sector using only a few common indicators, like gross income, gross value added or net farm income, however, may overlook important aspects and implications of the policy by concealing the effect on the financial and economic position of farmers. An increase in net farm income may not indicate the prosperity of the sector if the debt burden is steeply increasing. Similarly, higher net return on investment may not indicate the best utilisation of resources in the sector if the return is far below the opportunity cost. A declining asset value may also not imply a deterioration of financial position, if the farmers' ability to meet the debt using own investment (equity) has not worsened (Coetzee *et al*., 2002). Thus, financial and economic indicators like net return on investment, total cash flow, debt burden and net return on equity, which contain valuable information, should be used in evaluating the effect of economic policies on the financial and economic position of agricultural producers.

Conforti (2001) also noted that few of the agricultural sector's partial equilibrium models incorporate inputs from other industries such as fertilisers, pesticides and machinery. However, land and inputs produced within the agricultural sector such as such as feeds and primary products used as an input for other processed agricultural products are mostly included. Thus, these models largely analyse the impact of economic policies on the output side of the agricultural sector and few inputs. Furthermore, the recursive dynamic partial equilibrium model that comprises the net farm income model (FAPRI-CARD model) does not recursively link the agricultural input and output sides because the model treats the variable input costs that affect production decisions as being exogenous (Westhoff *et al.,* 1990 and Westhoff, 2008). Hence, evaluating the net implication of exogenous factors, macro economic variables and the dynamics within the agricultural sector that affect both agricultural inputs and outputs in these models is not possible. Thus, endogenisation of input costs in partial equilibrium models is essential to assess the net impact of economic variables on the agricultural sector.

The general review of the USDA net farming income model that is well documented by McGath *et al.,* (2009) also indicates that input expenditure and other components are estimated by adjusting the previous year's value using the index derived from the output model and input price index forecasts. Hence, input and output models are not recursively linked to enable the model in generating medium term outlook of net farm income and evaluate the recursive effect of input prices on the commodity production.

Agricultural producers generally respond to higher input cost by reducing the area devoted for production (Gafar, 1997; Meyer, 2006 and Mushtaq and Dawson, 2002). As a result, the total amount of production may be reduced and, depending on the size of the output reduction, output prices may be affected. An increase in input costs also affects the total input expenditure. The size of the impact, however, depends largely on the price elasticity of the agricultural input demand. If the input demand is price inelastic, higher input costs would result in higher input expenditure. Area reduction by producers in response to higher input costs could also reduce agricultural input demand, which may then affect the prices of some inputs. Thus, the effect of a change in agricultural input markets on output markets is recursive. Hence, an attempt to investigate the impact of this should take this into account to appropriately assess its effect on the sector.

Studies that have analysed the impact of input subsidies (especially fertiliser subsidy) on the agricultural sector rely heavily on estimating the price elasticity of fertiliser demand (Denbaly and Vroomen, 1993; Mergos and Stoforos, 1997; and Rayner and Cooper, 1994). Thus, they draw conclusions on whether or not input subsidies would be a viable option for spurring agricultural growth, based on how responsive the demand is to the change in fertiliser price. Since these studies largely assess the impact of price policies solely on the demand for inputs and not on how the prices will affect input expenditures and simultaneously how the change in input prices affects the output side, the net impact of the policies on the agricultural sector remains unaddressed. As Denbaly and Vroomen (1993) argued, the elasticity measure could only be used as a partial answer to assess the potential effect of fertiliser tax. Moreover, as input price subsidies affect all the commodities of the agricultural sector, a partial equilibrium model that incorporates the crop and livestock sub-sectors would be able to capture the real impact more appropriately than a single crop analysis (Denbaly and Vroomen, 1993).

1.3 Objectives

The general objective of the study is to integrate a model of agricultural input expenditure into the existing South African multi-market commodity model to enrich the result of a standard partial equilibrium models and thereby improve its ability to comprehensively assess the full impact of policy changes and exogenous shocks.

The specific objectives of the research are the following:

- To project a baseline of main aggregate variables for the agricultural sector that includes the gross value added and net farming income;
- To project a baseline for the financial and economic performance indicators of the agricultural sector;
- To compare and evaluate the impact of a rise in input costs (crude oil and world fertiliser prices) on the agricultural sector using an integrated model that recursively links and unlinks the input and output sides of the sector.
- To evaluate the net effect of exchange rate depreciation by assessing the simultaneous impact on both gross income and input expenditure.

1.4 Hypotheses

Integrating all input expenditures and other aggregate variables in a multi-market partial equilibrium model by recursively linking the output and input sides of the agricultural sector and endogenising domestic input costs improves the standard partial equilibrium model's ability to generate various baseline projections, including gross value added, net farming income and several other financial and economic performance indicators. Moreover, the integrated model is able to conduct a comprehensive analysis on the effects of factors that affect input costs on the agricultural sector, as their impact on both gross income and input expenditure is taken into account.

Thus, the study hypothesises that by evaluating the effect of economic policies on the gross value added and net farming income, the integrated model subdued the effect of policies that augment the gross income by simultaneously incorporating their increasing effect on input expenditures. Similarly, the integrated model increases the impact of policies that induce the fall of the gross income by considering their simultaneous decreasing effect on input expenditures.

The recursively linked integrated model is also hypothesised to cushion and lengthen the impact of input cost shocks that affect the sector slowly and in a cyclical pattern due to the incorporation of the recursive effect from the input to output side of the sector and vice versa than the integrated models that ignore the recursive links. Thus, the recursively linked integrated model replicates the dynamics of the agricultural sector more than the unlinked one.

1.5 Methodology and Data

Incorporating agricultural inputs into the multi-market modelling framework basically utilises the theory of derived demand, which states that demand for inputs exists as a result of consumer demand for the final output. If a given product does not have a demand, then all factors of production necessary to produce the item will not be in demand. Thus, changes in agricultural output markets (like gross income, commodity and animal products prices, the volume of production and the area planted) play an instrumental role in determining agricultural input demand. Besides the output market, input demand is also determined by its own price and other exogenous factors.

In integrating agricultural input expenditure into the multi-market (output) model, the projected value of the output side variables like the planted area is obtained from the output model and input prices are derived from the specified models. In general, three factors are the main drivers of domestic input prices, namely oil price, exchange rate and world price. Hence, these variables will be used to estimate the model of input prices. Thus, input expenditure for the sector can be calculated by multiplying the estimated price and quantity demanded. For input expenditures where the quantity data is not available, the expenditure value is deflated by its price index to obtain a proxy for the quantity (Maligaya and White, 1989). Once the expenditure values of main intermediate input have been estimated, they are added to produce the aggregate intermediate input expenditure for the sector.

All the components of the input expenditures that are useful in computing the gross value added and net farming income, are presented in Figure 1.3. The accounting relationship for both variables is given in equations 1.1 and 1.2.

$$GVA = GINC - INTEXP - OCONS + CLI \qquad (1.1)$$

Here *GVA* denotes the gross value added (agricultural GDP); *GINC* refers to the gross income of the agricultural sector; *INTEXP* refers to intermediate input expenditure; *OCONS* refers to own construction, which is the erection of new buildings and works, additions to and alterations of existing buildings and works done by agricultural producers; and *CLI* refers to a change in the value of livestock inventory. Once the gross value added has been obtained with equation 1.1, the following formula is used to calculate the net farming income.

$$NFI = GVA - INTPAID - LREMU - RENPAID - DEPRE \qquad (1.2)$$

In the above formula, *NFI* stands for net farming income; *GVA* denotes the gross value added; *INTPAID, LREMU, RENPAID* and *DEPRE* are respectively expenditures on capital (interest paid), labour (labour remuneration), land (rent paid), and the depreciation value of assets.

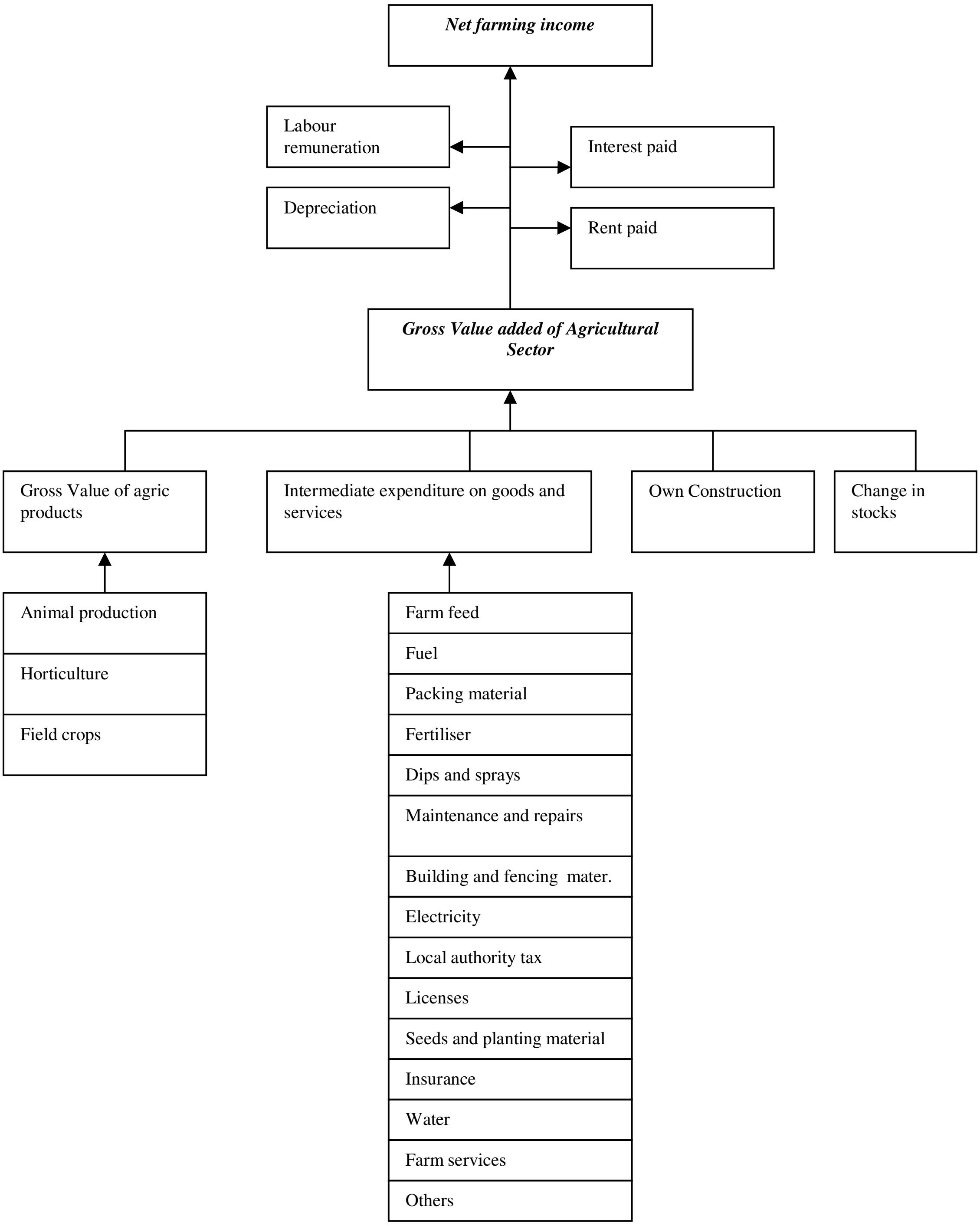


Figure 1.3: Graphical representation of the components of agricultural value added and net farming income

The model for own construction is indirectly determined by the variable from the output model, which is gross income, through its effects on the gross capital formation of the sector. In addition, variables from the sectoral model such as the area planted and gross income are used to estimate the rent paid by the agricultural sector. The depreciation value for the sector's asset value is computed using the annual depreciation rate used by the Department of Agriculture, Forestry and Fisheries (DAFF). The model for interest paid is largely determined by the amount of debt and the interest rate. The wage rate and employment estimates will also be used to calculate the amount of labour remuneration.

By setting the integrated model as mentioned above, the net effect of some exogenous variables like exchange rate and oil prices on the sector can be unlocked as their parallel effect on the output and input side will be taken into account. Thus, from the above two equations, it is shown that incorporating input expenditures and other components is important in evaluating the impact of input costs and other economic policies on the gross value added of the sector and net farming income. Disregarding the expenditure component and focusing only on the output of the sector as a proxy for the value added to evaluate economic policies cannot appropriately capture the actual impact as it disregards the cost of intensification using modern inputs (Irz *et al.,* 2001).

Once all input expenditure equations have been estimated, using projections of exogenous variables from other sources such as FAPRI and Global Insight, a baseline projection is presented for all the variables, including the net farming income and gross value added, for the period from 2010 to 2015. This baseline is then used as a benchmark to evaluate alternative scenarios.

In deriving aggregate input demands, the duality approach assumes that sectoral-level aggregate variable profit functions maintain all regularity conditions of profit-maximisation as expected at micro-level. However, according to Burrell (1989), many of the restrictions implied by the duality theory are rarely found to hold globally and *en block* in empirical models of agricultural production. Taylor (1984) also argued that the approach cannot be applied to derive input demand when expected profit functions depend on price expectations that are dependent on previous prices and when risk-averse producers maximise expected utility (Pope, 1980).

The other method used to estimate the input demand function is a single-equation approach. The method explained the input demand using prices and other shift variables. Basically, these specifications are loosely based on the theory of production and the model is largely evaluated by the coefficient signs and goodness of fit. This approach, however, could conclude the evidence of the validity of the relationship based on the spurious correlation between the dependent and independent variables (Burrell, 1989).

McQuinn (2000) noted that the specification of economic models for policy purpose brings its own modelling restrictions. Among these includes the need for incorporating as many policy levers in the model estimation and the importance of having the forecasted value of any exogenous variables incorporated in the model for the purpose of projections. In addition, the availability of data plays a critical role in the choice of the modelling approach.

As argued by McQuinn (2000), for policy focused models, a single-equation approach is preferred in estimating the aggregate input demand at the sectoral level than the duality approach for three main reasons. Firstly, it provides flexibility in incorporating many policy instruments (Binfield *et al*., 1999). Secondly, the theoretical reservations of the duality approach, especially the assumption that the aggregate variable profit function at the sectoral level satisfies all the regularity conditions of the conditions at the micro-level. Thirdly and most importantly the data limitations on the components of input expenditures, similar to this study, make the cost-share duality approach unfeasible. The USDA's net farming income has also applied a single-equation approach to project the capital expenditure of the sector. For the projections of input expenditure, however, it moves a base-year estimate using the change in the index of quantity factors and prices from the secondary sources (McGath *et al.,* 2009).

The single-equation approach in this study is estimated based on the general-to-specific methodology pioneered by Hendry (1995). It starts with a general model (autoregressive distributed lag, (ADL)), which contains a series of simpler models nested within it as special cases (Roche, 2001). Thus, by applying a variety of restrictions on the model one can test different hypotheses. In general, this method avoids the criticism of data mining and prior beliefs that the traditional approach of specific-to-general methodology has (Roche, 2001).

Most of the data were sourced from the Department of Agriculture Forestry and Fisheries (DAFF), which includes all intermediate input expenditures and their respective price indices, own construction, change in livestock inventory and the components of net farming income, which are depreciation value, labour remuneration, rent paid and interest paid. The same source was used to obtain the data for the asset value, gross capital formation and total debt value of the sector. The data on interest rates, consumer price index, producer price index and exchange rates were obtained from the Reserve Bank and the quantity and prices of fertilisers were sourced from GrainSA. Domestic and global shares of fertiliser consumption by commodity and country were obtained from the Fertiliser Society of South Africa (FSSA) and the International Fertiliser Association (IFA).

1.6 Outline of the Study

Following the introduction in chapter one, chapter two provides an economic review of the South African agricultural sector by looking into the changes of outputs, inputs and the general economic and financial performance of the sector over the past decades. Chapter three presents a literature review of how inputs are treated in partial equilibrium models. It also reviews the theory of input demand and various studies regarding inputs in the South African context. The model specification of each equation and estimation procedure is explained in chapter four. Empirical results of individual equations are discussed in chapter five. Chapter six provides the application of various statistical techniques to evaluate the model performance and chapter seven presents the baseline projection and the results of the model comparison and a policy analysis of the model. The summary and conclusions of the study are given in chapter eight.

CHAPTER TWO

ECONOMIC REVIEW OF THE SOUTH AFRICAN AGRICULTURAL SECTOR

2.1 Introduction

This chapter highlights the importance of integrating agricultural inputs and other key aggregate variables into the sectoral multi-market model in generating various economic and financial indicators to evaluate the agricultural sector by reviewing the changes in South African agricultural outputs, inputs and assess its financial and economic performance during the past decades. By providing several performance indicators, an integrated model could serve as a handy tool to analyse the effects of economic policies on the agricultural sector and to assess its performance.

The organisation of the chapter is as follows. The current policy environment of the sector is briefly discussed in the following section to shed light on the main issues surrounding the sector. The trends of agricultural outputs and inputs are discussed in sections two and three respectively. The performance of the sector in terms of its contribution to the economy is presented in section four and the trend of the profitability of the agricultural sector using various financial and economic indicators is reviewed in section five. A summary of the chapter is given in section six.

2.2 Policy Environment

South African agriculture has undergone major policy changes since the early 1980s. A complete summary of these changes is extensively discussed in Kirsten *et al.,* (1994), Van Zyl *et al.,* (2001), Viljoen (2004); Vink (1999); Vink and Kirsten (2003a); Vink and Van Rooyen, 2009 and World Bank (1994). Currently, the complete deregulation of agricultural markets, the dualistic nature of the sector and the attempt to deracialise the sector mark the three main economic features of the agricultural sector in South Africa (Vink and Kirsten, 2003b). This has also been stressed by the common vision stipulated in the Agricultural Strategic Plan, whose core strategies are promoting equitable access and participation by providing support to emergent farmers, strengthening global competitiveness and profitability and establishing institutions for a sustainable use of resources (DAFF, 2001).

Thus, the following sectoral and economic policies, among others, have been designed to attain the outlined objectives and to redress the injustice of past policies (Kirsten and Vink, 2002; Van Zyl *et al.,* 2001; Viljoen, 2004; and Vink and Van Rooyen, 2009):

- Trade policy: South Africa has joined the multilateral trade agreement of the WTO by lowering tariffs, adopting tariffication for non-tariff barriers and by complying with sanitary and phytosanitary standards. Moreover, the country is engaged with various bilateral and regional trade arrangements that aim to increase market access.
- Marketing policy: A complete deregulation of the agricultural markets was effected by the Marketing of Agricultural Products Act (Act 47 of 1996) by establishing the National Agricultural Marketing Council (NAMC) whose main purpose is to expand market access and to bring market efficiency.
- Water policy: Under the promulgation of the new water act, priority for water usage is given to human and environmental use. Among others, the subsidisation of water price is terminated, an integrated catchments management system is implemented and the riparian principle of water rights is culminated.
- Labour market policy: Farm workers' legal rights and employment conditions, which had been largely excluded from various labour acts applied in other sectors, have now been incorporated. Among others, these are embraced in the Labour Relations Act (1997), the Skills Development Act (1998) and the Employment Equity Act (1998).
- Redressing land ownership: This policy attempts to redress the historical legacy of land ownership in the country through land reform that comprises land redistribution, land restitution and tenure reform. Though the implementation began in 1994, the pace has been very slow (Lyne and Darroch, 2003). Currently, it aims to distribute 30% of the land to previously disadvantageous communities

by 2014 (Strategic Plan, 2009). Similarly, sectoral Broad-based Black Economic Empowerment (AgriBEE) has been introduced to facilitate the wider participation of blacks in all levels of agricultural activities and enterprises, which includes ownership, skill development, management control and enterprise development.

- Agricultural and rural finance: In an attempt to extend access of financial services to smallholder farmers, the government established MAFISA (Micro Agricultural Financial Institutions of South Africa) which assists farmers a loan up to R100 000.
- Agricultural extension: By integrating the previous extension services that were segregated to the commercial and smallholder farmers, the extension services has expanded the scope to assist the emerging farmers' needs in various initiatives including marketing, finance and institutional development.
- Agricultural research: In order to enhance agricultural research, the Agricultural Research Council (ARC) has been established in 1992, which mainly focused in addressing the issues and needs of smallholder farmers. Moreover, the National Agricultural Research and Development Strategy have been adopted in 2007 to guide and coordinate research in the agricultural sector.
- Biofuels: The Biofuels Draft Strategy aims to achieve a biofuels average market penetration of 4.5% of liquid road transport fuels (petrol and diesel) by 2013, which will achieve 75 % to the national renewable energy target.

The estimates of the South African Producer Support Equivalent (PSE), (often used to measure the intervention of government in the agricultural output market) showed that South Africa's average PSE in 2007 was 3% (OECD, 2009a). The PSE value is low compared to the 2007 average value of OECD countries (22%) and it is similar to Brazil's (5%) and Australia's (6%) (OECD, 2009b). However, variability is observed across agricultural commodities. The PSE for South African agricultural products concentrates mainly on sugarcane and mutton, which receive between 10% and 20% of gross farm receipts of each commodity (OECD, 2009a). However, the general low aggregate value of PSE shows that South African government policies are less distortive on the functions of agricultural output market.

2.3 Agricultural Outputs

The real gross value or income of the agricultural sector is derived from the sub-sectors of field crops, horticulture and animal production. Gross value refers to the part of agricultural production marketed at basic prices and includes the production for own consumption valued at the same prices (DAFF, 2004). As shown in Figure 2.1, real gross income of agricultural products showed an upward trend during the 1970s and reached its peak in 1981. The average annual growth rate during 1970-1981 was 5%. This period was characterised by high real producer prices and benign state support in the form of subsidies. Furthermore, as the aim of agricultural policy during the period was to attain food self-sufficiency, it largely focused on increasing output, regardless of cost (Vink, 1999).

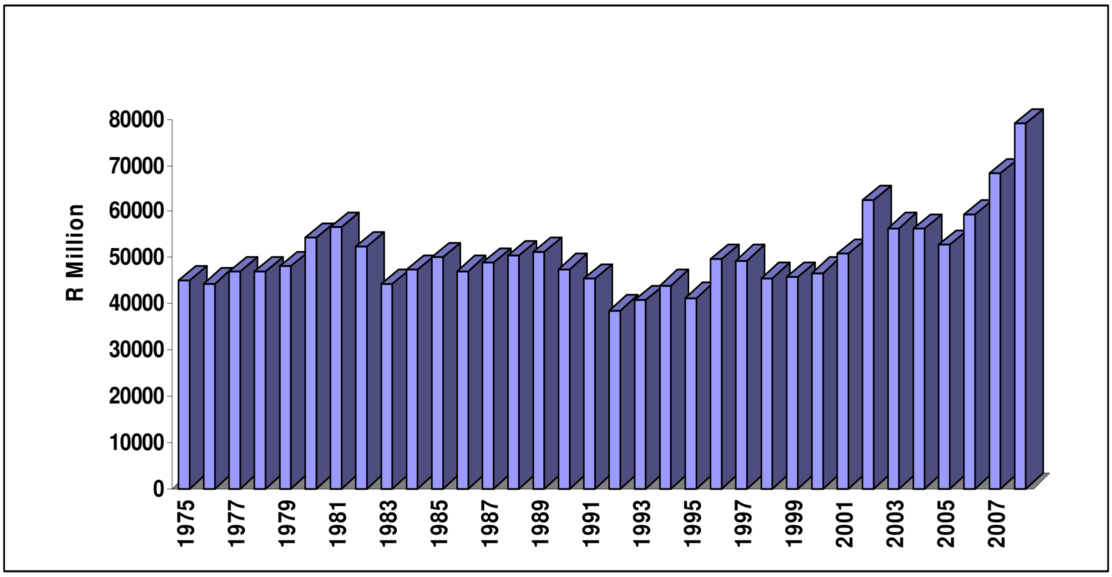


Figure 2.1: Gross value of the agricultural sector: deflated by CPI (2000=100).
Source: Adapted from DAFF (2009).

The middle of the 1980s, however, showed the start of deregulation of the markets and the fall in real prices of major commodities. Moreover, the regional droughts that occurred in 1983, 1984 and 1986 and the Land Conversion Scheme, which subsidised the withdrawal of crop land and the establishment of perennial pastures, dampened agricultural production (World Bank, 1994). Hence, real gross value during this period (1981-1992) fell at an annual average rate of 3% and reached its lowest point in 1992. The trend, however, reversed after 1992, though fluctuations are observed due to the vagaries of the weather. Real gross income has significantly increased during the past three years as a result of record world agricultural commodity prices.

The average real gross value of the sub-sectors of the agricultural sector is depicted in Table 2.1. Real gross income from horticulture is the only sub-sector that has displayed a consistently increasing trend. The income from field crops, which was the largest in 1970s as a result of higher domestic prices, showed a declining trend when the deregulation of markets started in the early 1980s. The trend reversed, however, after the mid-1990s. The average real gross income from animal production, on the other hand, stagnated in the late 1980s and showed a fall in the early 1990s following the decline of field crops, which is its main source of inputs. Similar to field crops, the trend of the real income for animal production reversed after the mid-1990s.

Table 2.1: Average real gross value of sub-sectors and the total agricultural sector (Million Rand)

Period	Field crops	Horticulture	Animal production	Total agricultural sector
1970-1975	16,480.62	6,843.39	16,483.09	39,807.10
1976-1980	20,723.08	8,194.07	19,429.49	48,346.64
1981-1985	18,554.36	8,700.51	22,884.94	50,139.82
1986-1990	16,842.45	9,649.67	22,558.68	49,050.80
1991-1995	12,317.65	10,054.26	19,677.61	42,049.52
1996-2000	14,152.82	12,351.94	20,961.16	47,465.93
2001-2005	15,449.73	15,697.57	24,503.59	55,650.89
2006-2008	17,755.80	17,492.44	33,285.99	68,896.74

Note: Gross value is deflated by CPI (2000=100).
Source: Adapted from DAFF (2009).

The significant fall in real income from field crops and the simultaneous rise in the other sub-sectors' income, therefore, has shifted the relative contribution of these sub-sectors to total agricultural value during the past decades. Thus, the share has largely shifted from field crops to horticulture and animal production. Field crops' share fell drastically from

41% in the early 1970s to 25 % during 2006-2008. Currently, animal production is the largest contributor to the gross income of agriculture (48%) and both field crops and horticulture contribute roughly the same share (25%) (see Table 2.2).

Table 2.2: Percentage contribution of sub-sectors to total agricultural value

Period	Field crops	Horticulture	Animal production
1970-1975	41.12	17.34	41.54
1976-1980	42.86	16.95	40.20
1981-1985	36.59	17.47	45.94
1986-1990	34.34	19.70	45.96
1991-1995	29.13	23.98	46.89
1996-2000	29.76	26.11	44.13
2001-2005	27.54	28.27	44.19
2006-2008	25.33	25.50	48.63

Source: Adapted from DAFF (2009)

Generally, deregulation of the agricultural output market has increased productivity (Vink and Kirsten, 2003a) and the change in trade policy has expanded market access (Jooste *et al.,* 2003). Hence, it has brought a shift of resources to the production of high value products, which implies a shift from field crops to horticultural and animal products (Vink and Kirsten, 2003a). In addition, the food and beverage manufacturing sector has showed a steady growth in response to market liberalisation. Among these includes, the stupendous rise of wine export from 21 million litres in 1992 to 411 million litres in 2008 (SAWIS, 2009) and the growth in real export value of processed agricultural products from R 5901 million in 1992 to R 36082 million in 2008 (Directorate: Agricultural Statistics, 2010). Previous agricultural policies, on the other hand, focused on food self-sufficiency and led to increased production of maize, and of livestock that depend heavily on maize, at the expense of the fruit export industry (Vink, 1999).

The average volume indices of agricultural production given in Table 2.3 indicate that horticulture and animal production show an increasing trend, which has played a positive role in augmenting the gross income of these sub-sectors. The volume of field crop production, however, fluctuated and showed no positive trend. Hence, this partly contributed to the fall of this sub-sector's income.

Table 2.3: Average indices of volume of agricultural production (2000=100)

Period	Field crops	Horticulture	Animal production	Total agricultural sector
1970-1975	58.95	47.05	48.12	65.42
1976-1980	88.42	50.66	73.70	73.56
1981-1985	90.16	61.28	84.54	79.80
1986-1990	94.08	69.44	91.04	86.06
1991-1995	78.78	77.16	99.08	85.58
1996-2000	93.04	95.14	99.82	95.60
2001-2005	89.48	108.90	105.06	100.10
2006-2008	83.40	116.20	125.67	108.10

Source: Adapted from DAFF (2009).

The real price received by the three sub-sectors follows a similar pattern. It declined since the mid-1970s and only increased after the early 2000s (see Table 2.4). Relatively, however, the price of field crops showed a severe decline after the start of deregulation in late 1980s. Thus, the generally poor growth in the real gross income of the sector is largely due to the low growth rate of real income from field crops and the general decline of real agricultural prices. The reverse of the real income trend during 1996-2000 was largely due to the rise in agricultural production, and after early 2000s the rise is attributed to higher producer prices.

Table 2.4: Real price indices of agricultural sub-sectors (2000=100)

Period	Real price indices: field crop	Real price indices: horticulture	Real price indices: animal production	Real price indices: combined
1970-1975	156.95	148.31	137.52	146.92
1976-1980	167.06	147.95	143.70	152.37
1981-1985	169.83	126.69	142.97	149.29
1986-1990	130.76	115.49	134.85	128.65
1991-1995	121.20	94.34	109.09	109.16
1996-2000	110.02	94.10	106.81	104.66
2001-2005	122.23	117.51	115.02	117.85
2006-2008	145.58	117.88	131.77	133.26

Note: Price indices are deflated by CPI (2000=100).
Source: Adapted from DAFF (2009).

2.4 Agricultural Inputs in South Africa

Agricultural inputs generally consist of intermediate inputs (fuel, feed, chemicals, fertiliser, seed etc.), labour, land and capital. In addition, knowledge, which incorporates management, is also a key component of agricultural inputs. The trends of main inputs during the past decades are discussed below.

2.4.1 Intermediate Input Expenditure

The intermediate input expenditure of the agricultural sector refers to the value of goods and services that are purchased for consumption as inputs during the process of production (DAFF, 2004). It comprises, among others, expenditure on fuel, fertiliser, farm feeds, dips and sprays, packing materials, maintenance and repairs, seed, and other related expenses. Intermediate input expenditure is the largest component deducted from the gross value of the agricultural sector to compute the gross value added of the agricultural sector.

Figure 2.2 depicts real intermediate input expenditure trends for South African agriculture. High agricultural product prices coupled with subsidised interest rates and fertiliser prices largely explain the rising trend of input expenditures in the 1970s (Vink, 2000). Moreover, as South African agriculture became commercialised, more intermediate inputs were utilised during this period. The average annual growth rate of the intermediate input expenditure from 1970 to 1982 was 6%. Since the mid-1980s, however, the financial pressures and various droughts reduced the expenditure of intermediate inputs. Moreover, the general decline in area production as a response to the fall of real agricultural prices dampened intermediate input expenditure and the average annual growth rate fell by 1.8% until 1992. The trend, however, has reversed since the early 1990s as a result of better prospects for exports and it grew at an average annual rate of 4.9% between 1992 and 2006. In 2008, the record prices for fuel and fertiliser increased real intermediate input expenditure by 17% from the 2007 level.

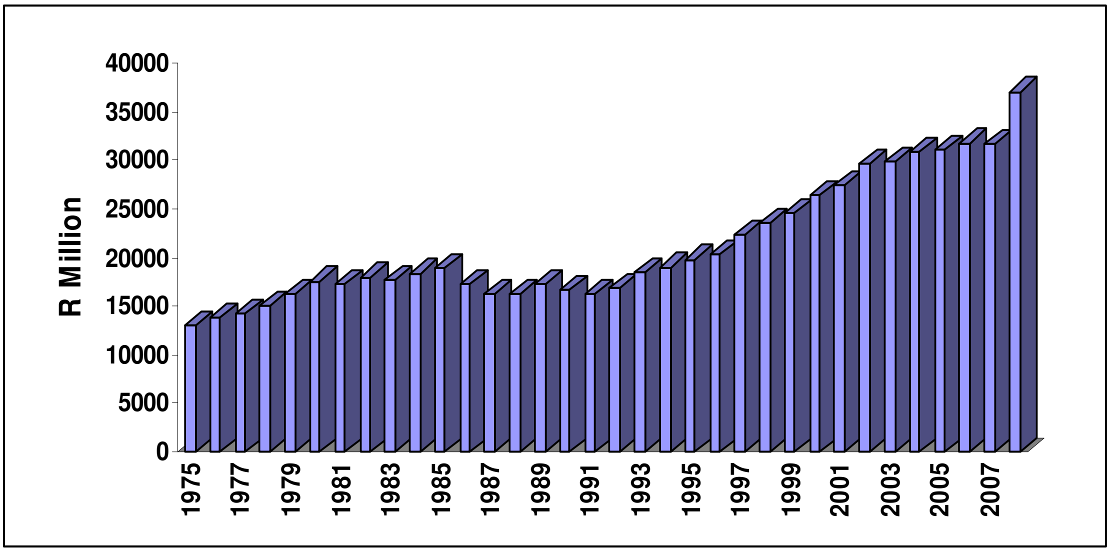


Figure 2.2: Intermediate input expenditure deflated by PPI (2000=100).
Source: Adapted from DAFF (2009)

Figure 2.3 shows the share of selected inputs contributing to the total intermediate input expenditure during the sample period of the past eighteen years. The share of feed expenditure is growing and accounted for approximately 28% of all expenditure in 2005. This trend is due to the rise in the volume of animal production. The share of fertiliser expenditure, which was the second largest expenditure in 1995, declined markedly by 2005 due to the general fall in field crop production. The share of fuel expenditure has remained relatively constant, as the rise in expenditure by animal production is compensated by the fall in expenditure by field crop production. In 2008, however, the share of fuel and fertiliser expenditure rose markedly as the result of record prices for both inputs. While the share of feed expenditure declined from 28% in 2005 to 22 % in 2008, the share of fuel expenditure increased from 11.6% in 2005 to 19.5% in 2008. Similarly, the share of fertiliser expenditure soared from 7.3% to 13.2% during the same period.

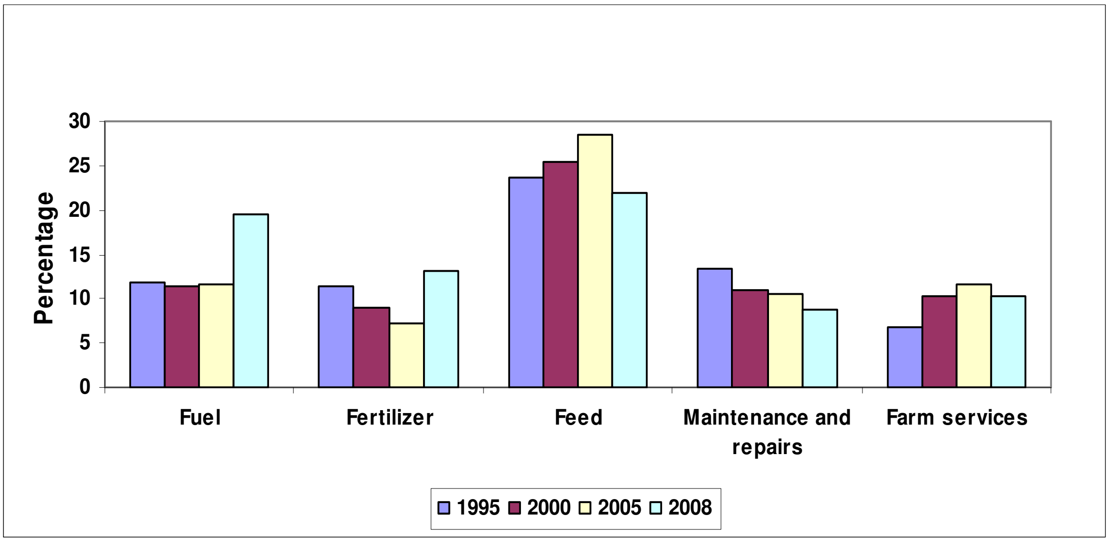


Figure 2.3: Percentage shares of selected intermediate inputs.
Source: Adapted from DAFF (2009)

The growth rate of selected intermediate inputs and total intermediate expenditure is shown in Table 2.5. In general, it shows an upward trend after 1990. Expenditure on fertilisers, however, showed a negative growth rate between 2000 and 2005 largely as a result of the drop in field crop planted area and improved farming techniques that reduced fertiliser needs. Farm services, which represent the expenditure of producers on various services such as extension, showed a significant increase after 1985, followed by feed expenditure, which has displayed marked growth since the late 1990s. During 2006-2008, however, fertiliser and fuel expenditures have shown exceedingly sharp growth rates due to the record prices for both inputs. Feed expenditure, on the other hand, showed a decline partly due to the stupendous growth of commodity prices during the same period. Comparison of the growth of real total intermediate expenditure and gross income showed that the growth rate of the former has outpaced the latter since 1990. During the past few years, however, the trend has reversed due to record agricultural commodity prices.

Table 2.5: Percentage growth rate of selected intermediate inputs

Period	Farm services	Feed	Fuel	Maintenance and repairs	Fertiliser	Total intermediate expenditure	Gross income
1985-1990	4.36	-0.80	-5.77	-0.02	-7.33	-2.48	-1.02
1990-1995	12.98	3.84	-0.58	3.10	1.36	3.51	-2.75
1995-2000	15.14	7.29	5.12	1.75	0.97	5.87	2.50
2000-2005	5.68	5.72	3.70	2.52	-0.93	3.32	2.34
2006-2008	1.94	-2.56	25.9	-0.60	29.05	6.09	14.55

Source: Adapted from DAFF (2009).

The percentage share of intermediate input expenditure in the gross value of the agricultural sector also shows that producers have spent their income increasingly on intermediate inputs during the past three decades (see Figure 2.4). The share, which was under 40% during the 1970s and remained largely under 50% during the 1980s and 1990s, has increased to above 50% since 1998 and reached 60 % in 2005. It declined during 2007-2008 to an average of 52%, due to the higher growth rate of gross income in comparison with intermediate input expenditure. In general, the trend clearly shows that intermediate input expenditure has largely consumed producers' gross income for the past decades and has thus put strain on the growth of the value added by the sector. Its implication for net farming income, however, depends also on the trend of expenditure on other factor of production, namely: land, labour and capital.

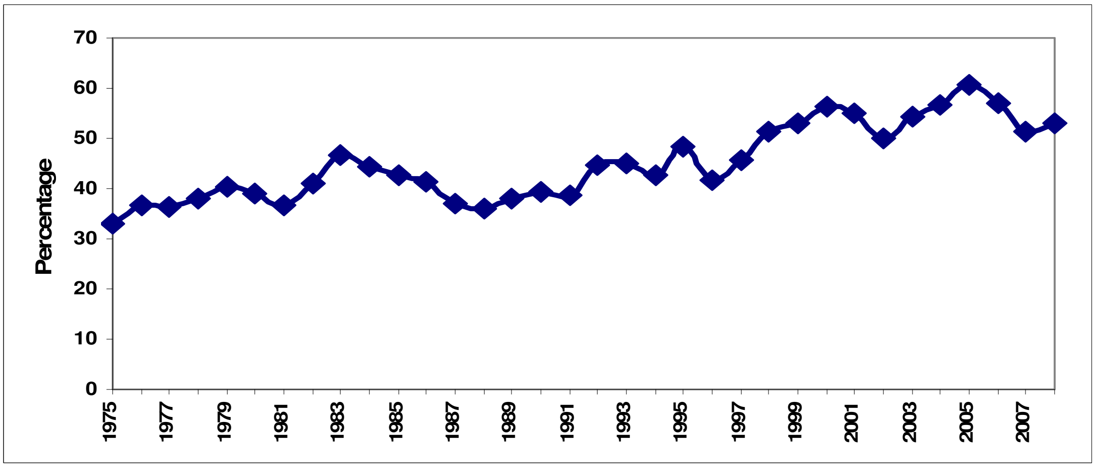


Figure 2.4: The percentage share of intermediate input expenditure in the gross value of agricultural products.
Source: Adapted from DAFF (2009)

2.4.1.1 Fuel

Fuel expenditure, which includes all expenditures on diesel oil, illuminating paraffin, petrol, lubricating oil and grease, contributed approximately 12% of the total intermediate input expenditure in 2006 and reached 19.6% in 2008. During the same period, the total expenditure had increased from R5.4 billion to R13.1 billion in 2008. The real value of fuel expenditure and fuel price in the past decades by the sector is shown in Figure 2.5. As shown in the figure, the trend of fuel expenditure is largely correlated with the movement of the fuel price.

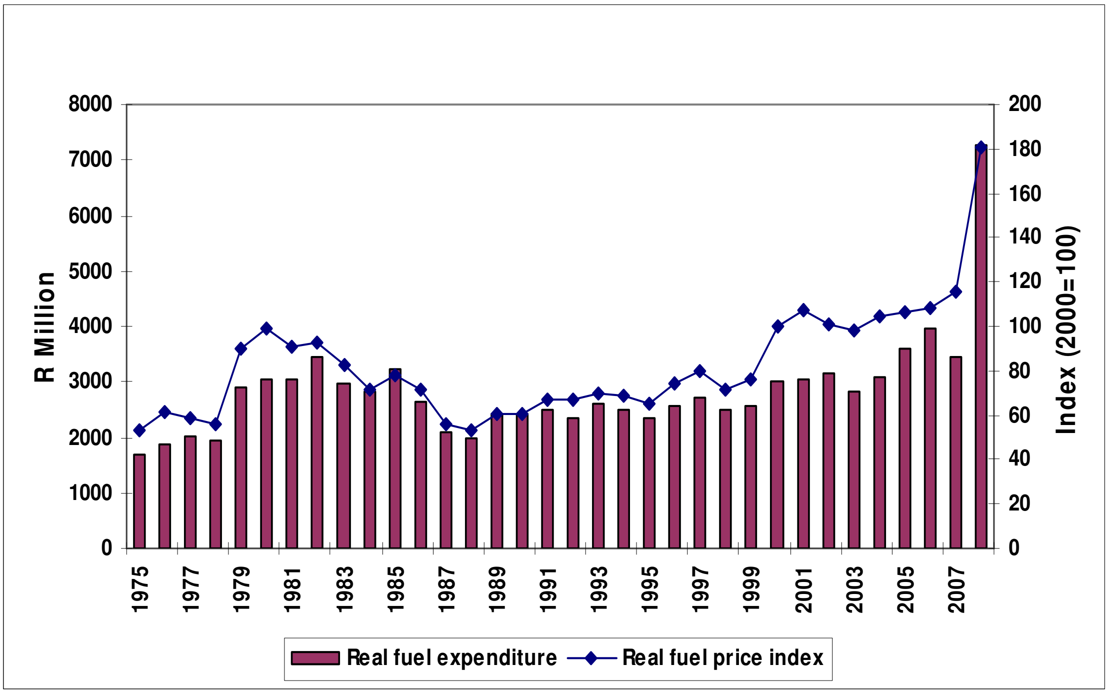


Figure 2.5: Fuel expenditure and fuel price index: deflated by PPI (2000=100)
Source: Adapted from DAFF (2009)

The two most notable periods of high oil prices were during the late 1970s when OPEC curtailed production and in 2008 when world oil prices soared to a record level. These periods also induced parallel rise in fuel expenditure as shown in Figure 2.5. Because expenditure also increases when fuel prices rise, it suggests that the sector's fuel demand is price inelastic.

2.4.1.2 Fertiliser

The fertiliser expenditure displayed in Figure 2.6 shows an increasing trend since mid-1975 and reached its peak during the early 1980s when the industry was operating under price controls and in a protected environment. In 1981, the total fertiliser subsidy reached R11 million (Kirsten and Van Zyl, 1986). Thereafter, a severe drought and a recession in the economy and the suspension of the fertiliser subsidy by 1987/88 reduced fertiliser consumption, which reached its lowest in 1992. Since then, it has shown an increasing trend with fluctuations. Between 2000 and 2007, the average real fertiliser expenditure of South African agriculture was more than R3.2 billion, representing about 11% of total intermediate input expenditure. In 2008, however, input expenditure skyrocketed, increasing by 122% to reach R7.2 billion. This unprecedented rise in expenditure was induced mainly by the rise in the fertiliser price during the same period.

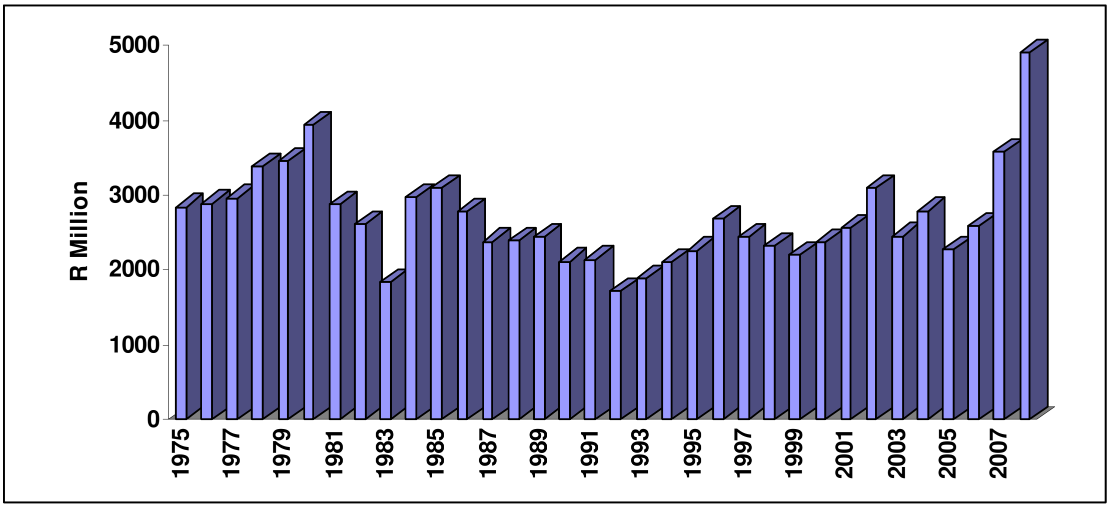


Figure 2.6: Fertiliser expenditure deflated by PPI (2000=100)
Source: Adapted from DAFF (2009)

The South African fertiliser industry currently produces 2 million tonnes of fertiliser products (750,000 tonnes of $N+P_2O_5 + K_2O$) annually for the domestic market at an annual value of R3 billion and it accounts for 20% of the South African chemical industry, excluding oil (Van der Linde and Pitse, 2006). The industry is currently operating in a deregulated market where there is neither trade protection nor any form of government support. The three major fertiliser suppliers in South Africa are Omnia, Sasol and Yara SA (previously Kynoch). The raw materials for nitrogen fertiliser are derived from ammonia and urea, which are largely supplied by Sasol and some from Mittal steel (Iscor). Due to the restructuring of Kynoch, South Africa currently imports its entire urea needs. Phosphate concentrates needed for phosphorous are supplied by Foskor, which is one of the world largest producers of phosphate and phosphoric acid.

The dominance of fertiliser supply in South Africa by three major industries implies that there is an oligopoly in the fertiliser market. Thus, there is a room among producers to create a collusion to fix prices. Recently the Competition Commission initiated an investigation of anti-competitive behaviour against Sasol for collusion with Foskor and found Sasol contravening the collusion Competition Act. Hence, Sasol was fined a record R250 million, which is equivalent to 8% of its Nitro division's turnover (Competition News, June 2009).

The domestic production, consumption and trade for nitrogen, phosphate and potash are presented in Figures 2.7-2.11. South Africa imports all of its potassium consumption and less than 10% of its phosphate consumption. In the case of nitrogen, mostly urea and LAN are imported. In general, the data shows that domestic fertiliser production is unable to satisfy local needs; hence, the country has been a net importer of nitrogen since 2000 and of phosphate since 1982.

Among the South African provinces, the Free State, Kwazulu-Natal and the Western Cape consume 60% of domestic supplies, with each accounting for 20%, and Gauteng, Mpumalanga, Limpopo and North-West account for the remaining 40% of total fertiliser consumption (FAO, 2005). From the sub-sectors of agriculture, field crops account for 80% of the total fertiliser consumption and horticulture consumes the remaining 20%. Among field crops, maize production is the largest user of fertilisers, where it accounts for 40 %, followed by sugar cane (18%), wheat (7%) and vegetables (6%).

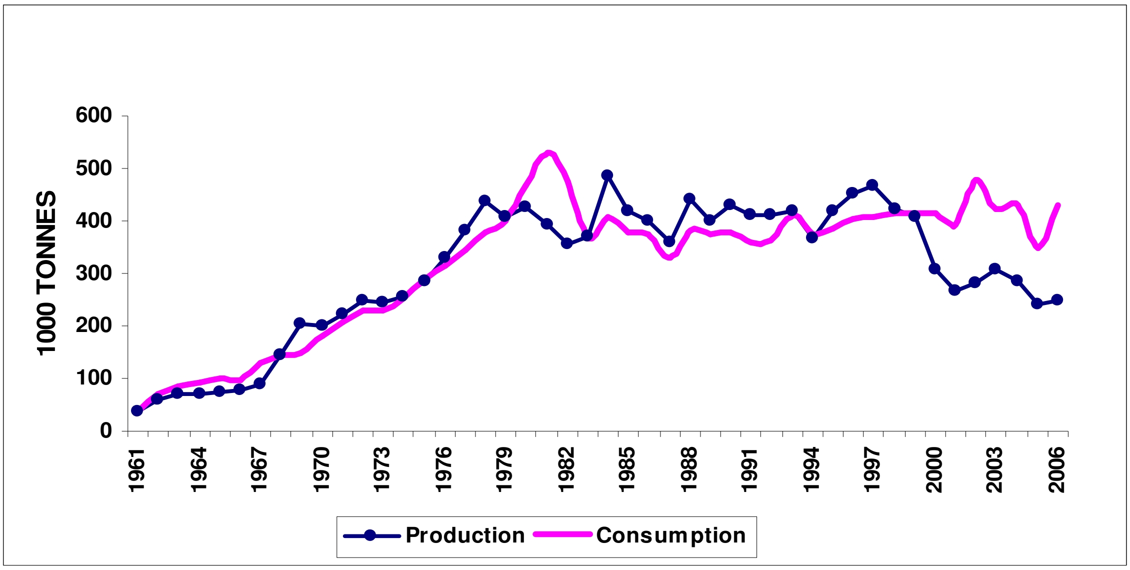


Figure 2.7: Total quantity of nitrogen production and consumption
Source: IFA (2009a)

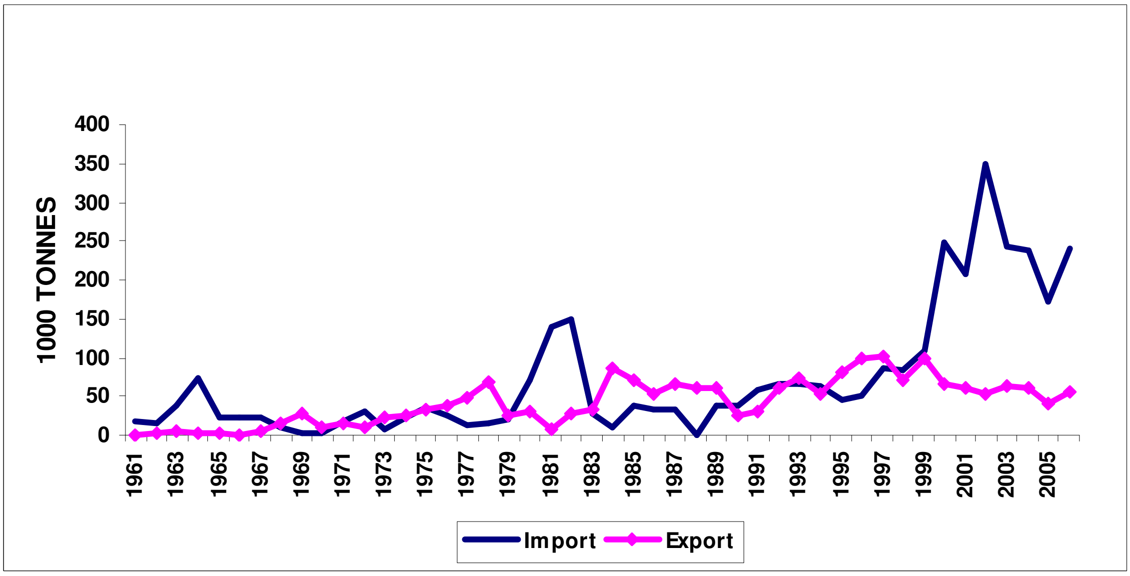


Figure 2.8: Volume of nitrogen traded in South Africa
Source: IFA (2009a)

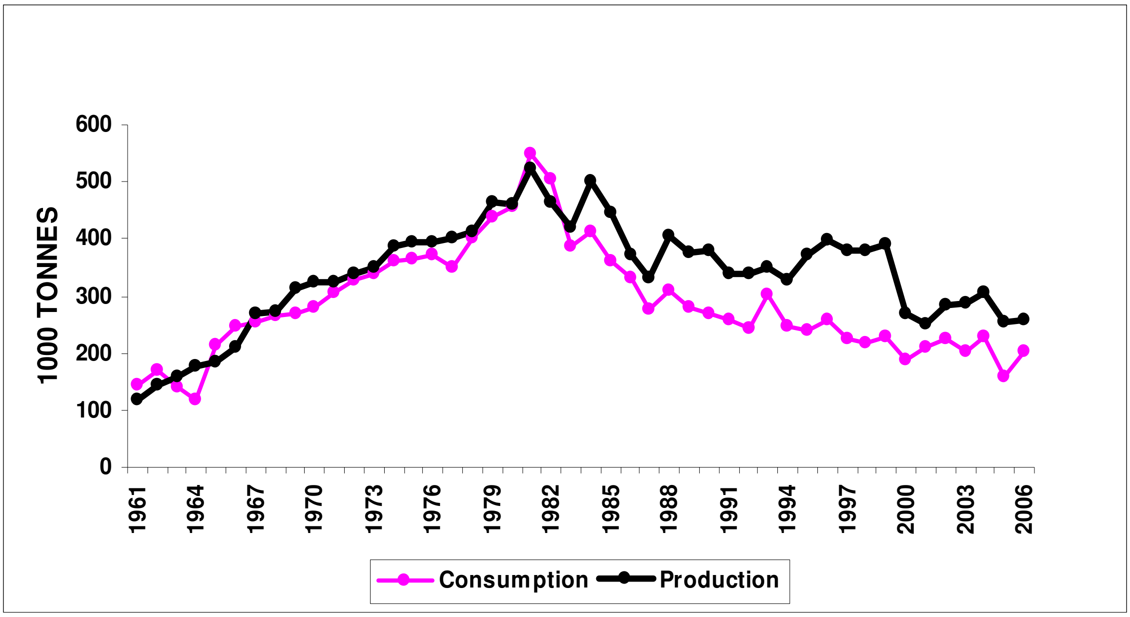


Figure 2.9: Total quantity of phosphate production and consumption
Source: IFA (2009a)

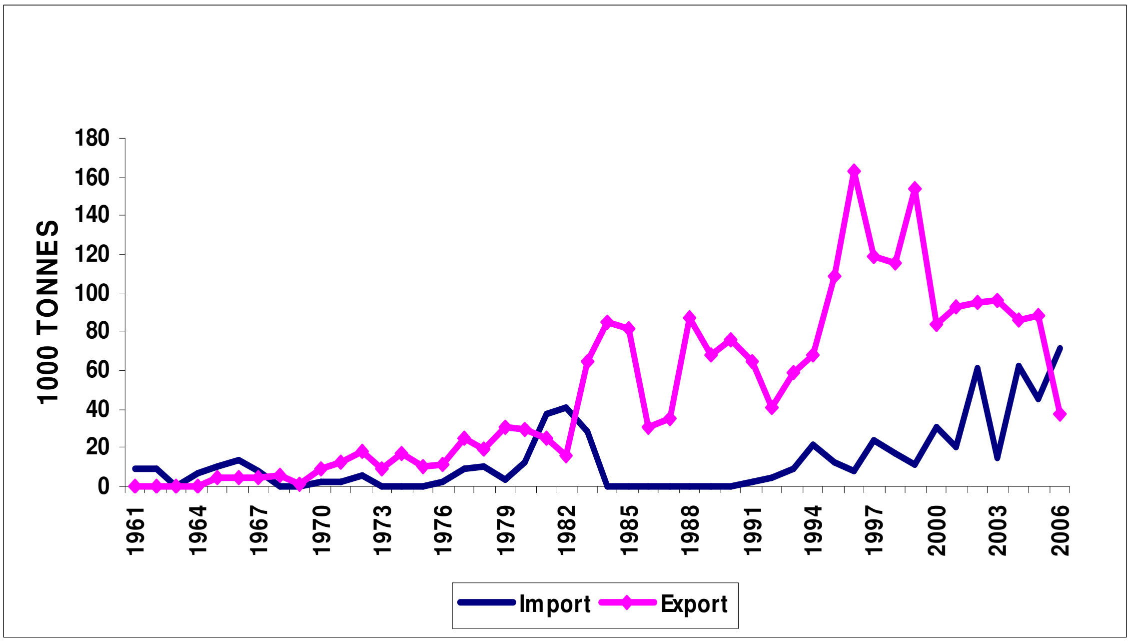


Figure 2.10: Volume of phosphate traded in South Africa
Source: IFA (2009a)

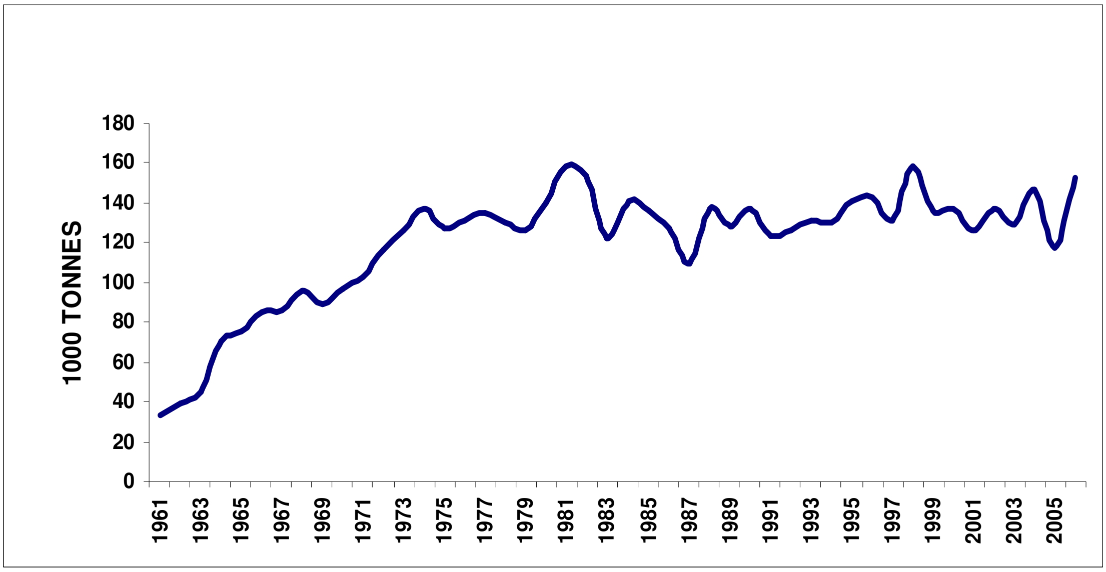


Figure 2.11: Total quantity of potash consumption
Source: IFA (2009a)

The major fertiliser prices displayed only slight growth in price from 2002 to 2007 (see Figure 2.12). However, there was an unprecedented price rise in 2008, due to the rise in world fertiliser prices (see Figure 2.13). The international price showed a steep rise due to the increase in oil price (which sharply increased the costs of energy, transport and raw material inputs) and the general rise of consumption in China and India, among others (Huang, 2009). Recent data on the share of world fertiliser consumption shows that China and India account for 43% of total world NPK fertiliser consumption (IFA, 2009b). Similar to the price trend of each fertiliser, the real aggregate domestic fertiliser price index portrayed in Figure 2.14 also shows a significant rise in 2008, after remaining roughly constant for several decades.

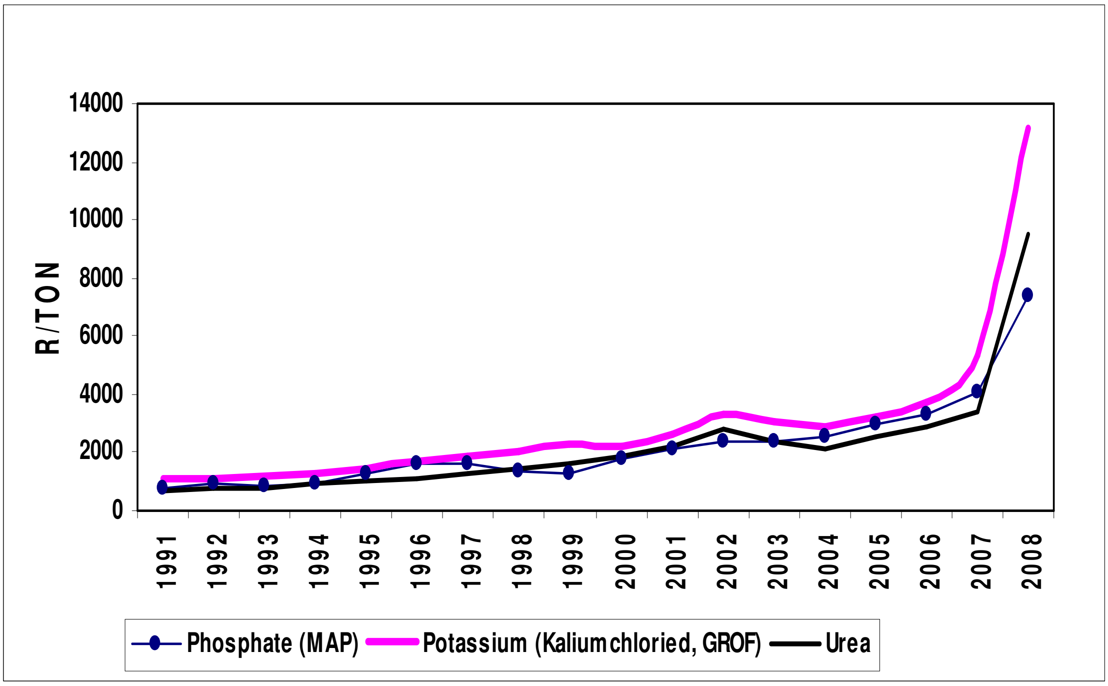


Figure 2.12: Domestic fertiliser prices of three major fertilisers
Source: GrainSA (2009)

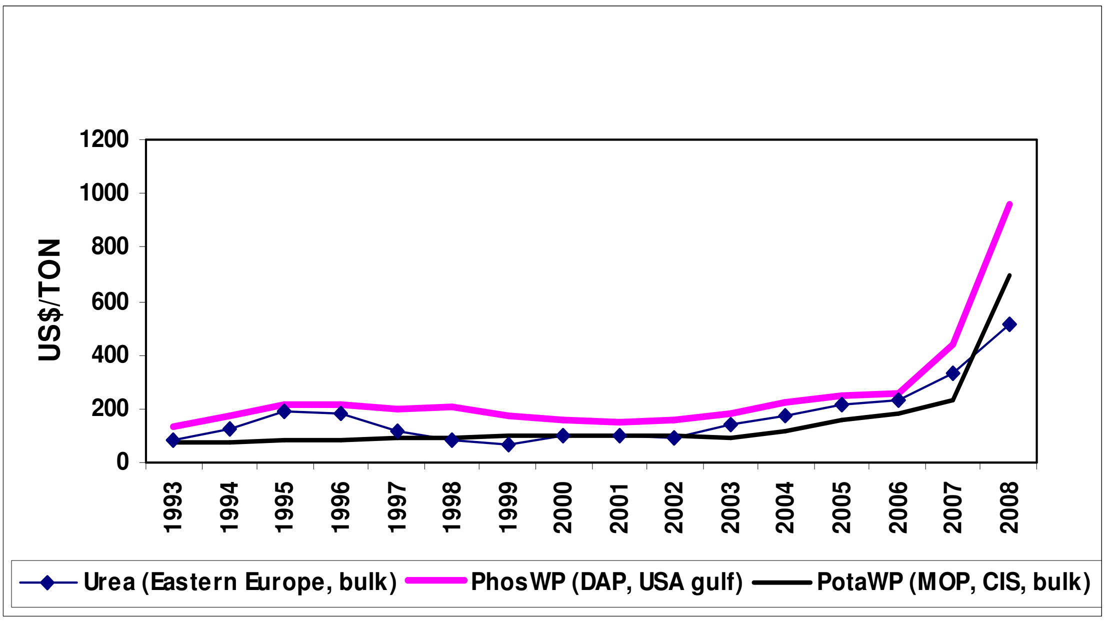


Figure 2.13: International prices of three major fertilisers
Source: GrainSA(2009)

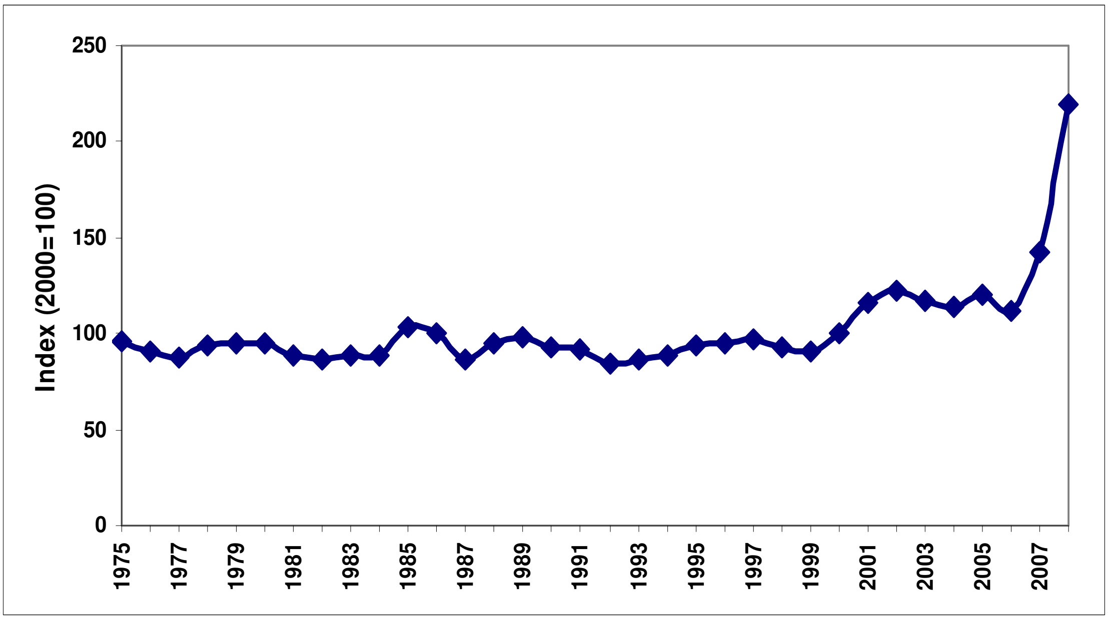


Figure 2.14: Real fertiliser price index
Source: Adapted from DAFF (2009)

2.4.1.3 Animal Feed

Feed expenditure is the largest expenditure item of all intermediate inputs in South African agriculture. The animal production sub-sector spent R14.7 billion on animal feed in 2008. The general trend of the real feed expenditure, as shown in Figure 2.15, reveals that it has greatly increased since 1997, which is partly as a result of an increase in animal production. The average annual growth rate between 1997 and 2006 was 9%.

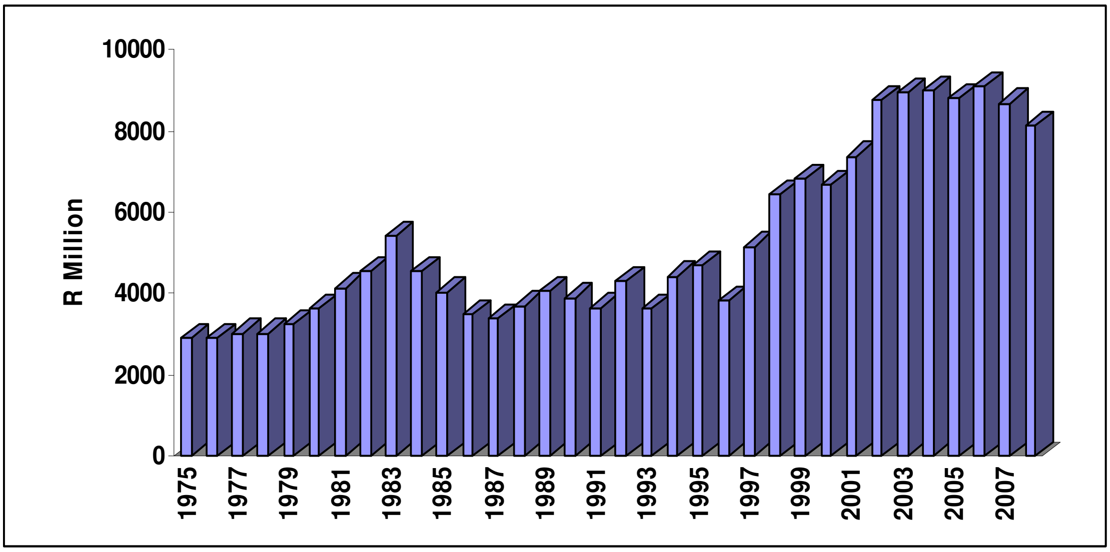


Figure 2.15: Feed expenditure: deflated by PPI (2000 =100)
Source: Adapted from DAFF (2009)

As shown in Figure 2.16, animal production has been increasing steadily since the mid-1970s and the gross income from animal production also reveals a similar increasing trend (see Table 2.1). Hence, the general rise of animal production and its gross income are the main drivers for the increasing trend of the feed demand and expenditure.

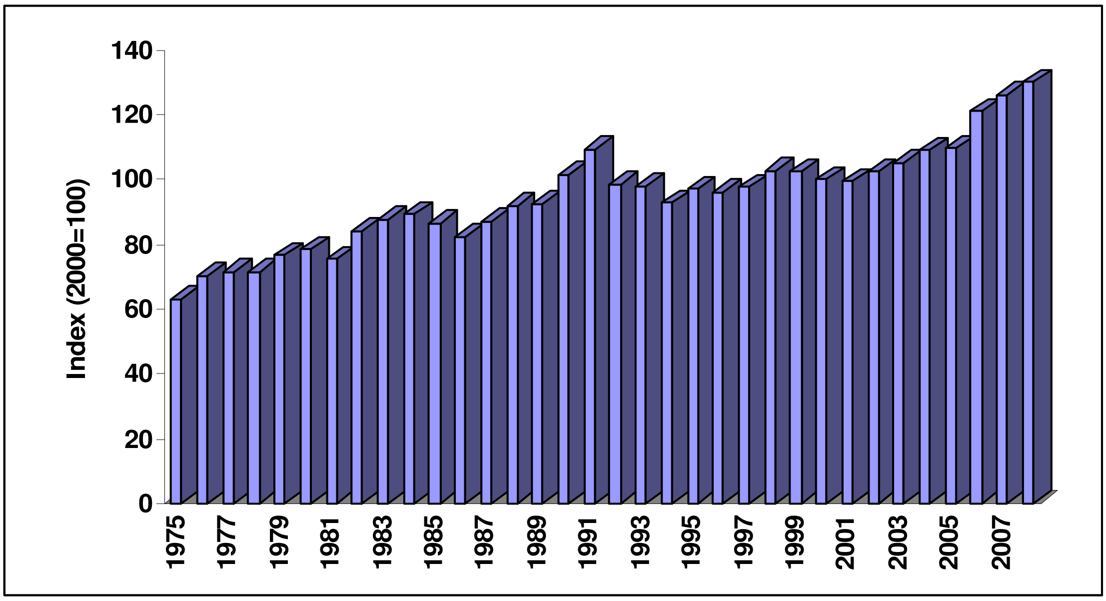


Figure 2.16: Animal products volume index
Source: DAFF (2009)

Recent data on the total feed production in South Africa showed that feed production for the broiler, beef, sheep and dairy industries constitute the largest share of total feed production in South Africa (see Table 2.6). These products contributed 75% of feed production in 2007/2008.

Table 2.6: National animal feed production during 2007/2008 (1000 Tons)

Feed type	National feed production
Dairy	1,408
Beef and Sheep	2,959
Pigs	917
Layers	986
Broilers	2,824
Other (Dogs, Horses, Ostriches and Aquaculture)	497
Total	9,591

Source: AFMA (2008)

2.4.1.4 Pesticides

Agricultural chemical industry produces products like pesticide, herbicide, insecticide, and fungicide to protect the health of the crops. Among the manufacturers of agric chemical includes Bayer, Novartics, Dow Agro sciences Zeneca, rohne-Poulenc manufacture and ICI Baer, Pfizer and Hoechst. The agricultural sector spends roughly R 2.5 billion on dips and sprays (see Figure 2.17). Data of agro chemicals trade shows that SA is in general a net importer of pesticides (see Figure 2.18-2.23). From the components of the pesticides, however, South Africa is a net exporter in herbicides. The real price of dips and spray showed in Figure 2.23 displays a general declining trend.

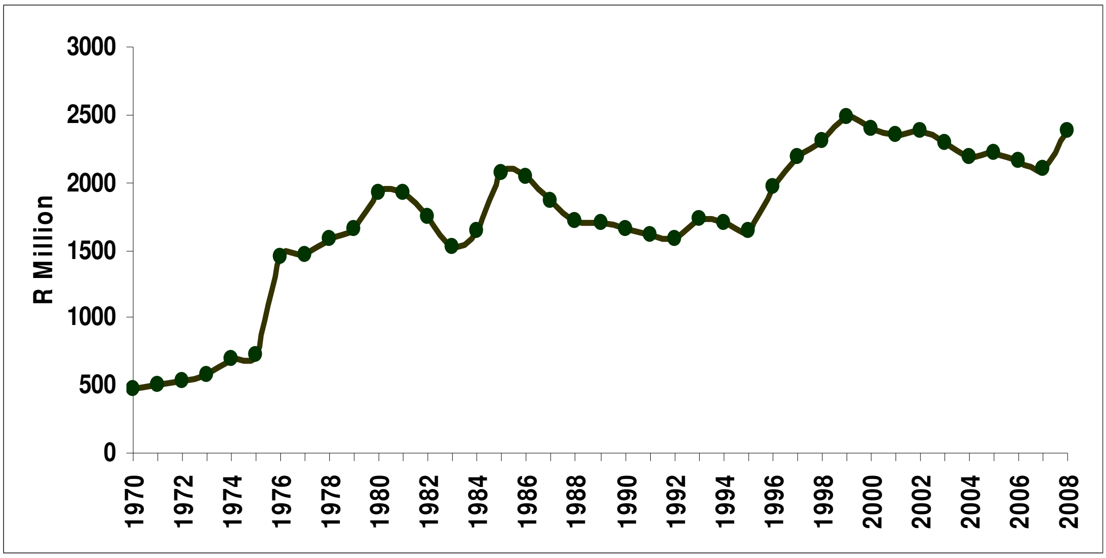


Figure 2.17: Expenditure on dips and sprays: deflated by PPI (2000 = 100)
Source: Adapted from DAFF (2009)

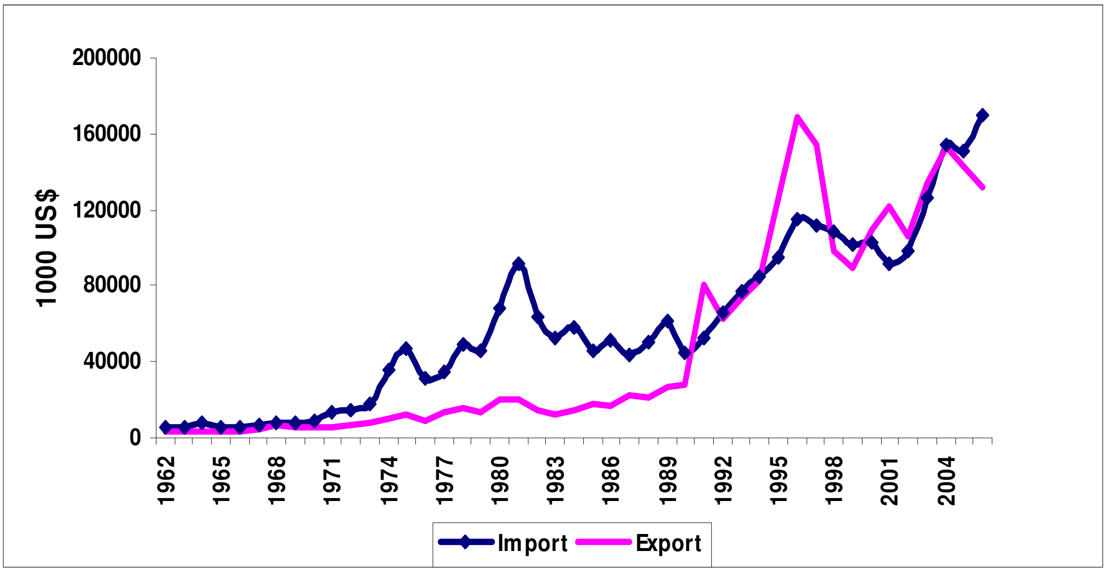


Figure 2.18: Value of South Africa's trade in pesticides
Source: FAO (2009)

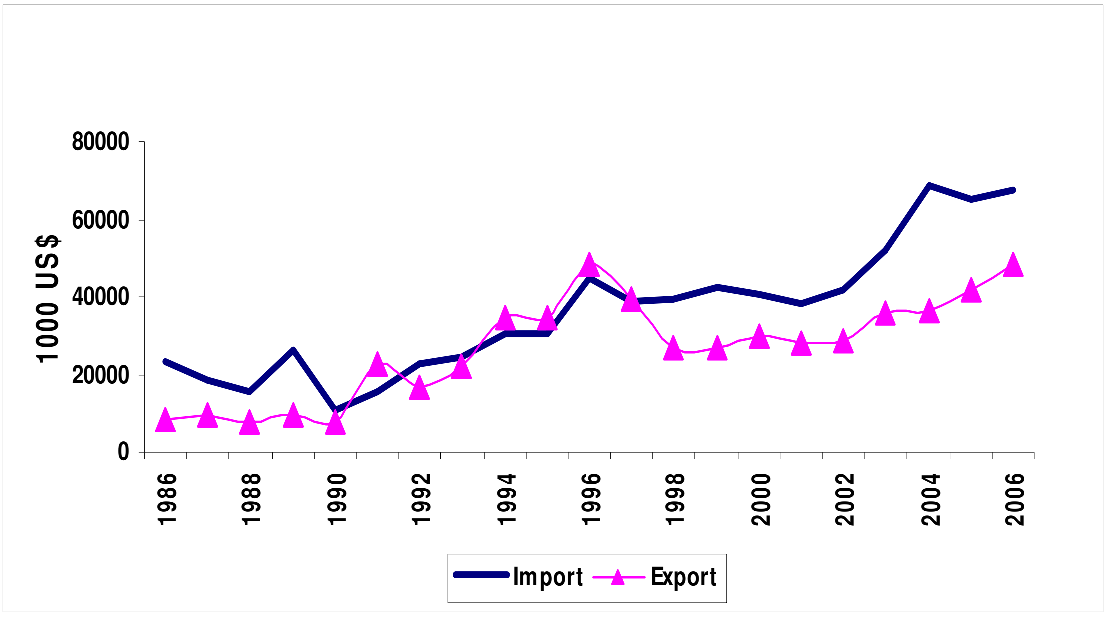


Figure 2.19: Value of South Africa's trade in insecticides
Source: FAO (2009)

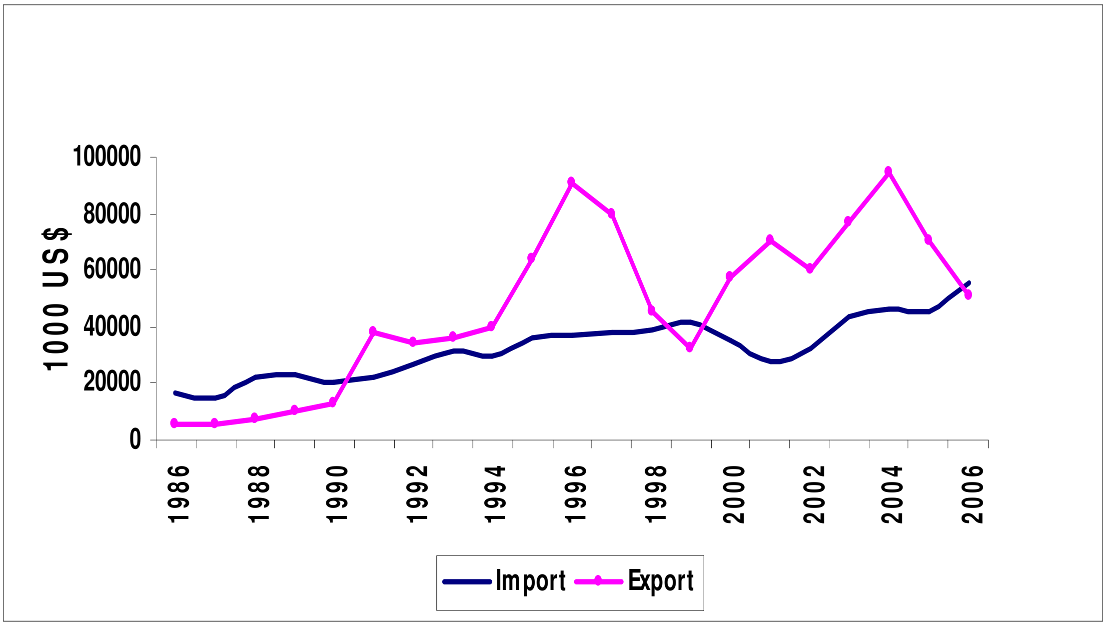


Figure 2.20: Value of South Africa's trade in herbicides
Source: FAO (2009)

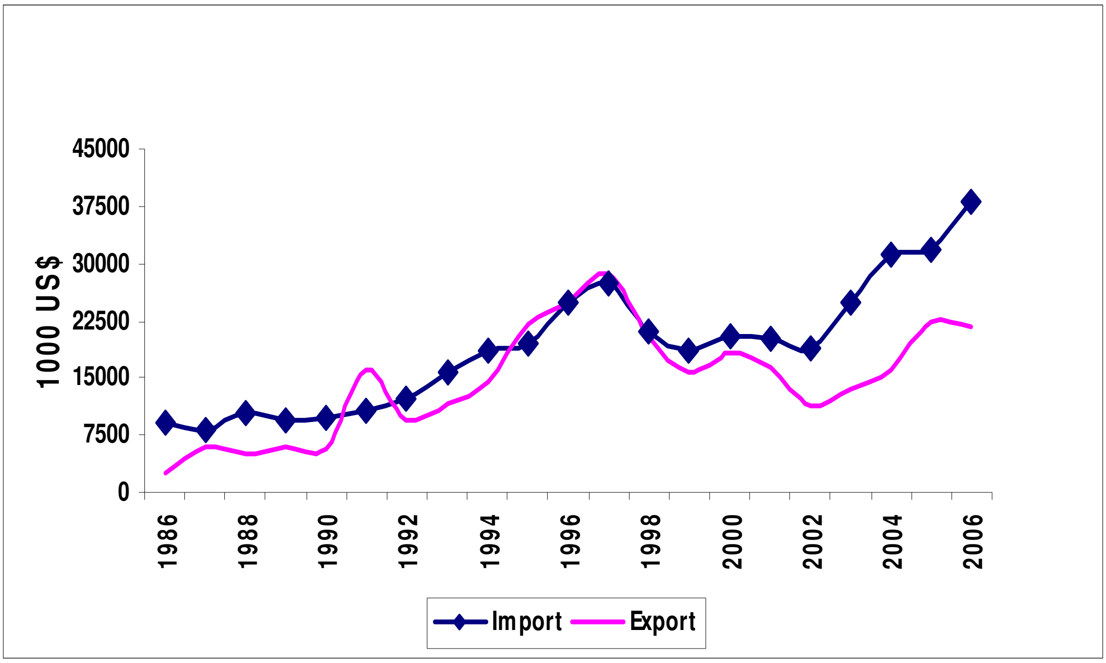


Figure 2.21: Value of South Africa's trade in fungicides
Source: FAO (2009)

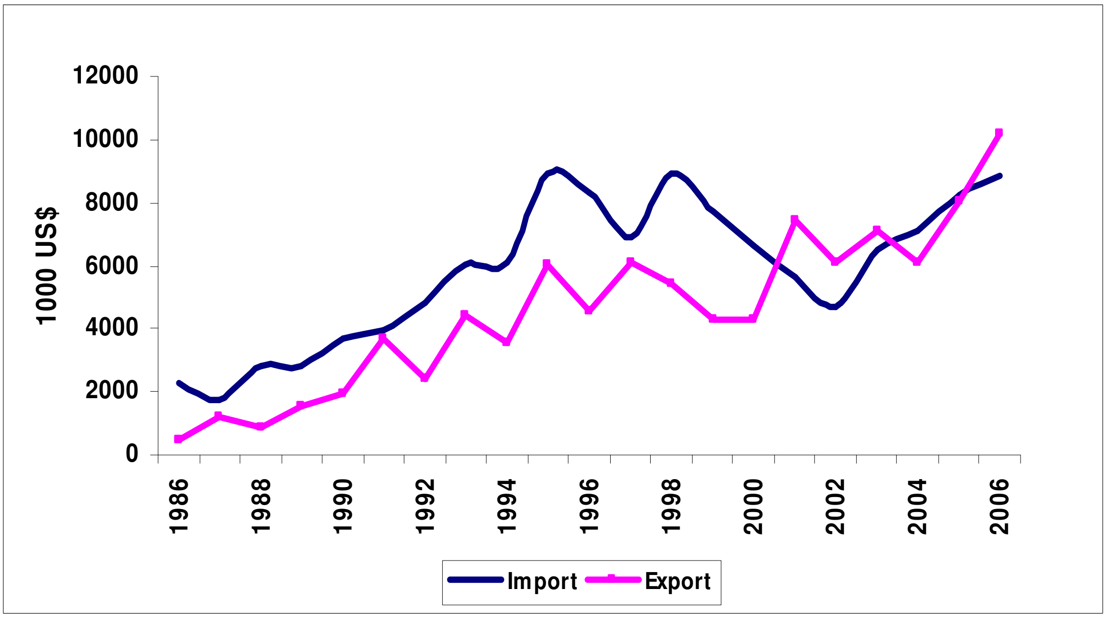


Figure 2.22: Value of South Africa's trade in disinfectant
Source: FAO (2009)

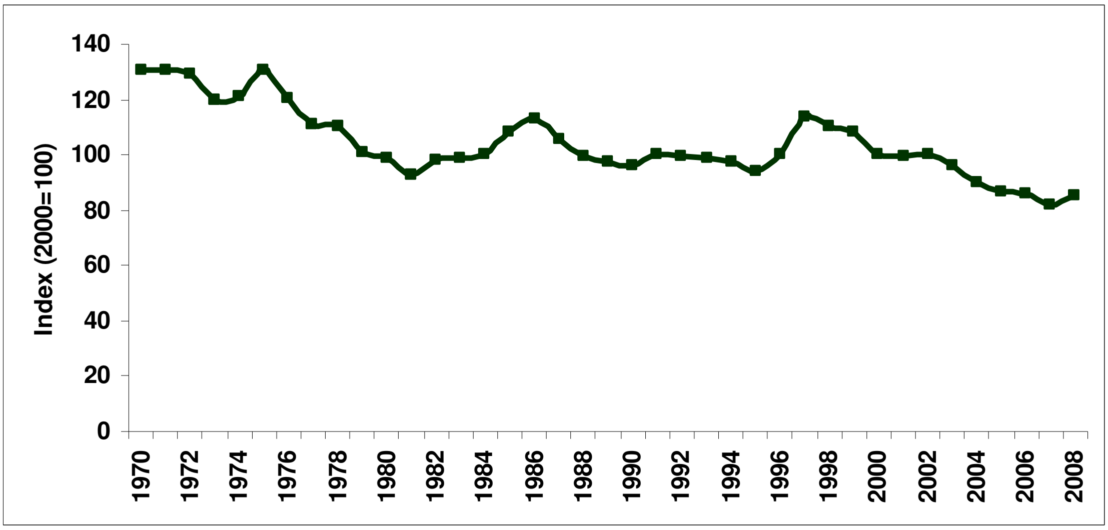


Figure 2.23: Dips and spray price: deflated by PPI (2000=100)
Source: Adapted from DAFF (2009)

2.4.1.5 Seed and Plants

Seed is largely manufactured locally and currently more than 2,000 varieties are available to producers. The South African National Seed Organization (SANSOR) monitors the seed industry; hence, it has a mandate to monitor seed certification, the seed trade and seed production. According to SANSOR (2009), the largest contributor of the seed market for agronomic crops is maize, which contributes more than 75% of the seed market. Moreover, the total seed market value for both local and export markets for agronomic, horticultural and forage (pasture) crops during 2008/09 was R2 083 million, R457.96 million and R240.95 million respectively.

Table 2.7: South Africa's seed market for agronomic crops 2008/09

Crop	Locally sold (MT)	Export market (MT)	Total market value based on retail selling price(R million)
Barley	3996.91	0	7.3
Cotton	79.4	261.9	6.8
Dry bean	2.609	603	68.5
Dry pea	3.974	0.99	0.13
Grain sorghum	737.226	2,490	45
Groundnut	2,290.060	220	32
Kidney bean	16.250	0	0.97
Maize	33,555.9	15,153	1,564
Oil seed rape (Canola)	213	0	6.7

Crop	Locally sold (MT)	Export market (MT)	Total market value based on retail selling price(R million)
Soya bean	3,369	97.7	45.5
Sunflower	1,567.8	1,229	175.6
Tobacco	0.011	0.05	0.6
Wheat	24766	468	123
Total			2,083

Source: SANSOR (2009)

Plants expenditure also represents the nursery industry that uses plants to propagate production. Plants are widely used as main input in the horticultural sub-sector. Recent data shows that agricultural producers spent more than R 4 billion on seed and plants in 2008 (DAFF, 2009). The expenditure has shown a steady increment, especially since early 2000 (see Figure 2.24), when seed and plant prices started to climb. The seed industry exports mainly to African countries and sparsely to Asia, the USA and Europe. Its main sources of imports, mainly for seeds of horticultural crops, are the USA, Europe and Asia.

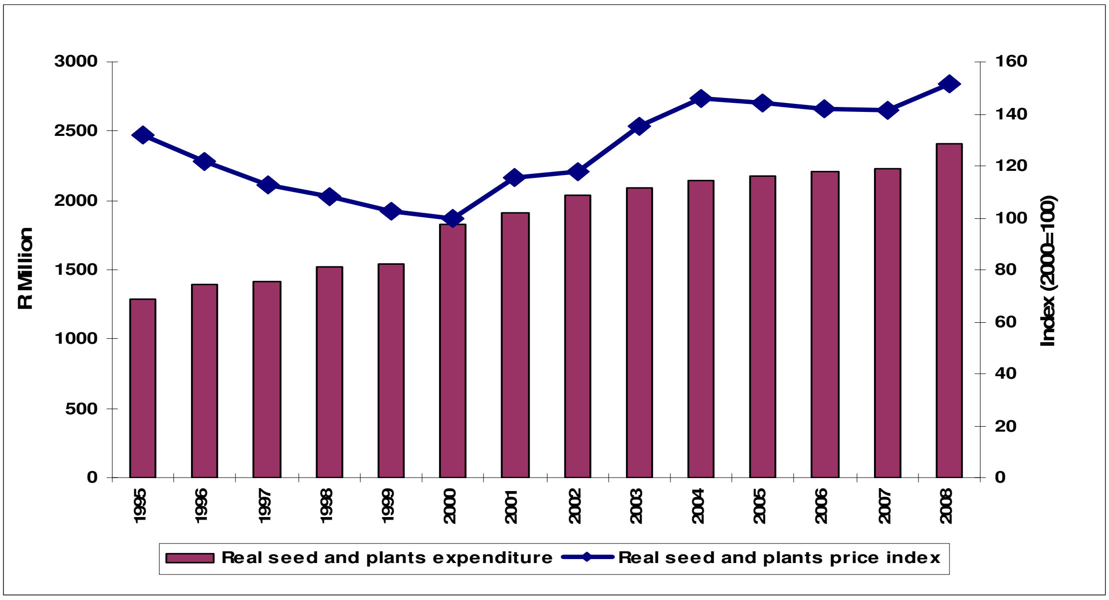


Figure 2.24: Seed and plants expenditure and seed cost: deflated by PPI (2000=100)

Source: Adapted from DAFF (2009)

2.4.1.6 Other intermediate inputs

Among the intermediate input expenditure that are becoming increasingly significant part of the intermediate expenditure are farm services and maintenance and repairs. Both of these expenditures have showed a steady rise during the past decades (see Figure 2.25). Currently both expenditures comprise 25% of total intermediate input expenditure. Maintenance and repairs expenditure mainly includes expenditures on equipment and implements used to repair the machineries, tractors and implements used by the sector. Moreover, it includes the labour cost of repairing and maintaining the equipment. Farm service expenditure, on the other hand, refers to all expenditures on the services offered to the farmers such as consultancy and extension support.

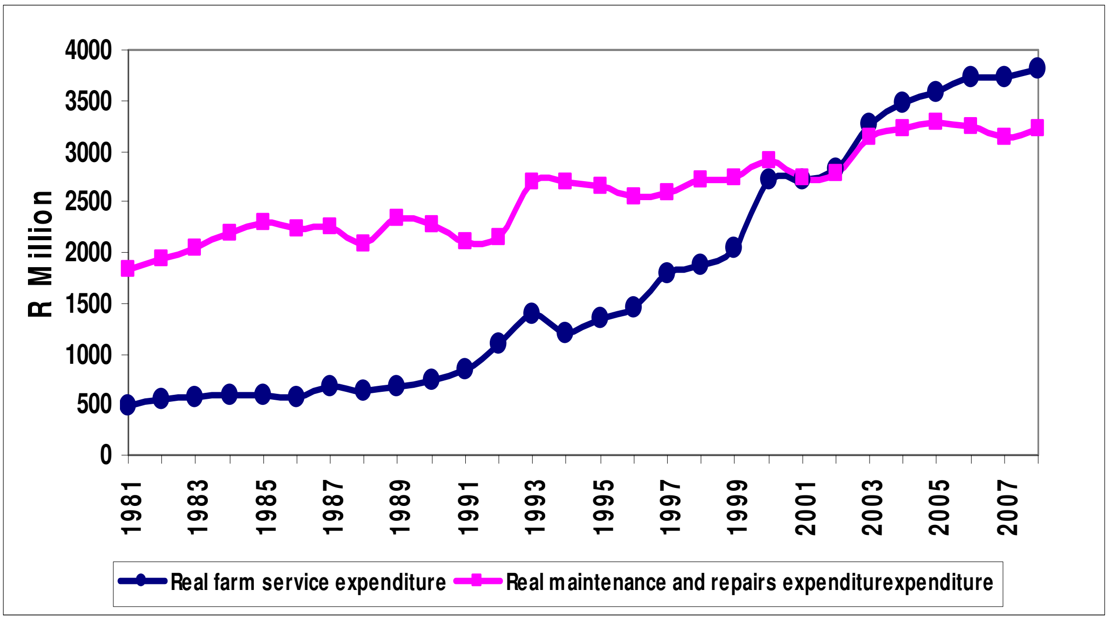


Figure 2.25: Real farm services and maintenance and repairs expenditure: deflated by PPI (2000=100)
Source: Adapted from DAFF (2009)

2.4.2 Capital Formation in the South African Agricultural Sector

Gross capital formation represents agricultural investments in tractors, machinery, motor vehicles and fixed improvements. Figure 2.26 shows that gross capital formation of tractors, machinery and implements reached its peak in the early 1980s, followed by a declining trend until the early 1990s. The two most important variables that influenced capital formation in the sector are real interest rate and tax legislation (World Bank, 1994).

The interest rate was subsidised by the Land Bank from the early 1970s, and was negative for almost 15 years except during 1982-1984 and in 1987 (see Figure 2.27), which reduced the effective price of capital. Furthermore, tax legislation in 1977 wrote off the full cost of machinery and implements against tax income in the year of purchase, thus increasing investment in capital goods, until it was later changed to depreciate over three years (50%, 30% and 20%) like any other business. Hence, capital formation soared during this period and the average annual growth of capital formation for tractors, machineries and implements during 1970-1981 was 8.6% (World Bank, 1994).

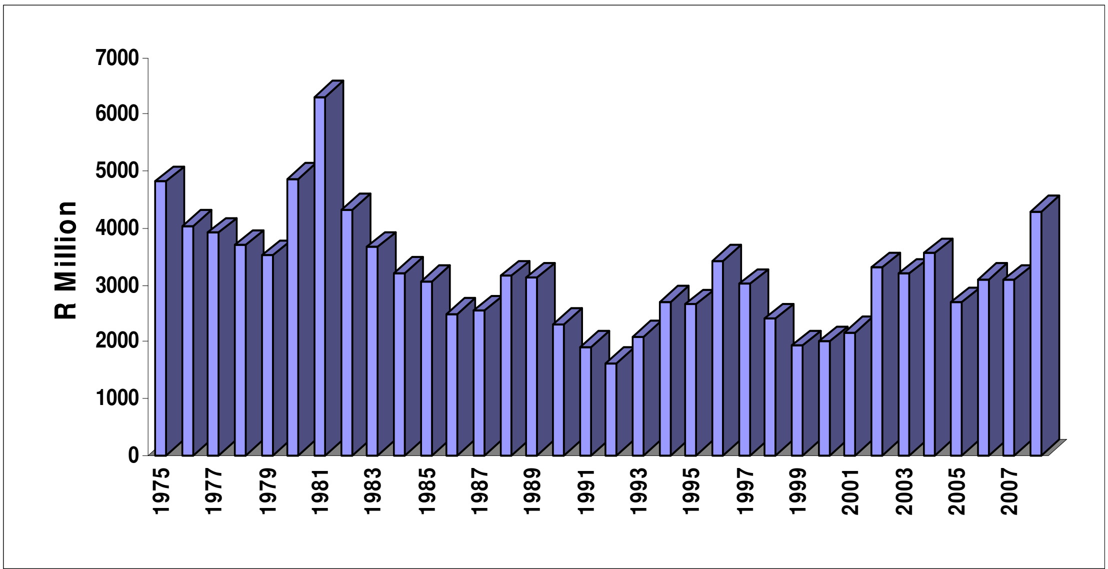


Figure 2.26: Real gross capital formation: Tractors, machineries and implements: deflated by PPI (2000=100)
Source: Adapted from DAFF (2009)

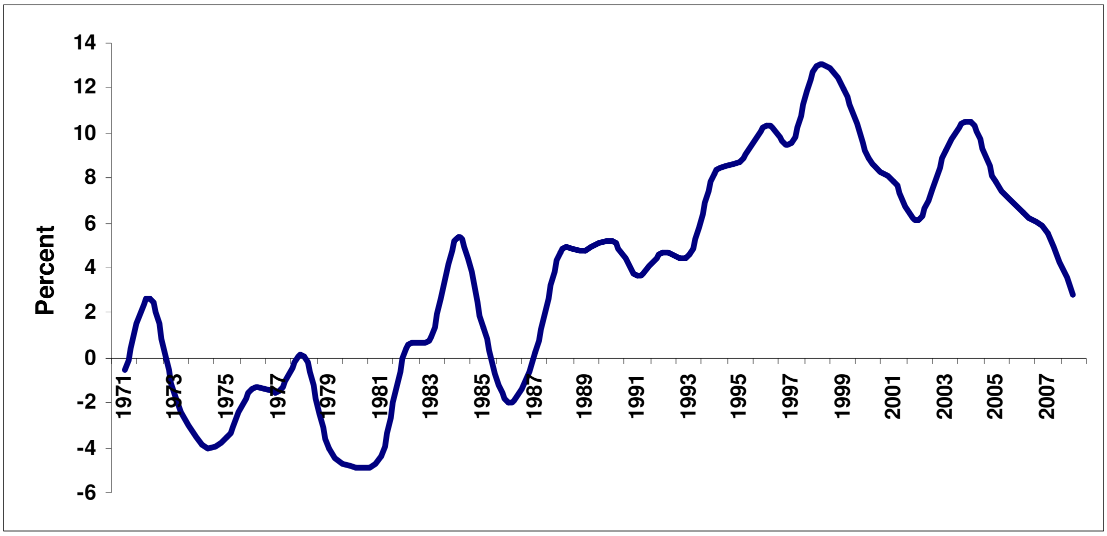


Figure 2.27: Average real interest rate: (average nominal interest rate – inflation)
Source: Adapted from Directorate: Agricultural Statistics (2009)

By the end of 1983, however, successive drought periods, the elimination of credit and tax concessions, coupled with a drop in the gold price and the devaluation of the Rand reversed the trend of capital formation in the agricultural sector (World Bank, 1994). Thus, the average annual growth rate of capital formation during 1981-1993 was -8.2%. From 1993, capital formation showed an upward trend with fluctuation, often due to poor rainy seasons. Thus, the reversal of the trend shows the positive reaction of producers to political changes, real positive interest rates and increased market access (Van Zyl *et al.,* 2001).

The number of tractors and harvesters in South Africa, shown in Figures 2.28 and 2.29, shows a declining trend since the early 1980s, partly due to a reduction in the gross income of the sector. However, the decline in numbers is attributed to the introduction of large tractors and the increasing average age of the tractor fleet (Vink, 2000). Recent data from Agfacts (2009) shows that new tractor sales for 2008 were 7 338 units, which is 44.3% up from 2007 sales (6,371 units)). Moreover, the average power of tractors in the South Africa tractor park has increased from 58.6 kW twenty years ago (1988) to 62.0 kW ten years ago (1998) to 73.1 kW currently. Similarly, the average age of these tractors has reduced from a level of approximately 13 years during the period 1995 to 2000, down to approximately 10.4 years currently.

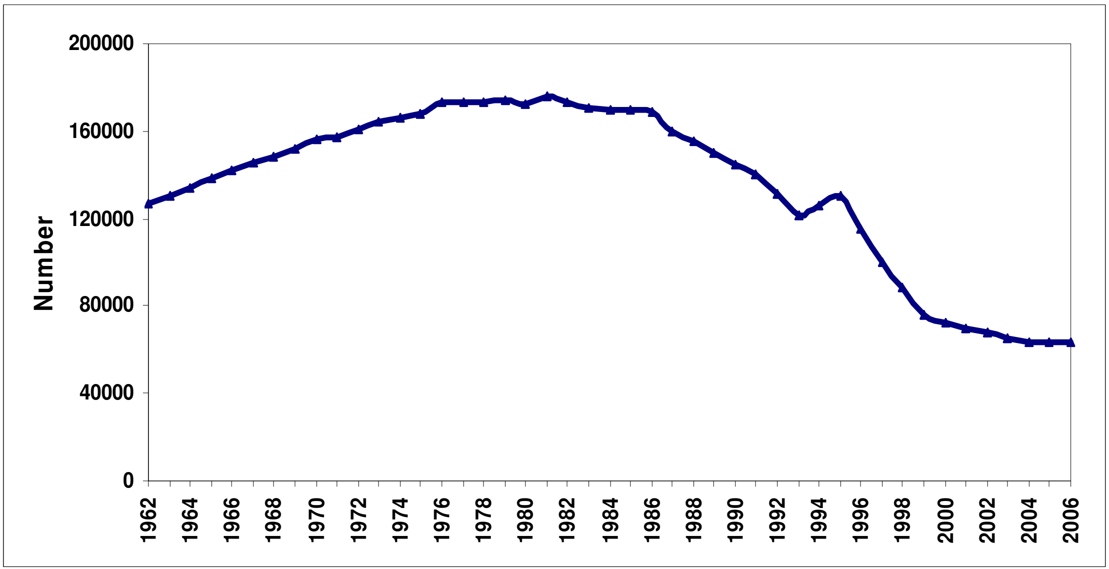


Figure 2.28: The number of agricultural tractors in use in South Africa
Source: FAO (2009)

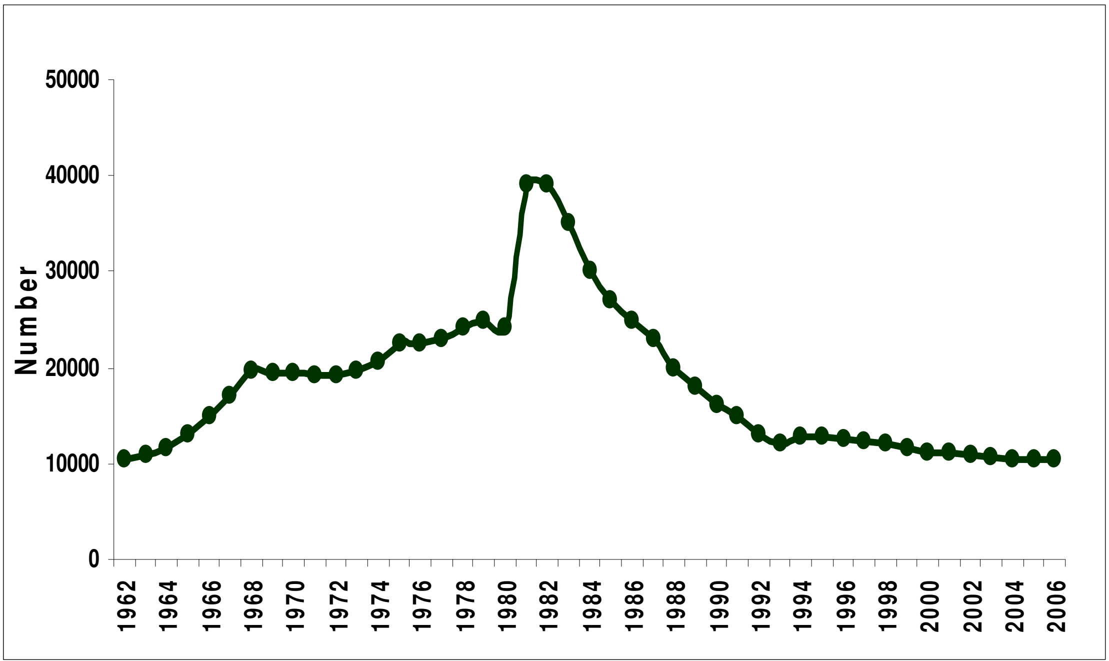


Figure 2.29: The number of combine harvesters-threshers in use in South Africa
Source: FAO (2009)

South Africa is a considerable net importer of machinery. Similarly, the trade value in overall agricultural requisites, which consist of all machinery, fertiliser and other key inputs for South Africa, shows that the country is a net importer of aggregate agricultural equipment and inputs. Hence, exchange rates and trade policy play a crucial role in influencing the profitability of the sector by affecting the cost of inputs.

The gross capital formation of fixed improvements also showed a similar trend (see Figure 2.30). It depicted a general upward trend until the early 1980s in response to benign state support for the sector and it was followed by a decline due to the end of subsidisation on farm construction, especially on housing construction for hired labour (World Bank, 1994). The trend has reversed since 1992, signalling a positive response to the general economic environment surrounding the sector.

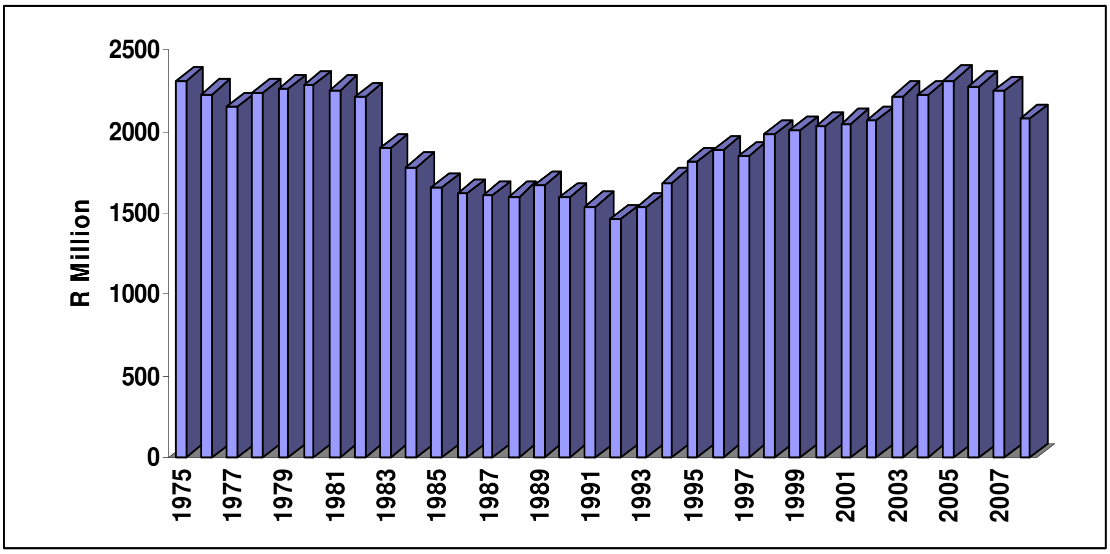


Figure 2.30: Gross capital formation: fixed improvement, deflated by PPI (2000=100)
Source: Adapted from DAFF (2009)

The share of the agricultural, forestry and fishing sectors' gross fixed capital formation in the total economy, shown in Figure 2.31, displays a declining trend. The share, which had been 12% in 1960, 7% in 1980 and 4% in 1990, has remained above 2% since 2000. The fall is in line with the general declining share of agriculture in the economy.

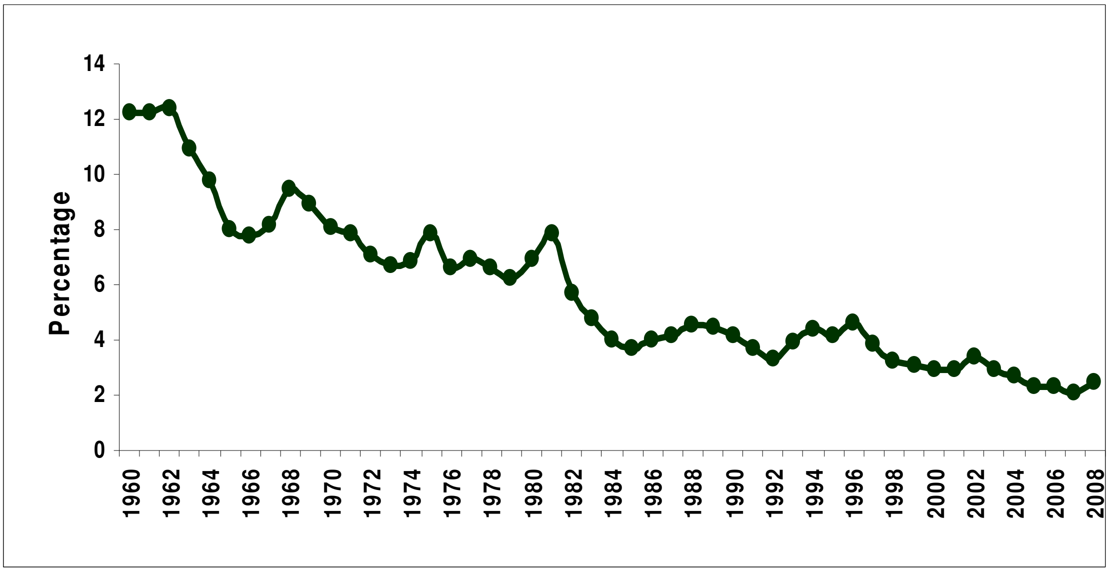


Figure 2.31: Agricultural investment as a percentage of total investment
Source: Reserve Bank (2009)

2.4.3 Employment in the Agricultural Sector

The trends of employment in the agricultural sector shows that it increased by 65% from 1951 to 1970 and declined again by 60% from 1970 to 1991 (World Bank, 1994). Before 1970, the introduction of tractors increased cultivated area, which resulted in higher demand for labour, and increased utilisation of fertiliser and improved seed varieties. The significant fall in agricultural employment after 1970, however, is attributed to two factors (World Bank, 1994). Firstly, the fall in farm profits relative to other sectors made it difficult to compete with urban wages and secondly, even though mechanisation was introduced before 1970, substitution and displacement of labour started after 1970, owing to favourable policies that reduced the effective cost of capital through credit subsidy, overvalued exchange rate and tax policy (see Figure 2.32).

In 1983, however, this trend reversed because of the termination of preferences, which resulted in a high cost of capital. Thus, until 1987, labour was substituted for capital. The decline of employment after 1987, however, may have been due to greater political uncertainty (World Bank, 1994). A further reduction since early 1990s is also partly with the introduction of new labour legislation that increased the cost of labour (Sparrow *et* *al.;* 2008). As shown in Table 2.8, the primary sector accounts for around 7.8% of the total employment in the economy, despite its low GDP contribution to the economy. A recent labour force survey also shows that agriculture, forestry and fisheries sector has employed 723 000 people in 2007 (StatsSA, 2009a). In addition, the sector spent more than R 11.7 billion in 2009 on labour remuneration. As shown in Figure 2.33, the remuneration showed a steep increment after the introduction of the minimum wage for farm employees in 1993. Since then, however, it has remained relatively constant.

Table 2.8: Employment in the agriculture, hunting, forestry and fishing industries

Number of workers	2001	2002	2003	2004	2005	2006	2007
	Thousands						
Agriculture, hunting, forestry and fishing	1,178	1,420	1,212	1,063	925	1,088	1,041
Skilled agriculture[1)]	521	706	341	329	302	432	341
Total employment[2)]	11,181	11,296	11,424	11,643	12,301	12,800	13,306
% of workers in agriculture, hunting, forestry and fishing to total employment	10.5	12.6	10.6	9.1	7.5	8.5	7.8

1) Skilled agriculture workers are included in the number of workers in agriculture, hunting, forestry and fishing.
2) Total employment refers to all employment in all sectors.

Source: Labour Force Survey, Statistics South Africa as cited in Directorate Agricultural Statistics (2009)

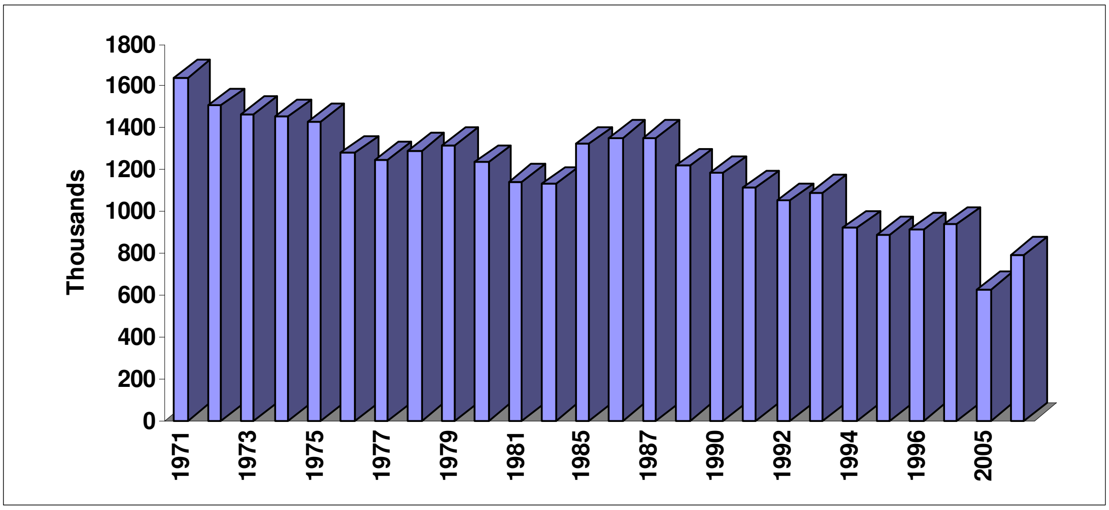


Figure 2.32: Total number of farm employees (permanent, casual and seasonal)
Source: Directorate Agricultural Statistics (2009) and StatSA (2009)

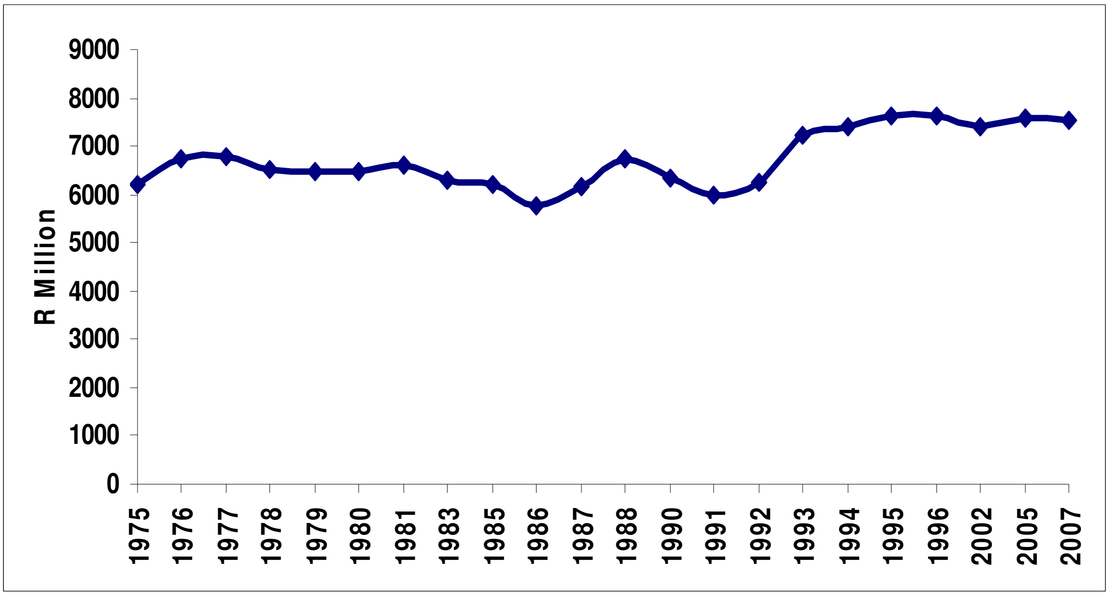


Figure 2.33: Labour remuneration: deflated by CPI (2000=100)
Source: Adapted from DAFF (2009)

The unit cost of labour measures the share of labour cost on each Rand received from agricultural output. Hence, it is a good indicator of whether labour expenditure is becoming a burden for producers. As shown in Figure 2.34, the value, which remained below 13 cents between 1978 and 1991, had risen to 18.4 cents in 1995. In 2002, however, it showed a steep decline (11.9 cents) and since then has remained below 14 cents. The unit cost of labour reached its lowest point in 2007, when it was 11.1 cents due to the relatively higher growth of agricultural gross income. In addition, the declining trend of employment contributed to the fall of the unit cost of labour in the agricultural sector.

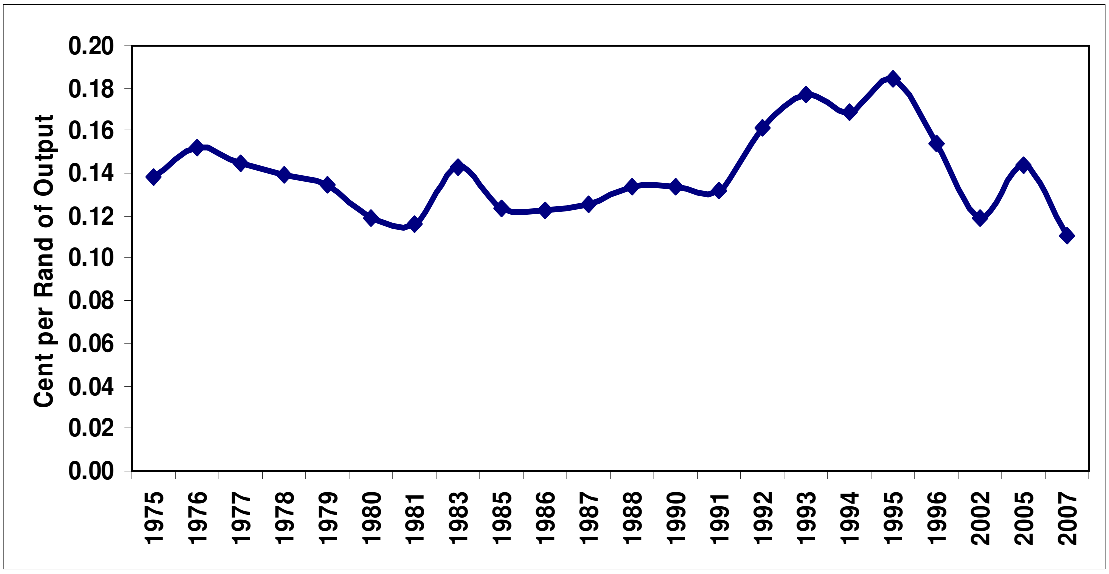


Figure 2.34: Unit cost of labour (Cent per Rand of agricultural output)
Source: Adapted from DAFF (2009)

2.4.4 Land Rent Paid

Land rent represents the rent paid to the land under production. The previous agricultural policies that subsidised agricultural producers to attain self-sufficiency encouraged the increase in capital formation that necessitates an increase in planted area (World Bank, 1994). Hence, the rise of the area followed the expansion of capital formation in the sector induced the amount of rent paid to increase from the 1970s until the start of the deregulation in mid 1980s (see Figure 2.35).

Following deregulation, however, area planted for field crops declined steadily; hence, it induced a similar falling trend in the rent paid until 1991. Thereafter, the rent paid showed a marginal declining trend, in line with the similar trend of the area planted during the same period (see Figure 2.36). The declining trend of the rent paid could also be partly related to the falling trend in farming units (numbers), which has declined from 57 980 (1993) and 45 818 (2002) to 39 982 (2007) (StatsSA, 2009b).

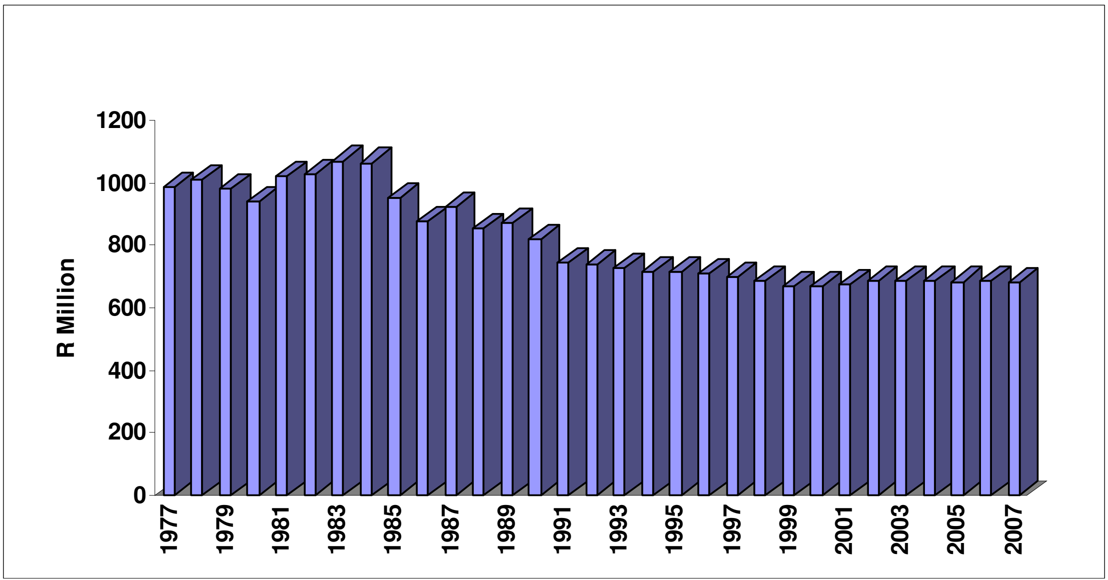


Figure 2.35: Rent paid deflated by CPI (2000=100)
Source: Adapted from DAFF (2009)

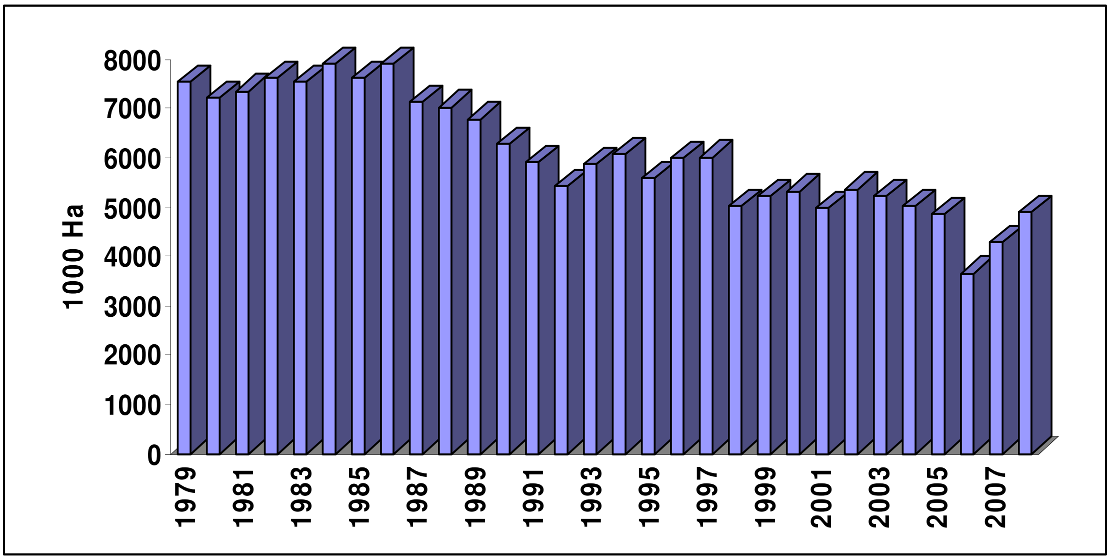


Figure 2.36: Planted area of main field crops
Source: DAFF (2009)

2.4.5 Interest Paid

The amount of interest paid by producers showed that it remained relatively low and constant until 1979, which was largely due to the negative real interest rate and low debt level (see Figure 2.37). Then it showed a stupendous growth rate of 30% at an annual average rate until 1985. Thus, the amount paid on interest in 1985 was triple that in 1979. The payment increased in the 1980s due to the huge borrowing (debt accumulated) during the negative real interest rate in earlier years. Hence, debt repayment was the highest input cost for producers in the 1980s. The general fall of gross capital formation in the agricultural sector after the mid-1980s reversed the trend of the interest paid by the sector.

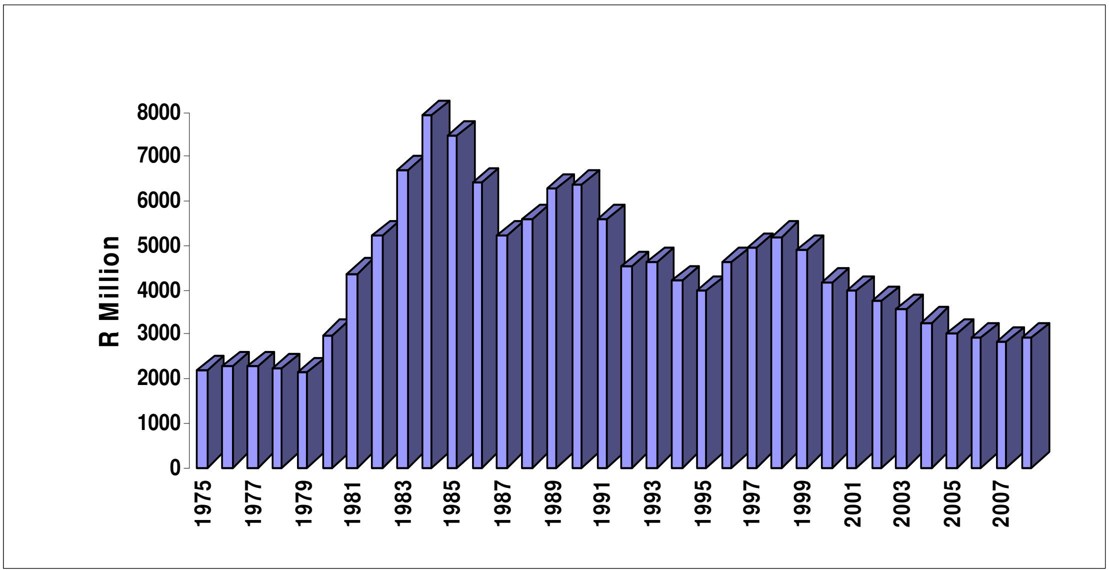


Figure 2.37: Interest paid: deflated by CPI (2000=100)
Source: Adapted from DAFF (2009)

2.4.6 Changes in the Input Substitution in South African Agriculture

A study undertaken by Van Zyl *et al.,* (2001) compared substitutability among agricultural inputs during 1971-73 and 1996-1998 and showed that:

- The elasticity of substitution between capital and labour has increased, though marginally.
- Labour and intermediate goods complementarity has dropped, which shows an increase in farmers' flexibility.

- The reaction of farmers to the volume of inputs in response to the change in input prices has generally increased.
- Substitutability between capital and intermediate goods and between land and intermediate goods, however, has not changed.

Thus, the general improvement in the flexibility of farmers to change input mix shows that farmers are able to adopt new modes of production in reaction to various input price changes. Despite this increase in flexibility, however, the sector still reveals a persistent bias towards the use of capital, which is unjustifiable considering the resource endowment of the country (Vink, 2000).

2.5 Agricultural Sector Growth

The declining share of the agricultural sector's contribution to the South African economy over the past three decades reveals the normal economic development path of a country where the manufacturing and service sectors overtake the agricultural sector in income contribution to the whole economy. However, as argued by the World Bank (1994), the low GDP share of the South African agricultural sector is mainly the result of previous misguided policies contrary to the natural endowment of the country and the dominant role of the mining sector in the economy. The agricultural sector's contribution to the economy shrank from 10% in 1960 to 3.2% in 2007 (DAFF, 2009). However, the importance of the sector, when evaluated by its role in deriving foreign exchange and employment remains significant (Meyer, 1998). Moreover, farming remains the major income source of rural communities; hence, it plays a crucial role in alleviating poverty and achieving food security (Baiphethi & Jacobs, 2009; Machethe, 2004 and Pauw, 2007). Recent study also shows that around 4 million people from 2.5 million households are involved in agriculture as a means of supplementing the household food supplies (Aliber and Hart, 2009).

The changing structure of the agricultural sector during the past decades in terms of utilisation of more intermediate inputs and supplying primary inputs to the agro processing industries also shows that the sector plays a considerable role in the economy through its forward and backward linkages.

During the past decades, the average annual growth rate of the agricultural, forestry and fisheries sector showed a variable growth rate compared to other sectors (see Table 2.8). The sector, however, is still experiencing growth, though the rate during the period 1994 to 2008 was among the lowest, and below the average growth of the whole economy.

Table 2.9: The annual average growth rate of industries in South Africa's economy

INDUSTRY	1975-1980	1980-1985	1985-1990	1990-1995	1995-2000	2000-2005	2005-2008	1994-2008
PRIMARY INDUSTRIES	2.61	0.59	0.15	-1.59	1.75	1.62	-0.23	0.4
Agriculture, forestry and fishing	4.06	0.07	3.66	-4.04	5.66	1.53	4.25	1.83
Mining and quarrying	2.06	0.80	-1.65	-0.19	-0.37	1.66	-2.29	-0.27
SECONDARY INDUSTRY	3.90	-0.28	0.75	0.32	2.25	3.21	4.90	3.4
Manufacturing	4.47	0.95	1.59	0.15	2.46	2.75	3.48	3.07
Electricity, gas and water	6.09	6.02	3.40	2.83	2.05	1.25	1.51	1.64
Construction	-1.71	-1.37	-0.61	-2.36	0.69	8.17	14.65	6.46
TERTIARY INDUSTRY	2.83	2.86	1.98	1.61	3.41	4.54	4.95	4.23
Wholesale and retail trade	0.06	3.48	0.89	0.92	4.18	4.73	4.26	4.52
Transport and communication	4.91	1.16	1.60	3.37	6.54	6.16	5.31	6.43
Finance, real estate and business services	3.26	3.31	2.00	1.92	4.41	6.32	6.28	5.44
General government services	3.61	3.07	3.01	1.09	0.03	1.56	3.57	1.39
ALL INDUSTRIES AT BASIC PRICES	3.13	1.36	1.40	0.79	2.93	3.92	4.46	3.62

Source: Adapted from Reserve Bank (2009)

2.6 Profitability of the Agricultural Sector

The financial and economic position of the agricultural sector is mainly determined by the changes in agricultural income and input expenditure of the sector. Some of the relevant indicators used to assess the financial and economic position of the agricultural sector include net farming income, cash flow of farmers, total asset and debt values of the sector, the net return on assets and own equity and the financial liquidity of agricultural producers.

2.6.1 Real Net Farm Income

Real net farm income is a solid indicator of agricultural producers' profitability. It is the amount of money that goes into the pockets of the producers after spending on all input expenditures including the depreciation value of assets. The trend of real net farm income showed a decline from the mid-1970s, owing to the deterioration of the terms of trade and it further dampened as a result of a notable reduction in real agricultural output prices and unfavourable weather patterns (see Figure 2.38).

Van Zyl *et al.,* (1993) showed that the two factors that most affect net farm income are changes in terms of trade and in productivity. Net farm income can grow, despite deterioration in terms of trade, only if producers acquire higher productivity growth that is able to compensate the fall in terms of trade. As shown in Table 2.10, the terms of trade deteriorated from the mid-1970s. Among the reasons for higher input costs includes the concentration of market powers in the farm input industries. Furthermore, higher inflation since 1974 made input prices rise faster than output prices, thus entailing a cost price squeeze in the agricultural sector (Van Zyl *et al.,* 1993). During times that this deterioration is compensated for by an increase in factor productivity, net farm income has shown a growth.

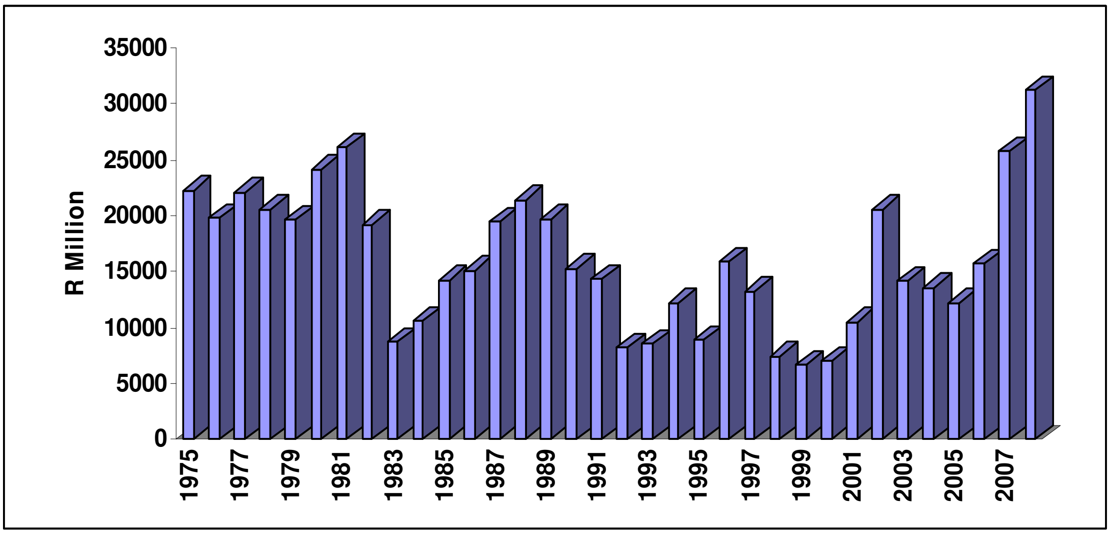


Figure 2.38: Net farm income: deflated by CPI (2000=100)
Source: Adapted from DAFF (2009)

The net farm income in general showed a fluctuating and declining trend until the early 2000s. A significant decline occurred in 1983 due to drought and it then increased until 1988, despite a fall in gross income. This was due to an increasingly declining rate of intermediate input expenditures and debt servicing charges. This is also noted by the increase in productivity by 4.6% annually from 1983 to 1991 (Van Zyl *et al.,* 1993). Real net farming income fell until 1993 and fluctuated until 2001. The sharp depreciation of the exchange rate in 2002 and the higher agricultural output prices registered since 2006, however, reversed the trend of net farm income steadily, and its value has doubled in just two years (2006-2008). The recent high growth in the net farming income is also due to the utilisation of inputs purchased before the spike of input cost in 2008.

Table 2.10: Average annual growth rate of terms of trade and net farm income

Period	Terms of trade	Net farming income
1975-1980	-2.46 %	-1.17 %
1980-1985	-2.47 %	-10.42 %
1985-1990	-3.01 %	2.33 %
1990-1995	1.50 %	-8.03 %
1995-2000	-3.26 %	-4.25 %
2000-2005	-2.08 %	5.45 %
2005-2008	1.98 %	23.65 %

Source: Own calculations

2.6.2 Cash Flow of Farmers

Cash flow of farmers indicates the difference between actual income and expenditure by the producer. Hence, it excludes own construction, change in livestock inventory and the depreciation component from net farming income. It is, in short, an indicator of cash availability for producers and measured as a percentage of gross income. As depicted in Figure 2.39, the percentage showed a fluctuating downward trend until 2005. Since then, the share of the cash flow has started recovering and it almost doubled in the past three years, reaching 40% of gross income in 2008.

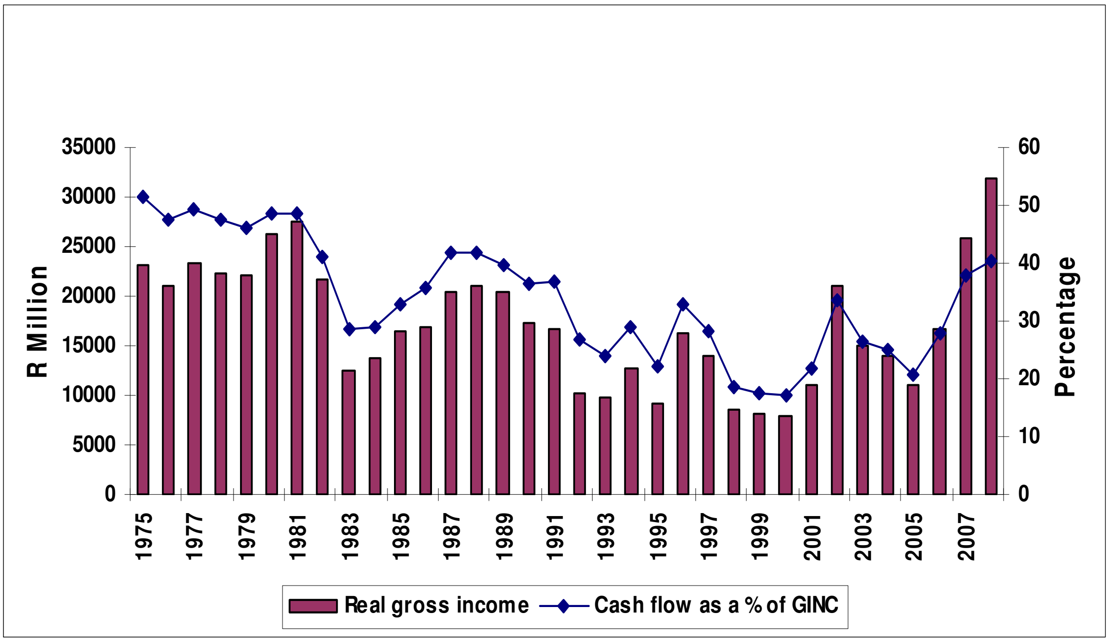


Figure 2.39: Cash flow of farmers as a percentage of gross income
Source: Adapted from DAFF (2009)

2.6.3 Asset Value of the Agricultural Sector

The real total asset value of the agricultural sector represents the asset value of land, fixed improvements, motor vehicles, tractors, machinery and livestock. In 2008, the value of land accounted for 40% of the total asset value of the agricultural sector. The asset value of the sector has since been declining, owing to the fall of the land value and a decline in capital formation in the sector since the mid-1980s (see Figure 2.40) . The real land value index fell by 40% between 1981 and 1990 as a response to the fall in the real subsidy index (Van Schalkwyk and Van Zyl, 1994).

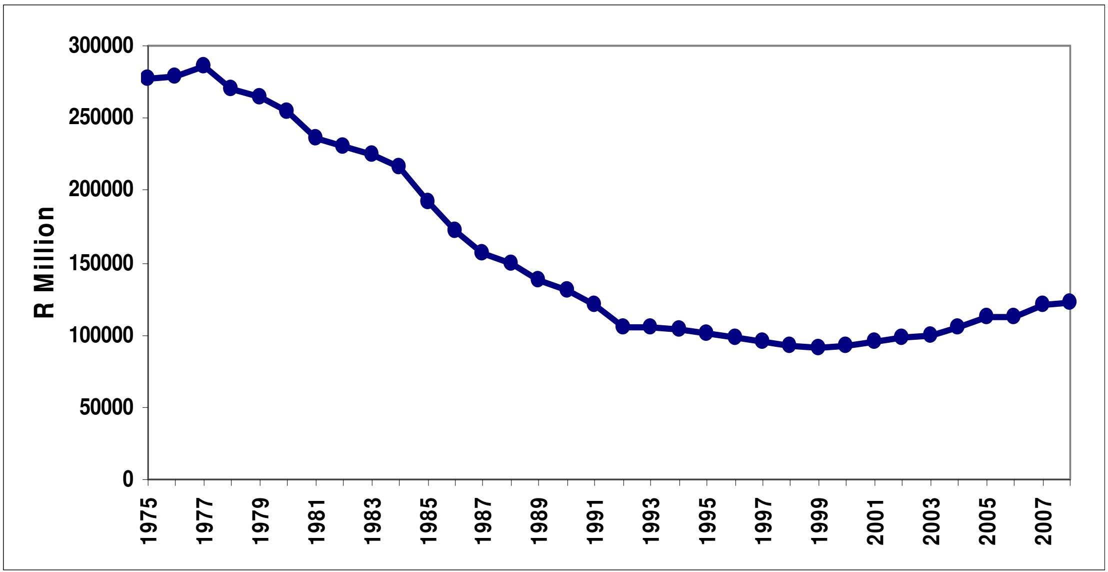


Figure 2.40: Total asset value of the agricultural sector: deflated by CPI 2000=100)
Source: Adapted from DAFF (2009)

Net return on assets of the agricultural sector reveals a positive trend, partly due to a fall in the asset value. Net return on assets in general indicates how efficient producers are in generating income by utilising their assets. Put differently, it shows how effective producers are in converting their total investment into income, and it is measured by dividing the net farming income by the total asset value of the sector. The value was marginal during the early 1980s, due to the fall of agricultural income and high asset value. In periods when drought and low agricultural prices prevailed, the return fell below 10%. The return, however, reached its peak in 2008 (21%) owing to an enormous rise in net farming income. When the net return is compared to the average cost of borrowed capital (opportunity cost), it is mostly below the opportunity cost. The picture only improved after 2002, when income increased due to the depreciation of the Rand, and after 2007, when record agricultural prices prevailed (see Figure 2.41).

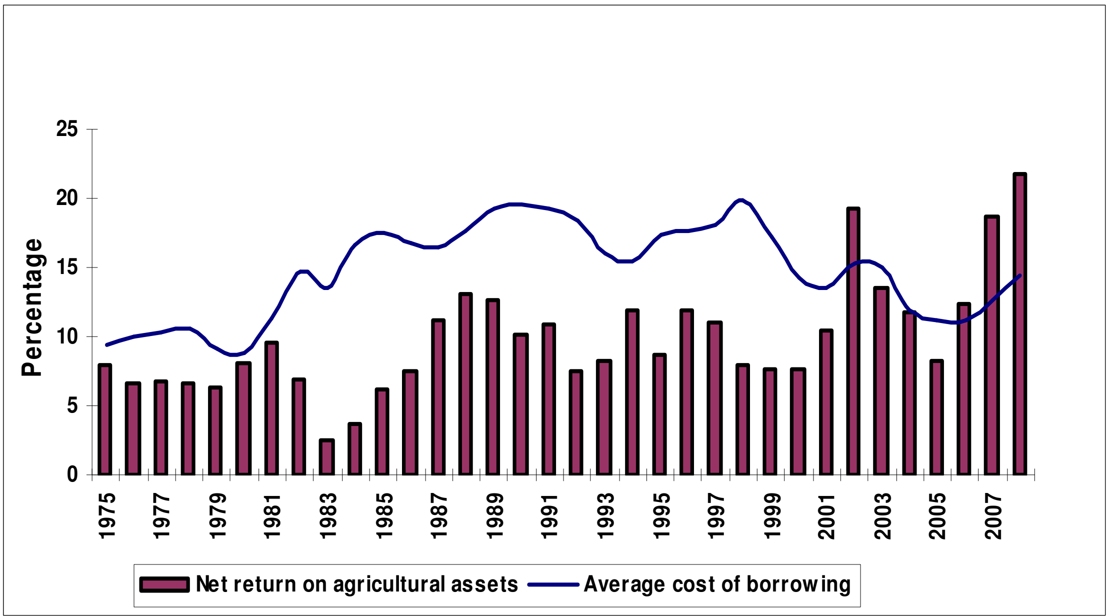


Figure 2.41: Net return on agricultural assets and average cost of borrowing
Source: Adapted from DAFF (2009) and Directorate: Agricultural Statistics (2009)

2.6.4 Agricultural Debt

Real total debt of the agricultural sector reached its peak level in the mid-1980s and declined thereafter (see Figure 2.42). The high debt is ascribed to drought, high rate of inflation and an increase in interest rates (Kirsten *et al.,* 1994). Furthermore, a decline in net farm income during the period built up the debt burden of the sector. After the mid-1980s, however, the fall in investment in the sector due to the rise in real interest rate (see Figure 2.27) contributed largely to the decline of the debt value.

The debt burden, which is measured as a percentage of the total debt to the total asset value, indicates the financial risk of the sector by showing how much of the sector's asset is financed by debt. A higher debt burden implies that the industry is in a risky position if creditors demand repayment and could be hit hard when the real interest rate rises. A value less than 0.5 (50%) indicates that the majority of the asset is contributed by equity (producer's own investment). As shown in Figure 2.42, the value remained above 25% from 1985 to 2000 and has remained at roughly 25% since then. The sector's inability to reduce the debt level below the twenties range displays the diminishing capacity of the sector to accumulate debt (De Klerk, 1993).

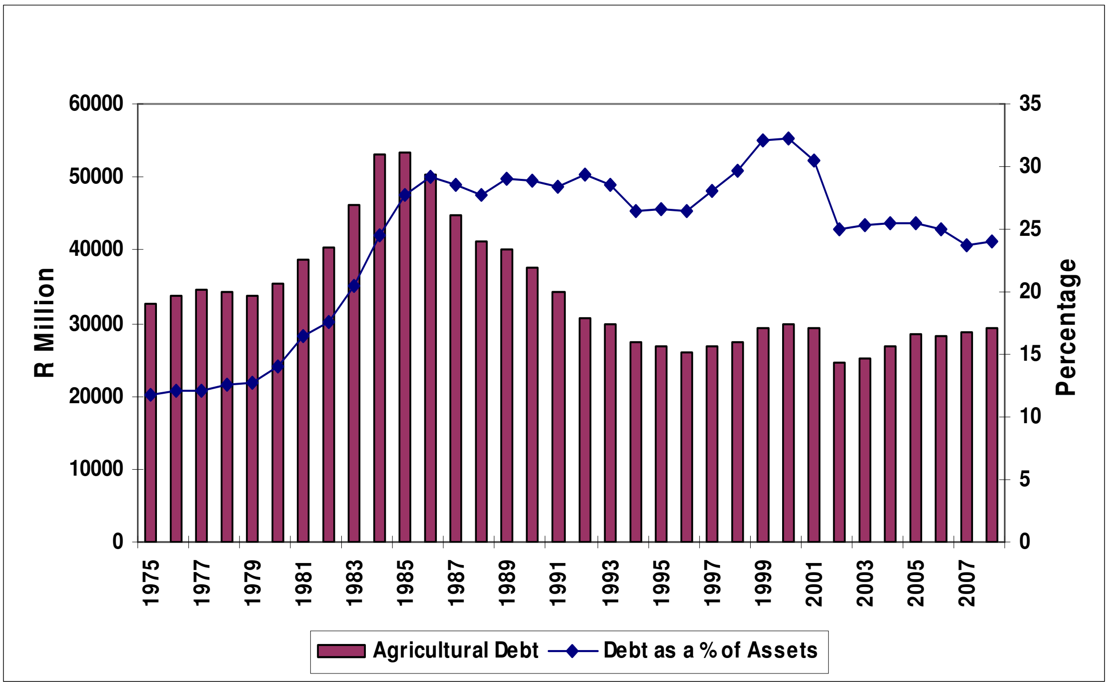


Figure 2.42: Total debt value of the agricultural sector: deflated by CPI 2000=100) and debt burden (debt as a percentage of total assets)

Source: Adapted from DAFF (2009)

2.6.5 Agricultural Own Equity

Net return on own equity is another measure that shows the return on the producers' net worth. Stated differently, the return shows how much profit is earned from the money invested by producers. It is computed by dividing the net farming income with own equity. The higher value showed that producers are able to generate more profit from their investment. Net return on equity has shown a positive trend since 2000, which is above 15%, except in 2005, and which reached its peak level of 28% in 2008. When the net return is compared to the average cost of borrowed capital (opportunity cost), it exceeded the cost only after 2000 and has shown a wide positive margin for the past three consecutive years.

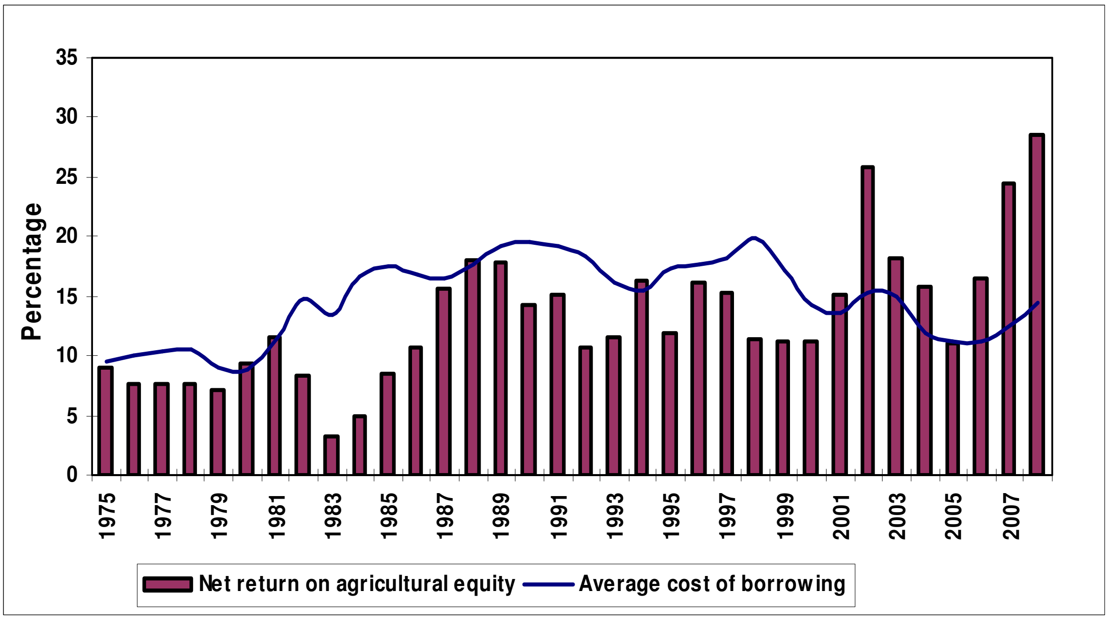


Figure 2.43: Net return on own equity of the agricultural sector and average cost of borrowing

Source: Adapted from DAFF (2009) and Directorate: Agricultural Statistics (2009)

The proportion of equity and debt used to finance the agricultural producers' assets is measured using the leverage ratio, which is computed by dividing the total debt level by net worth (own equity). In addition, it indicates producers' ability to meet the total liability using own capital. A ratio of 0.15, for example, indicates that for every rand contributed by own capital, 15 cents from outside capital is invested in the sector. Thus, a high leverage ratio indicates that producers are using more debt to finance their growth. Hence, it may result in a risky position and volatile earnings because of rising interest rates. As shown in Figure 2.44, the ratio was very low until the early 1980s, predominantly due to the low level of debt. It rose, however, when debt levels soared in the mid-1980s. Despite the falling trend of debt levels, the leverage ratio remained fairly constant until 1997, due to the parallel fall in the asset value of the agricultural sector. The rise in debt in the late 1990s pushed the leverage ratio up. However, since 2002, it has remained fairly constant, at around 0.34.

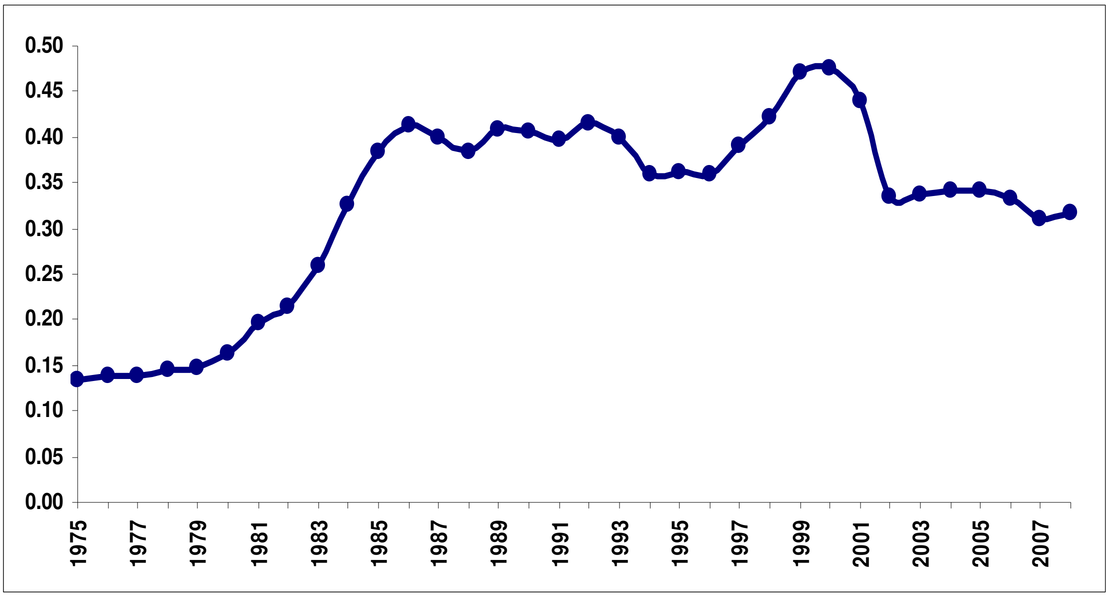


Figure 2.44: Leverage ratio of agricultural producers
Source: Adapted from DAFF (2009)

2.6.6 Main Economic and Financial Indicators

A summary of agricultural economic and financial indicators is presented in Table 2.11 in order to show the performance of the sector over the past decades. Several important conclusions can be drawn from the table. First, the financial position of farmers as shown by the debt-asset ratio (debt burden) has been relatively constant since 1986 and has improved a bit since 2001. Second, the net return on assets and own equity (total asset minus total debt) is increasing during the past decade due to the low capital output ratio of the sector. However, when compared to the cost of borrowing capital (average interest rate), the return on assets only excelled between 2006 and 2008, while the net return on equity has excelled since 2001. For a long period, however, both returns were below the opportunity cost. Hence, the sector has generally underperformed economically. Third, farmers' liquidity is measured by the ratio of net farming income to short term debt (debt to commercial banks and cooperatives) as a proxy and it shows the ability of producers to meet short-run debts. The rise in the ratio reveals that the sector is able to meet the repayment of the short-run debts at short notice. The trend of the ratio in general showed a severe decline from 1981 to 1985 and a recovery since 2001. The fall of the ratio is also related to the increase of short-term debts from commercial banks by producers, compared to long-term loans from the Land Bank and the agricultural sector, which have markedly declined due to the low profitability of the sector (World Bank, 1994).

Table 2.11: Agricultural financial and economic indicators

Period	NFI/Short term debt	Debt burden	Capital /output	Net return on assets	Net return on equity	Average interest rate
1975-1980	1.44	12.6	5.74	7.06	8.1	9.7
1981-1985	0.59	21.4	4.41	5.79	7.31	14.7
1986-1990	0.72	28.7	3.05	10.93	15.31	17.9
1991-1995	0.63	27.8	2.55	9.46	13.09	17.3
1996-2000	0.60	29.7	1.98	9.21	13.03	17.4
2001-2005	0.85	26.3	1.84	12.66	17.15	13.4
2006-2008	0.95	24.2	1.74	17.56	23.14	12.7

Source: Own calculation

2.7 Summary

An economic review of the South African agricultural sector over the past decades shows that its average annual growth rate has been marginal. Factors that have contributed to the dismal growth rate include a fall in agricultural prices and a rise in intermediate input expenditure. Thus, the sector's contribution to the total GDP has steadily fallen. Although this decline seems to reflect an advanced stage of development in the country, it is also largely the outcome of past misguided policies. Despite its declining contribution to the GDP, however, the sector plays an important role in maintaining food security and alleviating poverty.

The trend of intermediate input expenditure has been increasing since 1992 and its share of gross income has exceeded fifty percent since 1998. Thus, its rise coupled with fluctuating and a modest growth rate of gross income, has limited the growth of the gross value added and net farming income. Among intermediate input expenditure, feed accounts for the largest share, and the record fuel and fertiliser prices in 2008 triggered a steady rise in the share of both these input expenditures.

After a declining trend since the start of deregulations in the mid-1980s, agricultural investment has shown a positive trend since 1992. The financial and economic position of the sector also shows that the net return on assets was below the average cost of borrowing capital for a considerable part of the past decades. The net return on equity, however, has exceeded the cost of borrowing since 2001. Despite the modest trend of most performance indicators, the agricultural sector has performed well both financially and economically for the past three consecutive years due to the record increase for most agricultural prices.

This chapter in general shows that employing several indicators to evaluate the performance of the sector and assess the impact of economic policies gives more powerful insights than relying on a few indicators. Constructing most of these key indicators, however, requires an unravelling of the implication of policies on input expenditures, net farming income, total asset values and the debt of the agricultural sector, among others. Thus, a partial equilibrium model that encompasses all components of the agricultural sector is useful in investigating the implications of economic policies on a wide range of economic and financial indicators.

CHAPTER THREE

AGRICULTURAL INPUTS IN PARTIAL EQUILIBRIUM MODELS

3.1 Introduction

Due to their coverage of the whole economy, general equilibrium models take into account the factor flows across a sector. Partial economic models, however, capture the impact of variables beyond the specific sector, through exogenous variables. Thus, partial equilibrium models are often applied in cases where the sector is too small to have a significant influence on the other sectors of the economy or when an in-depth treatment is required to assess the effect of various policies on the sector.

This chapter sheds light on how inputs are treated in partial equilibrium models and how the current BFAP output model captures input costs and it is composed of the following sections. The next section reviews partial equilibrium models and this is followed by a discussion of net farming income models in section three. The basic economic theory of input demand is presented in section four. Various approaches to estimating input demand are discussed in section five. Section six explains how agricultural inputs are treated in partial equilibrium models, and section seven gives a review of literature on South African agricultural inputs. A summary of the chapter is given in section eight.

3.2 Partial Equilibrium Models

Partial equilibrium models are the most widely used models to assess the effect of various policy interventions on the agricultural sector. They are specifically justified in cases where the sector is relatively small in the economy, inputs are mainly specific to the sector and competition for factors with the other sectors is limited (Conforti, 2001). In these cases, therefore, the effect of the agricultural sector on the whole economy can be safely considered negligible. The effect of the economy on the agricultural sector, however, is captured using exogenous variables.

The fundamental assumption of equilibrium models (including general equilibrium) is that the balance between consumption and production in the economy is maintained by consumers and producers maximising utility and profit respectively (Garforth and Rehman, 2006). Thus, the key behavioural assumptions of economic agents in these models are utility and profit maximisation. However, since partial equilibrium models do not account for the full opportunity cost of resources in the whole economy and ignore the link between factor income and expenditure, their ability to model the impact of policies using a limited data set is their main strength, compared with general equilibrium models, which have an edge on the theoretical level (Conforti, 2001).

Though there are various classifications among partial equilibrium models, they are mainly categorised according the estimation method used to obtain the parameters that measure the relationship among explanatory and dependent variables and how the dynamics of the model are specified (Van Tongeren *et al.,* 2001). There are two approaches to estimating the parameters that measure the relationship between the explanatory and dependent variables. They are the econometric and calibration approaches. In the econometric approach, coefficients are estimated using various econometrics techniques (single equation, simultaneous equation, two stages least square, etc,), depending on the availability of data and the appropriate techniques for a given situation. In the calibration approach, which is also called the synthetic approach, parameters are obtained from the benchmark data and the model's theory (Van Tongeren *et al.,* 2001). In this approach, estimated elasticity from other sources is calibrated according to the functional form and initial equilibrium data set to obtain the coefficient. One of the limitations of this approach is that the parameters estimated cannot be statistically assessed (Conforti, 2001).

Global agricultural models that apply econometrics to estimate parameters include the FAO and FAPRI models. The calibration approach is used by AGLINK, SWOPSIM and ESIM models. These global models incorporate major producers and importer nations and the rest of the countries with minor influence on either the demand or supply of the given commodity are aggregated as a single country under 'the rest of the world'. Thus, they are able to project world commodity prices and other key variables, which are used as exogenous variables in partial equilibrium models dealing at a country level.

The other distinction among partial equilibrium models is the way dynamics are specified in the model. There are two kinds of specifications, namely dynamic and comparatively static specifications. With dynamic specifications, adjustment is included using lagged endogenous variables according to recursive criteria. Thus, an equilibrium solution is obtained for each exogenous variable, based on the endogenous values obtained in the previous period. Thus, agents' behaviour is optimal in each single period but not through time. In a comparatively static specification, the impact of different exogenous variables is compared in two solutions obtained in two different periods. The adjustment path of the endogenous variables is not indicated in this specification, but the change of the variables in the model indicates the period in which the adjustment of endogenous variables is supposed to have taken place (Conforti, 2001).

Garforth and Rehman (2007) provide a succinct summary of main EU partial equilibrium models with their characteristics and other key features, which is given in Table 3.1. The review of global partial equilibrium models that analyse the Common Agricultural Policy by Conforti (2001) is given in Table 3.2. Most global partial equilibrium models focus largely on assessing policy impacts on the output side of the sector, which includes output prices, area planted, total production and gross income. As Conforti (2001) noted, the demand for inputs such as fertiliser and machinery are included only in a few models. Even in these models, all intermediate input expenditures and other components necessary to comprehensively evaluate the effect on the agricultural sector are not included. Thus, the net impact of economic policies on the sector could not be totally uncovered if the simultaneous implication on all inputs and other aggregate variables is not encompassed.

Table 3.1: A brief summary of main EU models

Features	AGLINK	FAPRI-EU GOLD	CAPRI	CAPSIM
Sponsor/ Developer	OECD	Universities of Missour-Colombia, Iowa State in collaboration with Teagsac, Ireland	EU's FAIR programme EU's DG-RSRCH Led by University of Bonn in association with 6 other universities and research institutes	EUROSTAT Developed at the University of Bonn
Purpose /goal	Provides the basis for OECD's outlook work. Analysis of the impact of agricultural policies on principal agricultural commodities	Annual baseline projections off trade in major commodities, with emphasis on the US agricultural sector. Medium to long term forecasts; GOLD extension treats major EU countries individually. Quantitative evaluation of international agricultural policies. Uruguay round	Projection and simulation of agricultural policies and their regional impact in the EU. The original version was developed to assess the consequences of the Agenda 2000 reforms. Scope has now widened to include trade and environmental policies	To provide a policy simulation tool for EUROSTAT including an explicit treatment of the land market
Model characteristics	Partial equilibrium Static except for livestock, which is modelled as recursive 'dynamic' perfectly competitive markets with homogenous products	Partial Equilibrium. Recursively dynamic Econometric	The core is a programming model for each region to maximise aggregate income, using PMP and maximum entropy techniques. Implies regional behavioural variation. Thouhgt an iterative procedure markets are cleared to achieve the balance in markets partial equilibrium static.	Partial equilibrium; depends upon exogenous input of macro variables. Comparative static. Rigorous calibration. Deterministic. A net trade model and its structure is very complex
Policies represented	Direct price support Trade policies supply management tools-guaranteed price, output quotas Semi-direct payments	WTO negotiation and reform of the Common Agricultural Policy	Mid Term Review of the CAP ATO Doha round (2003)	Premiums/support and production quotas; intervention; set-aside; border measures and WTO restrictions.
Key applications	OECD's annual and medium term outlooks	Uruguay round and WTO negotiation and CAP Mid Term Review	Agenda 2000 ex antae assessment Dairy Reforms 2002 Environmental Impact of the CAP reform	Agenda 2000 reform proposals. Evaluation of the long term outlook for the EU agriculture
Number of regions (r)/sectors(s)/ countries (c)	11 (c) 2 (r)	24 (s)	250 (r) …EU27 + Norway (c)	2
Number of farm (f) or processed (P) products	6(f) 13(p)	24(f)	40(f+p)	30(f) 17(p). 5 non-marketable agricultural products
Global coverage	Yes	Yes	For trade yes	Yes

Source: Garforth and Rehman (2006)

Table 3.2: Summary of general characteristics of Partial equilibrium models used for CAP analysis

	ESIM	FAO/ WFM	FAPRI	MISS	SPEL/EU	SWOPSIM	WATSIM
Aim of analysis	Simulations (extension of CAP to the CEECs)	Forecast and simulations (1994 GATT agreement)	Forecasts and simulations (US agric, GATT and 1994 MacSharry reform, Agenda 2000)	Simulations (1994 GATT agreement, MacSharry reform)	Forecasts and simulations (Agenda 2000)	Simulations (1994 GATT agreement scenarios and agreement)	Forecasts and simulations (agricultural and trade policies)
Base year	1994-96	1993-95	From 1988 on	1986 and 1990	From 1986 on	1984 and 1986	1994
Time frame	Fifteen years	Ten years	Ten years (maximum)	Three-five years	Six years (maximum)	Medium-term	Medium-and long-term
Max.no.of products	27	13	24	10	114	22	29
Max.no.of countries or regions	9	146	29	4	2; 15 EU member states	36	15
Static/ dynamic	Static	Recursive dynamic	Recursive dynamic	Static	Recursive dynamic	Static	Static
Parameters	Calibration and estimate	Calibration	Estimate and calibration (little)	Calibration	Simulate and calibration	Calibration	Calibration
Theoretical restrictions	Homogeneity, symmetry and curvature	None	Homogeneity, symmetry and curvature (depending on the parts)	Homogeneity, symmetry and curvature in most recent versions	Homogeneity and symmetry	Homogeneity and symmetry only in some parts and applications	Homogeneity and symmetry
Data sources	EUROSTAT, OECD, CEEC	FAOSTAT, OECD	USDA	EUROSTAT	EUROSTAT	USDA	FAOSTAT, PS&D View, OECD

Source: Conforti (2001)

A simple representation of a partial equilibrium model is given in Box 3.1, below. The structure of the model basically contains the supply, demand, price transmission, trade and model closure component. The equations for estimating the supply of crops and livestock products are given in equations 1 to 3 and equations 8 to11. Area allocation and yield for each commodity are modelled using their determinants and policy variables in equations 1 and 2. Thus, their product renders total supply of crops. Similarly, the products of the heads number modelled in equation 8 and the yield per head in equation 10, which is largely influenced by feed cost (equation 9), will give the total supply of animal products.

Box 3.1: Simplified version of the standard structure of partial equilibrium models

Crop products | ***livestock product***

supply

Crop products:

(1) $s_{i,n} = s(p_{v,i,n,} p_{v,j,n}, Pols)$
(2) $r_{v,i,n} = r(P_{v,i,n,} PR)$
(3) $Qo_{v,i,n} = s_{i,n}\, r_{v,i,n}$

Livestock product:

(8) $c_{i,n} = c(p_{z,i,n,} P_{z,j,n,} Polc)$
(9) $AL = al(p_{v,i,n,} p_{v,j,n})$
(10) $r_{z,i,n} = r(p_{z,i,n,} AL, PR)$
(11) $Qo_{z,i,n} = c_{i,n}\, r_{z,i,n}$

demand

Crop products:

(4) $Cu_{v,i,n} = cu(p_{v,i,n,} Y_{n,} POP_n)$
(5) $AA_{v,i,n} = aa(Qo_{z,i,n})$
(6) $SE_{v,i,n} = se(s_{v,i,n})$
(7) $Qd_{v,i,n} = Cu_{v,i,n} + AA_{v,i,n} + SE_{v,i,n}$

Livestock product:

(12) $Qd_{z,i,n} = qd(p_{z,i,n,} Y_n, POP_n)$

price transmission

(13) $p_{i,n} = p(p_{i,w,} tc, Polp)$

trade

(14) $(E_{i,n} - I_{i,n}) = Qo_{i,n} - Qd_{\,i,n}$

closure

(15) $\Sigma(E_{i,n} - I_{i,n}) = 0$

Where:
i,j = products;
v = crops;
z = livestock;
n = country;
And
s = land (hectares);
c = heads (number);
AL = index of feed cost;
r = yield (per hectare or per head);
Polp = policies directly affecting prices;
Pols = policies based on land;
Polc = policies based on livestock heads;
Qo = supply;
P_n = price in country n;
P_w = world price;
Cu = demand for human consumption;
AA= demand for feed;
SE = demand for seeds;
Qd = total demand

E = exports
I = imports;
tc = exchange rate
PR = yield trend;
Y = GDP;
POP = population;

Source: Conforti (2001)

The demand component for crops is an identity composed of three aggregate demands, which are the demand for feed, seed and human consumption. Each demand is modelled in equations 4 to 6, using their determinants. For human consumption, for example, income, population and the price of the product are specified to determine the demand. The specification of livestock product demand is also similar to crop products demand for human consumption, which is given in equation 12.

The price transmission that links world and domestic prices is given in equation 13. Exchange rate, various policies affecting domestic price such as tariffs are specified in the model as main determinants. The trade component in this partial equilibrium model is based on excess supply. Any unsaturated demand or excess supply is met by trade. The closure rule in this model is specified, as all the excess supply in all markets remains nil.

Although this simple presentation of the partial equilibrium model serves well to show the key components of such models, it has many simplifications such as the absence of stochastic components for yield and non-agricultural inputs. Furthermore, stocks are not modelled; hence, the presentation is a comparatively static model. The trade model also assumes perfectly homogenous goods.

3.3 Net Farming Income Models

To assess and predict the net farming income for Kansas State, a single equation method is used by Nivens *et al.,* (2000). Their model explains net farming income using variables of income from livestock, income from crops, input expenditures and the satellite imaginary crop condition variable. The latter variable was collected using remote sensing that measures the vegetation health and vigour. The result of the model indicates that the inclusion of the satellite imaginary crop condition variables has considerably improved the prediction ability of the net farming income model.

A single-equation methodology to estimate and forecast the net farming income may indicate the direction of the trend. However, the dynamics among agricultural commodities, livestock products and inputs expenditure are difficult to discern using a single equation. In addition, the single-equation is inappropriate to investigate the effect of various policies on the net farming income due to its inability to track the direction of the effect in a theoretically consistent way. Thus, a partial equilibrium framework that encompasses the dynamics among agricultural outputs and input expenditure is relevant to undertake such economic policy analysis.

Devadoss *et al.,* (1993) noted that net farming income model is one of the components of the whole FAPRI system of models. The FAPRI model, however, does not recursively link the agricultural input and output sides because the model treats the variable input costs that affect production decisions as being exogenous (Westhoff *et al.,* 1990 and Westhoff, 2008). Thus, assessing the net effect of exogenous factors, macro economic variables and the dynamics within the agricultural sector that affect both agricultural inputs and outputs in these models is not possible.

Nivens *et al.,* (2000) mentioned that the only viable model that is used to estimate the net farming income at national and regional level in USA is the model developed and maintained by USDA. Currently, the USDA model is the well-documented net farming income model (McGath *et al.,* (2009). The model generates the forecast of farm income indicators beyond the latest estimates for one or two calendar years. The three major income indicators forecasted by the USDA net farm income model are net value added, net farm income and net cash income. As McGath *et al.,* (2009) indicates most of the input expenditure models and other components are estimated by adjusting the previous year's value using the index derived from the output model and input price index forecasts. Hence, input and output models are not recursively linked to enable the net farming income model in generating long run outlook for net farm income and evaluate the recursive effect of input prices on the commodity production. For most of the input expenses, a forecast is generated by moving the previous year's estimate by the change in the input price index and quantity output index. Input price indexes are also forecasted using separate econometric models (Jinkins *et al.*, 1997).

This study, therefore, integrates input expenditure into the multi-market output model and endogenises input costs by creating a system of equations that will link them with output market, macro variables and exogenous variables. Thus, the model is able to analyse the dynamic and recursive effect of the change in input side on the outputs and vice versa. By integrating inputs and other aggregate variables of the sector into the existing South African multi-market commodity (BFAP) model, the integrated model would also be able to perform a comprehensive assessment of policy impacts, including the effect of various sectoral growth strategies and domestic economic policies on the agricultural sector's growth.

The impact of factors that simultaneously affect both inputs and outputs side of the agricultural sector could also be evaluated using the integrated model. Exchange rate depreciation, for example, increases the domestic price of the commodity; hence, it stimulates domestic exports. Conversely, the appreciation of the currency has a depressing effect on exports as it increases the domestic price of the commodity. For imports, however, it lowers the domestic price and hence increases the volume of imports. Hence, exporters (or importers) often benefit from the depreciation (or appreciation) of the exchange rate. Numerous studies have analysed the implication of exchange rate movements on the output side, which comprises price, trade, production and gross income. The availability of largely imported inputs and mostly exported outputs of the agricultural sector in South Africa, however, necessitates the investigation of the net impact of exchange rate movements on the sector by assessing the effect on both sides of the sector.

3.3.1 USDA's Net Farm Income Model

As McGath *et al.,* (2009) stated in the documentation of the USDA's short-term net farm income model, the model generates the forecast of farm income indicators beyond the latest estimates for one or two calendar years. The three major income indicators forecasted by the model are net value added, net farm income and net cash income. Net value added is the income earned by the factors of production utilised in the farm operation, regardless of form and ownership, after allowance has made to the capital consumption in the process. Hence, it represents the contribution of the sector to the economy. Net farming income, on the other hand, is the residual income accrues to farmers who have provided factors of production to agricultural production with out any previous determined compensation but accept the quantity and price risk related with the production. The net cash income is similar to the cash flow for farmers mentioned in the previous chapter. It represents the income left after the actual cash expense is deducted from the cash income. Hence, net cash income excludes depreciation and inventory adjustment.

The conceptual framework used by USDA for compiling the gross income is similar to the one used by DAFF, which is presented in chapter one. The exception is that revenues from services and forestry are included to the income derived from crops and livestock's in computing the gross income of the sector. The services and forestry includes machine hire and custom work performed by farmers using the materials owned by the farm. This value is forecasted by adjusting the previous year's value using the combination of crop output and the NASS Index of Prices Paid for Commodities and Services, Interests, Taxes, and Farm Wage Rates (PPITW).

The other component under the services and forestry category is sales of forest products. Though statistical agencies classify forest products such as timber, pulpwood and firewood are treated as forestry product, the revenue from these products sold from the establishments that are classified as farms are treated as non-commodity income of the farm. The forecast of the income from forest product is obtained by updating the previous year's estimation by the expected change in greenhouse and nursery cash receipts.

Other farm income embraced under services and forestry includes income such as the payment received for use of the farm land and bodies of water for recreational purpose, income earned from leasing grazing right, dividend received from farm cooperatives and contract production fees received for producing agricultural commodities owned by others. These components of *other farm income* are forecasted by multiplying the previous year's estimated value by the change in the forecast of broiler production, cattle on feed and GDP deflator.

Gross imputed rental value of farm dwellings is the last component of the services and forestry. It is similar to the own construction variable used in DAFF statistics and it largely consists of the land owned by farm dwellings. Since they are part of the real estate of the farm, the imputed rental value represents the return on the dwelling portion of the total asset. To estimate the value, dwellings are separated according to various classes and then each class is multiplied using the average rent for dwelling obtained from other sources. It is forecasted by multiplying the previous year's estimate with the ratio of the forecasted total value of farm real estate assets to the current year's value of real estate assets. The future farm real estate asset values are obtained from ERS forecast of asset values for the balance sheet of agriculture.

Similar to the intermediate input expenditure applied in DAFF, cash expense of inputs deal with only a purchased inputs used within the production season. Hence, it excludes capital expenditures and hired labour; however, expense on contract labour is treated as cash expense since it is used only for a production season. Purchased inputs are classified under farm origin expenses, manufactured inputs and other intermediate expenses. Farm origin expenses include purchases on feed, seed, livestock and poultry. Manufactured inputs include expense on fertiliser, fuel, electricity and pesticides. Other intermediate input expenses included all expenses on repairs and maintenance, machinery hire, custom work, marketing, storage, transportation, contract labour and miscellaneous inputs.

For most of the input expenses, a forecast is generated by moving the previous year's estimate by the change in the input price index and quantity output index. Input price indexes are forecasted using separate econometric models (Jinkins *et al.,* 1997). Both farm and non-farm economy influence and determine the input prices paid by the farmer. Input indexes such as feed and seed price are determined largely within the farm economy. Fuel price, on the other hand, is determined outside of the farm economy and both wage rates and fertiliser price are determined by both farm and general economy.

The estimation for the electricity expenditure is obtained from other sources such as the Department of Energy. The forecasted value of quantity output index is obtained from the commodity model. The index is computed for the all agricultural commodities included in the model. The forecasted output index, together with the input price index, is used for forecasting the input expenses. Feed expense, for example, is calculated by multiplying the previous value by the year-to-year change in feed price paid index and the output index of total livestock. Similar procedure is used for all input expenditures.

Net government transaction is the difference between the direct government payment and expense to the government. Direct government includes all funds directly granted by the federal government to the farmers in the form of farm support who produce program commodities, engage in resource conservation and receive compensation for natural disasters. Direct government support programs that include countercyclical payments, direct payments, loan deficiency payments, marketing loan gains and net value of commodity certificates are forecasted using equations. Other direct government support programmes such as Tobacco Transition Payment Program, Milk Income Loss Payments, Conservation Program Payments, Ad Hoc and Emergency Programs and Miscellaneous Program Payment are forecasted by adjusting the previous level by various indicators and expected changes in the budgeted funding level. The expense to the government is composed of property taxes and motor vehicle registration and license fee. The main property tax of the farm sector is the real estate taxes. The forecast value for the expense is derived by multiplying the change in the NASS taxes price paid index between the forecast year and the base year.

Gross value added is obtained by deducting all cash expenses from the gross income of the farmers and adding net government transaction to the difference. Once capital consumption is accounted from the gross value added, a net value added is obtained. The capital consumption is similar to the depreciation variable used by DAFF. Once, the total stock of capital asset for each category is estimated, capital consumption is estimated by multiplying a percentage derived from the average service of life. The forecast of capital consumption is based on the change in the price paid index for the value of each asset.

Capital expenditure is estimated using regression analysis. Major variables that determine capital expenditures include farm numbers, acres planted, cash receipts and the prime rate. For building expenditure variables such as acreage planted, cash receipt and debt values are used.

Payments to the stakeholders refer to a payment given to the non-operators who supplied labour land and capital to agricultural production. Since these contributors' did not bear the output and price risks, they receive a predetermined amount. The payments to stakeholders include payment to hired labour, interest payment for capital inputs and net rent to non-operators, which is the difference between the gross rent and government payment value to non-operator landowners and expenses such as real estate taxes. After these payments are undertaken, the residual represents the net farm income that goes to the farm operations and contractors. Contractors are companies that pay farm operation to produce a commodity under production contract.

The general review of USDA's net farming income model indicates that most of the input expenditure models and other components are estimated by adjusting the previous year's value using the index derived from the output model and input price index forecasts. Hence, they are not recursive and dynamic within the system of models in the equations to enable the model to generate a long run outlook of the net farm income and capture the recursive effect of input prices to the commodity production.

3.4 Basic Theory of Input Demand

Demand for factor inputs is called a derived demand since it exists because of the presence of a demand for the final output. If the final output has less demand, the respective demand for factor of production (labour, capital and land) required to produce the output will also be limited. Thus, when a government intends to increase employment of factors of production especially labour during recession, one of the policies employed to recover the economy is massive increment in aggregate spending to stimulate the final demand for outputs.

The demand for factors of production, however, is not only determined by the final demand but also by their own prices. By affecting the relative prices of the input, economic policies could determine the factors of production to be largely employed in the economy. If a policy provides cheap credit by subsidising interest rate or depresses capital price by overvaluing exchange rate, it often encourages the use of capital intensive and labour saving technologies in the country. Conversely, policies that augment capital prices promote capital saving technologies.

The magnitude of the change in inputs due to the change in own price is measured using price elasticity of input demand. The size of the elasticity is determined by many factors (Nicholson, 1998). Firstly, it is affected by the relative significance of the input on the total cost. The larger the share of the input cost, the more price elastic will be the input demand. This is because the increase in the demand as the result of a fall in the price contributes to greatly reduce the total cost. Secondly, the price elasticity of the final output demand determines the price elasticity of the input. If the final output demand is price elastic, the input demand will also be elastic. This is because the slight increase in the output price in response to the increase in the cost will drop the demand for the final output sharply. Thus, it necessitates a significant drop for the input demand. Thirdly and most importantly, how easily the factor is substituted with other inputs determines the magnitude of the elasticity. The more easily the input can be substituted by the other inputs, the higher will be the price elasticity of the input demand.

The flexibility of how one can easily substitute inputs is measured using elasticity of factor substitution. There are various ways of estimating the factor substitution, depending on the assumption about the variability of output, other inputs' prices and quantity. The basic definition of elasticity of substitution is given by Hicks (1932). He defined it as the change in the input ratio due to the change in relative prices of inputs and it is calculated using the following equation:

$$\sigma_{ij} = [(d \ln X_j / X_i)] / [(d \ln (P_i / P_j)]$$
$$= (d \ln X_j - d \ln X_i) / (d \ln P_i / d \ln P_j) \qquad (3.1)$$

Allen (1938) developed his own elasticity measurement based on the Hicks definition. Allen elasticity of substitution (AES) is computed using the following formula:

$$\sigma_{ij}^{A} = S_j E_{ij} \qquad (3.2)$$

Where S_j is the share of total cost attributed to input j, $E_{ij} = (d \ln X_i) / (d \ln P_j)$ evaluated at constant output. Morishima elasticity is basically the difference between the own and cross price elasticity holding output constant. It can be expressed using AES as follows:

$$\sigma_{ij}^{M} = S_j (\sigma_{ij}^{A} - \sigma_{ij}^{A})$$
$$= E_{ij} - E_{jj} \qquad (3.3)$$

The Shadow elasticity of substitution (SES) allows the variability of other inputs. Thus, it measures the long run elasticity of substitution. It is expressed using AES as follows:

$$\sigma_{ij}^{S} = [(S_i S_j)/(S_i + S_j)] [2\sigma_{ij}^{A} - \sigma_{ii}^{A} - \sigma_{jj}^{A}] \qquad (3.4)$$

In general, the time of adjustment plays a crucial role in determining the elasticity of substitution. The longer the time, the more easily factors would be substitutable for each other; hence, the higher the elasticity of substitution. In the short run, however, it is difficult to substitute factors due to the change in the prices because of technological constraints.

In a perfectly competitive market, the price of the inputs is determined by the interplay of supply and demand. Thus, input suppliers and users are price takers. In a market structure where the input provider controls all the input supply, however, the supplier exerts market power to set input prices above the competitive market by controlling the quantity supplied. In the oligopoly market structure, few firms control the supply of a particular input. Hence, they can set the prices higher than the perfect competitive market by creating collusion in limiting the amount of inputs supplied in the market. Imperfect market structures in input industries put additional costs on producers and create a dead weight loss to the society (McCorriston and Sheldon, 1992).

3.5 Estimating Input Demand Models

There are two main approaches for estimating an input demand model. The first approach is called a primal, where the input demand is derived from the profit maximisation equation and in the second approach, which is called duality, input demand is derived directly from the cost functions. Dynamics (adjustment to equilibrium) could also either be assumed to be instant, in which case it will be a static model, or incorporated using various methods in a dynamic input demand modelling.

3.5.1 Primal Approach

A primal approach drives the input demand from the maximisation of the profit function or minimisation of cost function given a technology constraint.

Mathematically, it can be represented as follows:

$$\max_{X,Y} \pi = \sum_{i=1}^{n} p_i y_i - \sum_{j=1}^{m} w_j x_j \qquad \textit{Subject to } F(Y, X) = 0 \qquad (3.5)$$

Where Y is vector output, X is vector inputs, F(Y,X) is known as transformation function (production function), which fulfils all the regularity conditions, and all inputs are considered variable, implying long run.

Properties of F(Y, X):

1. Monotonicity: if $x' \geq x$, *then* $f(x') \geq f(x)$
2. Quasi-concavity: $V(y) = \{x: f(x) \geq y\}$ *is a convex set*
   Concavity: $f(\theta x^0 + (1-\theta)x^*) \geq \theta f(x^0) + (1-\theta) f(x^*) \; for \; 0 \leq \theta \leq 1$
3. Weak essentiality: f(0n) = 0, where 0n is the null vector;
   Strict essentiality: $f(x_1 \ldots x_{i+1}, \ldots x_n) = 0$ *for all* x_i
4. $V(y)$ is closed and nonempty for all $y > 0$

5. f(x) is finite, non-negative, real valued, and single valued for all non-negative and finite x ;
6. *f(x)* is everywhere continuous and twice-continuously differentiable.

Applying a Lagrange approach to maximise the profit level of equation 3.5 would give the following two equations:

$$P_i + \lambda \frac{\partial F}{\partial y_i} = 0, \qquad i = 1,\ldots n \tag{3.6}$$

$$-w_j + \lambda \frac{\partial F}{\partial x_i} = 0, \qquad j = 1,\ldots n \tag{3.7}$$

$$F(Y, X) = 0$$

Applying simultaneous equations to solve the above equations, the following expression is obtained, which indicates that the marginal product of inputs should be equal to the input and output price ratio.

$$-\frac{\partial F / \partial x_j}{\partial F / \partial y_i} = \frac{\partial y_i}{\partial x_j} = \frac{w_j}{p_i} \qquad (i = 1, \ldots n; \quad j = 1, \ldots m) \tag{3.8}$$

Rearranging the terms, we can obtain the input and output equations as in the following expression.

$$Y_t^* = y_t^* (P, W) \qquad i=1,\ldots n \tag{3.9}$$

$$x_t^* = x_t^* (P, W) \qquad j=1,\ldots n \tag{3.10}$$

Putting back the equations into the profit function we will find the following expression.

$$\pi^* = \pi^*(P,W) = \sum p_i y_i^*(P,W) - \sum_{j=1}^{m} w_j x_j^*(P,W) \tag{3.11}$$

The equation represents the solution to the profit maximising firm given the technological constraints. It can also be referred as indirect profit function. Thus, it is possible to obtain factor demand by maximising profit functions (minimising cost function) given the constraint of production function. This approach, however, becomes complicated to derive input functions especially when the functional form of the production function is complex.

3.5.2 Duality Approach

The duality approach derives the input demand function from a given cost function of the firm. Basically, this approach stipulates that all the information needed to retrieve the production function is contained in the cost function and vice versa (Van Zyl, 1986). The cost function must, however, fulfil some regularity conditions.

Properties of the cost function:

1. Nondecreasing in w. If $w' \geq w$, then c (w', y) $\geq$ c (w, y).
2. Homogeneous of degree 1 in w. $c(tw, y) = tc(w, y)$ *for* $t > 0$.
3. Concave in w. $c(tw + (1-t)w', y) \geq tc(w, y) + (1-t)\,c(w', y)$ *for* $0 \leq t \leq 1$.
4. Continuous in w. $c(w,y)$ is continuous as a function of w, for $w > 0$.

From a cost function that fulfils all the regularity conditions, input demand could be found by applying Shephard's lemma.

Shephard's lemma:

Let $x_i(w,y)$ be the firm's conditional factor demand for input i. Then if the cost function is differentiable at (w,y), and $w_i > 0$ for i=1,…,n then

$$x_i(w,y) = \frac{\partial c(w, y)}{\partial w_i} \qquad i = 1, \ldots, n. \qquad (3.12)$$

Thus, by applying this theorem, factor demand functions could be easily derived from the cost function equation. As argued by Morana, (2007), the theoretical advances in duality theories and the modelling of dynamics are the two innovative concepts introduced in factor demand modelling since the seminal work of Cobb and Douglas (1945). In duality theory, various flexible functional forms have been introduced like transcendental (Halter, Carter and Hocking (1957) and translog functions (Christensen, Jorgenson and Lau, 1971) that relaxed the prior assumption of constant and unitary elasticity of substitution between inputs. Similarly, various approaches have been developed to model dynamics in input demand modelling.

3.5.3 Adjustment in Input Demand Modelling

The static input demand model assumes that all inputs will adjust instantaneously to their long-run equilibrium values. Hence, time dynamics is not incorporated into the equation. The duality approach discussed above represents a static factor demand modelling. Dynamic models, however, assume that the process of adjustment to long-run equilibrium can only be gradual. These models apply two methods to incorporate the dynamics. The first method models it empirically (on an ad hoc basis) (*first and second generation models*) and the second method explicitly includes the dynamics in the theoretical framework of the model (*third generation model*) (Morana, (2007).

The first generation model is based on the Koyck partial adjustment mechanism applied to a single equation, as shown in equation 3.13. Hence, these models do not allow interaction with the other factors demand.

$$X_t - x_{t-1} = M\,(x_t^{*} - x_{t-1}) \qquad (3.13)$$

The second generation of models introduced by Nadiri and Rosen (1969), on the other hand, explicitly model multiple equations using a partial adjustment model and recognise the interrelatedness of factor demands. They model how disequilibria in one factor market affect the other input markets, as given in equation 3.14.

$$X_{i,t} = \sum_{\substack{i=1 \\ j\neq i}}^{n} m_{ij} (x^{*}_{j,t} - x_{j,t-1}) + (1-m_{ii})x_{i,t-1} + m_{ii}x^{*}_{i,t} \qquad (3.14)$$

Recently, the development in time series econometrics, namely, general-to-specific methodology, cointegration theory and error correction models (ECM) has expanded the application of the dynamic factor demand models. The general-to-specific modelling utilises economic theory to encompass the long-run determinant variables and the short-term dynamics are determined by the data. Some of the issues that have to be considered for selecting the appropriate models include consistency with the theory, and white noise residuals. One of the strengths of this methodology is that it encompasses many rival models and evaluates each of them to choose a model that is capable of explaining the data. The other econometrics development that strengthens the second generation is the application of cointegration theory and error correction models. In this approach, long-run relationships of the variables are estimated and short-run deviation is specified using the error correction model to assesses how fast the deviation returns back to its long-run equilibrium.

The third generation models developed by Berndt *et al.,* (1977) introduced adjustment costs for quasi-fixed inputs. The standard third generation dynamic factor demand model of the firm is assumed to minimise the present value of a stream of future costs at time *t*. Unlike the first two generations, the third generation introduces dynamics theoretically within the model.

3.5.4 Modelling Technique Used in the Study

Empirically duality method have an advantage over primal in two respects (Ben Jemma, 2004). First, it is easily obtained from profit functions by differentiating the profit or cost function with respect to output and input prices respectively. Moreover, prices are used as exogenous variables than quantities, which are more realistic. Hence, it reduced multicollinearity and simultaneity problems. Besides, regular properties can be tested and modelling multi-product technologies is more flexible. Moreover, it does not impose a priori constraints on the pattern of factors substitution.

In deriving aggregate input demands, however, the duality approach assumes that sectoral-level aggregate variable profit functions maintain all regularity conditions of profit-maximization as expected at micro-level. However, according to Burell (1989), many of the restrictions implied by the duality theory are rarely found to hold globally and *en blocks* in empirical models of agricultural production. Taylor (1984) also argued that the approach can not be applied to derive input demand when expected profit functions depend on price expectation that is dependent on the previous prices and when risk-averse producers maximize expected utility (Pope, 1980).

The other method used to estimate the input demand function is a single-equation approach. The method explained the input demand using prices and other shift variables. Basically, these specifications are loosely based on the theory of production and the model is largely evaluated by the coefficient signs and goodness of fit. This approach, however, could conclude the evidence of the validity of the relationship based on the spurious correlation between the dependent and independent variables (Burrell, 1989).

McQuinn (2000) noted that the specification of economic models for policy purpose brings its own modelling restrictions. Among these includes the need for incorporating as many policy levers in the model estimation and the importance of having the forecasted value of any exogenous variables incorporated in the model for the purpose of projections. In addition, the availability of data plays a critical role in the choice of the modelling approach. Thus, McQuinn (2000) argues that single-equation approach is preferred over the duality-based approach to perform policy analysis for three reasons. Firstly, the need to incorporate policy variables in the equation, secondly, the theoretical reservations of duality approach and thirdly, data restrictions of detailed input components precludes applying the duality method. Furthermore, the importance of having projected values of exogenous variables to perform policy analysis necessitates a single-equation approach.

The approach is estimated based on general-to-specific methodology pioneered by Hendry (1995). It starts with a general model (autoregressive distributed lag, (ADL)), which contains a series of simpler models nested within it as special cases (Roche, 2001). Thus, by applying a variety of restrictions on the model one can be able to test different hypotheses. In general this method avoids the criticism of data mining and prior beliefs that the traditional approach of specific-to-general methodology has (Roche, 2001). Moreover, it encompasses a dynamic factor modelling mentioned in previous sections.

3.6 Treatment of Inputs in Partial Equilibrium Models

In general, producers take various considerations into account when making production decisions. These include expected prices of the output and competing output, costs of inputs for the output and competing output, government policies and weather variables. Accordingly, producers choose the output and its proportion to be produced reacting to these determinant variables. Since production level is affected by factors outside the control of producers, however, area planted is often used in policy analysis to gauge the response of crop farmers. The number of trees, on the other hand, is used for perennial fruits in the horticultural sub-sector and the number of livestock (volume of animal production) is used to measure the response of producers in the animal products sub-sector.

Expected prices in the area response equation are modelled using various model specifications. These include simple average of the lagged price by giving equal weights or by assigning different weights to the past values of the lagged price. Other model specifications include the average of past prices using geometrical and polynomial distributed lags and rational expectation models. When the expected price often deviates considerably from the actual one, the risk associated with this variation plays a role in determining the farmer’s supply response. In these instances, the risk component, often measured as weighted total price variability (Chembezi, 1991) could be incorporated in the equation to evaluate its impact on producer’s supply response.

The general model specification of the main determinants for area planted for a given crop is presented as follows (Ferris, 1998).

$$AREA = f(OP, OPc, OY, OYc, SP, SPc, FP, FPc, FUP, FUPc, CP, CPc, GVP, OTHERS) \quad (3.15)$$

Where, *AREA* = Area planted

OP = own price of the product,

OPc = price of competing product,

OY = yield per hectare of the product,

OYc = yield per hectare of the competing product,

SP = Seed price of own product,

SPc = Seed price of competing product,

FP = Fertiliser price of the product,

FPc = Fertiliser price of competing product,

FUP = Fuel price of the product,

FUPc = Fuel price of the product of competing product,

CP = Chemical/pesticide price of the product,

CPc = Chemical/pesticide price of the competing product,

GVP = Government policies,

OTHERS = technology

Separating the impact of individual variables on the supply response of the above equation becomes statistically unfeasible due to the multicollinearity and low degrees of freedom, which preclude the validity of most statistical inferences. Thus, in most partial equilibrium models, gross margins and ratios are often used to address these problems (Ferris, 1998).

Real expected gross margin for the product per hectare (REGMP) is computed as follows:

$$REGMP = [OP*OY - (aFUP + bFP + cSP + dCP)]/CPI \quad (3.16)$$

Where *a, b, c* and *d* are amounts of respective inputs applied per hectare of the product. Similarly, the gross margin per hectare for the competing products is computed as follows:

$$REGMPc = [OPc*OYc - (eFUPc + fFPc + gSPc + hCPc)]/CPI \quad (3.17)$$

Where *e, f, g* and *h* are amounts of respective inputs applied for the competing product. Hence, using the gross margin concept, the model specification in equation 3.15 could be condensed into the following model.

$$AREA = f\,(REGMP, REGMPc, GOV, OTHERS) \quad (3.18)$$

The merits of introducing the gross margin in the above equation include incorporating *a priori* information and reducing multicollinearity. Moreover, this approach conserves degrees of freedom and is able to provide projections of profit indicators for various enterprises (Ferris, 1998). However, this approach demands more data, especially on the cost side and it often produces a low adjusted R square. Furthermore, when the variables are collapsed as a single variable, the response to adjustment to lags of output and input prices could also not be easily differentiated (Ferris, 1998).

In computing the gross margin equation, variable costs are often used since they play a determinant role in influencing the decision making for short term horizons, which extends to five years. Moreover, compilation of data on variable costs display less inconsistency across a country than fixed costs. Thus, variable costs are more preferable than the fixed or total cost in computing the gross margin (Ferris, 1998).

The latest BFAP model uses the following equations and elasticity to estimate the area response for the summer and winter regions.

Table 3.3: Estimated equation in the BFAP model for summer grain area harvested

Variable	Coefficient	Elasticity
Summer Grain real expected weighted gross market return (lag)	0.62	0.3
Real fuel price (lag)	-126.49	-0.05
Real fertiliser price (lag)	-733.13	-0.07
Rainfall (summer region)	1.49	0.13

Table 3.4: Estimated equation in the BFAP model for winter grain area harvested

Variable	Coefficient	Elasticity
Winter Grain real expected weighted gross market return (lag)	0.075	0.29
Real Fuel price	-10.88	-0.04
Real Fertiliser price	-21.39	-0.07
Rainfall (winter region)	0.235	0.13
Real mutton auction price (lag)	-0.074	-0.17

The real expected weighted gross market return refers to the weighted sum of the expected gross market return for six grains for the summer area and three grains for the winter area. The weight for each commodity is given according to the share of its area to the total grain area. The expected gross market in the equation is obtained from the product of trend yield and prices of each commodity. Input costs that determine the winter area are expected to affect the current area response since the production and harvesting time occurs largely at the same year compared to the summer region. Once the total area response of the whole grain sector is estimated, the share of the area devoted for each crops will be estimated. For yellow maize, for example, the model is specified as follows (Meyer, 2006).

$$YMAH = f\,(YMRGMSA\ (\text{-}1)) \qquad (3.19)$$

Where, *YMAH* refers to the yellow maize percentage share of the total grain area. *YMRGMSA(-1)* stands for the ratio of lagged value of the yellow maize expected gross market return to the weighted sum of the expected gross return of the remaining crops. A similar model specification is also used for the other commodities.

Due to the lack of enough data to be used for computing the net return of each commodity, fuel and fertiliser prices are used as a proxy to capture the effect of variable costs on area planted. However, since these input costs are not endogenised in the model, the effects of factors that affect input costs such as crude oil price, world fertiliser price and increasing domestic demand could not be assessed. The variable cost component used in the FAPRI model is also exogenous to the model (Westhoff *et al.,* 1990). In this study, the input cost in the area response equations is endogenised so that the effects of all variables that affect input costs on the agricultural sectors are captured.

3.7 Studies on South African Agricultural Inputs

Studies on South African inputs have largely focused on estimating the input substitution elasticities, analysing the competitiveness of the input industry and evaluating the impact of minimum wages. The elasticity of input substitution among aggregate agricultural inputs in South African agriculture was estimated by Poonyth *et al.,* (2001); Van Zyl, (1986) and Van Zyl and Groenewald (1988). The study by Poonyth *et al.,* (2001) showed that unlike the previous studies that conclude rigidity in the production process for substituting inputs during 1980s, the flexibility of input substitution has improved after the deregulation, though marginally. Hence, farmers' ability (flexibility) to change input mix due to the change in relative prices has somewhat improved due to deregulation.

Using a Computable General Equilibrium model, a PROVIDE (the Provincial Decision-Making Enabling) project has analysed the aggregate impact of a rise in oil prices, fuel levies, and efficiency in agricultural production on the South African economy (PROVIDE, 2004, 2005a, 2005b, 2006). The result shows that the rise in 20% of crude oil price decreases the GDP of the economy by 1%. Moreover, it induces a rise in input cost in agricultural sector by 0.2%-0.9%. The net effect on the agricultural sector, however, is minimal (-0.1%) due to the gain of the agricultural sector through export as the result of the depreciation of exchange rate the scenario induces. Similarly, a 3 percentage point increase in fuel levies will bring a rise of 0.09% in intermediate input costs and 0.14% decline in value added of agricultural sector. Furthermore, the study shows that increase of 3% property rates on agricultural land will have a limited effect on production and resource allocation. The simulation on the impact of the efficiency gained by domestic and international agriculture also shows that the benefits to the economy occur through other sectors of the economy as it causes a decline in agricultural prices; hence, a fall in employment and output in the agricultural sector.

The competitiveness of South African input industry was examined by Esterhuizen and Van Rooyen (2001). The study applied a relative trade comparative advantage (RTA) index, which uses both exports and import values of a given industry or product to compute the revealed comparative advantage of the country. Based on the RTA index, the study showed that in general total farming requisites are marginally competitive, showing positive trends since 1980. The total competitiveness index of total agricultural machinery (tractors, harvesters and milking machines, etc.) is improving, but is not strongly competitive. The result also reveals that pesticide production is marginally competitive but displaying a negative trend. The fertiliser industry, on the other hand, is found to be competitive and displaying a positive trend.

The global changes that will shape the agricultural input industry were discussed by Kirsten (1999). Among the main issues noted to affect the industry are globalisation, advancement in science, precision agriculture and the higher need for integration and co-ordination among input providers. In addition, the focus on knowledge, private research and development and the changing size and scope of agricultural firms are mentioned as some of the recent changes occurring in the agricultural input industry.

The impact of sectoral determination of minimum wages on employment was studied by Goedecke and Ortmann (1993), and Newman *et al.,* (1997). The study found that producers easily replace permanent labour with contract labour as the result of the increasing minimum wage. A similar study by Murray and Walbeek (2007) on the sugar industry indicates that retrenchment due to the minimum wage was disguised by not replacing workers, reducing the working week to 27-36 hours and paying workers on an hourly rather than weekly basis. Moreover, it enhance the likelihood of employment for seasonal and contract labour rather than permanent workers in the future. Sparrow *et al.,* (2008) has also found that the wage elasticity of regular farm workers has increased from -0.23 (1960-1991) to -1.32 (1991-2002) implying that there was a marked structural decline in the demand for regular labour workers due to various labour legislations. Furthermore, they noted that machineries, chemicals and implements are technical substitute for regular farm labour in South Africa.

Vink (2001) has thoroughly discussed the aggregate trend of cost of production, input utilisation and profitability of the sector. The trend and composition of input costs for individual commodities like maize, wheat, fruit and potatoes was assessed by NAMC (NAMC, 2008a; 2008b; 2009). These studies, however, did not quantitatively analyse the impact of input costs either on input demand or production level and could not produce projections of input prices or expenditures.

The effect of exchange rate volatility on selected input prices was also examined by the study commissioned to investigate the likely causes of higher food prices in 2003. The result shows that exchange rate volatility positively affected the price of tractors and fertilisers. The study, however, did not examine the simultaneous effect of exchange rate volatility on the output price to evaluate the net impact on food prices (NAMC, 2003).

Breitenbach and Meyer (2000) developed a partial equilibrium model to model the fertiliser use in the grain and oil seed sector. The result reveals that the shift to free market for agricultural products has moved the production to the expected optimum level. Hence, the optimum solution results in a fall of production, exports and area cultivated. Thus, total fertiliser use by the sector will also decline.

In general, there is no study that has been undertaken to quantitatively analyse the impact of input costs on the agricultural sector in a partial equilibrium modelling framework. Moreover, there is no econometric model to analyse and project the input expenditure, the value-added growth and net farming income of the South African agricultural sector. The earlier version of the model developed in this study was the first to assess the impact of the proposed biofuel strategy on the agricultural sector's growth and net farming income (BFAP, 2007). In addition, the model was used to give a projection of net farming income in BFAP baseline since 2008 (BFAP, 2008). However, in earlier versions of the model not all the components of the agricultural sector were incorporated and both input and output sides of the agricultural sector were not recursively linked.

3.8 Summary

Reviewing recent literature on the partial equilibrium models of the agricultural sector shows that only a few models have incorporated input components. Hence, most of the models focus on analysing the impact of policies on the gross income side of the sector. Moreover, the input and output sides of the agricultural sector are not linked recursively in most of the partial equilibrium models. As input expenditure is affected by the change in the output side of the sector and vice versa, it is important to assess the net implication of economic policy on the agricultural sector by recursively linking both sides of the sector.

Area response in many partial equilibrium models uses gross margins and ratios to collapse a wide range of variables that affect it. This approach avoids the statistical problem of having numerous independent variables, which would result in multicollinearity and loss of degrees of freedom. Furthermore, introducing a variable cost in the net return equation would capture the impact of the change in any input cost on the profitability and production of agricultural outputs.

Generally agricultural input demands are called derived demands, since they are determined by the demand for the final output. Hence, factor employment (input utilisation) requires, among other things, stimulating the demand for the final output and reducing input prices. The extent to which input utilisation changes due to the change in its own price is measured by price elasticity of input demand. The value of the elasticity is influenced by the share of the input on total cost, elasticity of the final output demand and by how easily the input can be substituted with other inputs (the elasticity of substitution).

Estimating the demand of inputs uses either a primal or dual approach. In the primal approach, the demand is estimated by maximising the profit given the technology constraint. In the dual approach, the demand for inputs is obtained from the cost equations by applying Shephard's lemma. The two main theoretical developments of estimating input demand models are the accommodation of dynamics in the demand modelling and the introduction of flexible functional forms. By incorporating dynamics into input demand models, the *first generation* recognises the time of adjustment and the *second generation* incorporates the interrelatedness of factor markets. The cost of adjustment for quasi-fixed inputs was introduced in the *third generation* of models.

The objective of modelling for policy purposes often brought a modelling restriction. Hence, the need for the projected values of exogenous variables to enable projections, the necessity of introducing many policy variables in modelling most equations and the data limitation for conducting other approaches, necessitate the application of a single-equation framework. This method is widely applied in constructing many partial equilibrium models as it offers much flexibility. The model specification and the estimation procedure of the method will be dealt with in the next chapter.

CHAPTER FOUR

MODEL SPECIFICATION AND ESTIMATION PROCEDURE

4.1 Introduction

The main purpose of this chapter is to show how the input expenditure model developed in this study is specified and recursively integrated into the existing BFAP output model. Developing an input model basically utilises the theory of derived demand; hence, the variables from the output model largely determine the input demand. The recursive link between input and output model is also presented, using the two input prices, which are used as a proxy for the variable input costs that determine the area response equation in the BFAP output model outlined in the previous chapter. By applying the accounting relationship on all estimated aggregate variables, the two main targets of the model (gross value added and net farming income) are also computed.

The organisation of this chapter is as follows. Section two presents a schematic view of the model developed in this study and section three lists all endogenous and exogenous variables of the model. The model specifications of each equation are presented in section four and the estimation procedure of the specified models is discussed in section five.

4.2 Schematic View of the Model

A schematic view of how the input and other aggregate variables of the models are estimated is given in Figure 4.1. The arrows (⟶) in the figure indicate the direction of influence. Since all inputs are derived demand, they are largely determined by the demand for the final output. Hence, the variables from the output model or gross income components (which include area planted, commodity and animal product prices and production volumes) are the main drivers of input demand and they determine most of the input components both directly and indirectly.

The gross income components (area planted and gross income) determine rent paid directly. Together with the real interest rate, gross income also determines the gross capital formation of the sector, which in turn affects the asset values of the sector. Depreciation value is then directly influenced by the total asset value of the sector. Interest paid by the sector is determined largely by the total debt value and the real interest rate. Total debt value is also influenced by the interest rate and total asset value. Similar to the asset value, own construction of the sector is also largely influenced by the gross capital formation of fixed improvements, and labour remuneration of the sector is determined exogenously by the quantity of labour employed and real wage rate.

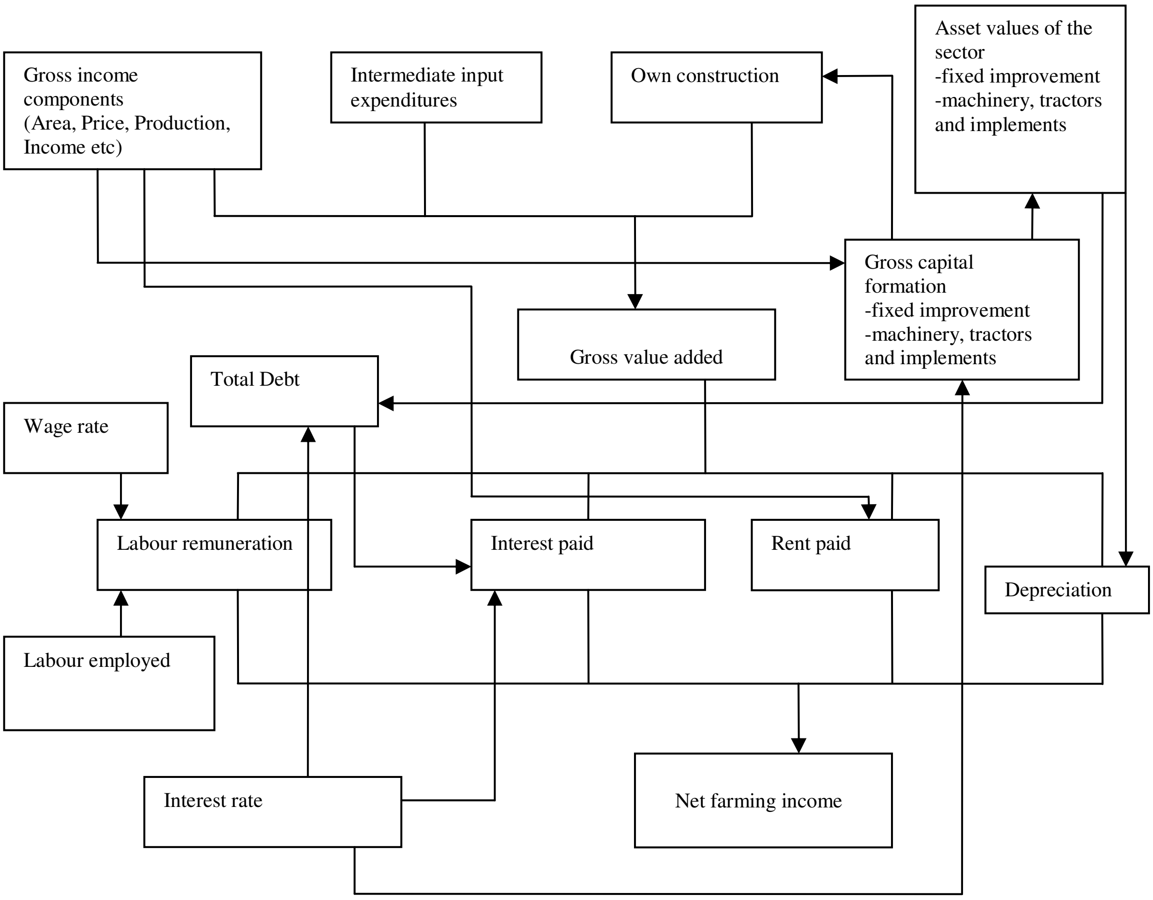


Figure 4.1: A schematic view of the behavioural equations of the model

A schematic view of how output and input models are recursively linked is presented in Figure 4.2. The figure also displays the common exogenous variables that influence both the output and input sides of the integrated model. As explained in chapter three, the proxies used for variable costs in estimating the area response by field crops are fuel and fertiliser prices. As shown in Figure 4.2, the area planted, which affects the production hence the price and income in the output model, also determines the quantity of inputs to be applied in the production process. Together with exogenous variables such as exchange rate and oil prices, the quantity of input demand also influences some of the variable costs, which subsequently determines the area planted for the next season. Thus, there is a recursive link between the output and input models where a shock introduced on one side will have a recursive effect on the other side and vice versa. Once the input demand and prices are estimated, the total input expenditure is obtained by the product of the quantity of input and costs, and the gross income of the sector is obtained from the output model by multiplying the output price, area planted and yield of the field crop.

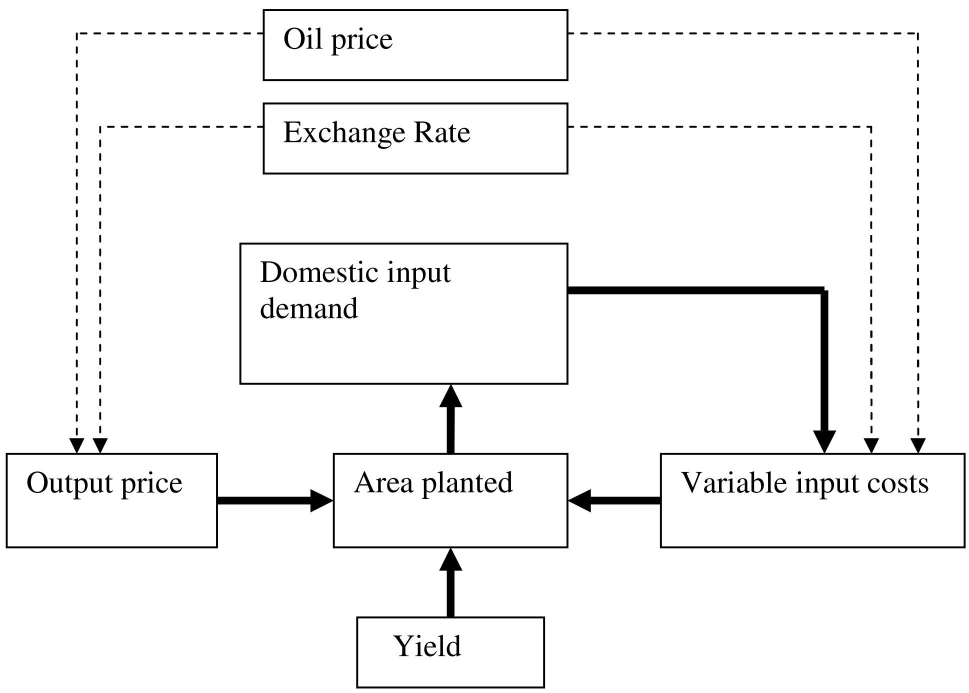


Figure 4.2: A schematic view of the recursive link between the output and input models

The general direction of the linkage between the input and agricultural output markets flows from the output side to the input markets. This arises because input demand is derived from demand that is largely dependent on the agricultural output market, particularly on changes in the gross income, output price and area planted. However, the effect of agricultural input markets on outputs in the model is largely captured by the input costs. Among the input costs that are recursively affected by the output market is the fertiliser price, which is linked with the output market through the gross income of field crops. However, the fuel price, which is regarded as a proxy for the variable cost in the area response, is not recursively linked with agricultural markets since it is determined exogenously by the international oil price and exchange rate.

For the recursively linked integrated model, therefore, the effect of a shock introduced in the integrated model is expected to be lengthened and converged slowly instead of making an abrupt halt. To compare the recursively linked and unlinked integrated model and to test the hypothesis of a lengthened and slow convergence of the effect of a shock in a recursively linked model, the recursive link between the input and output model will be 'switched off' and domestic input prices would remain exogenous so that the shock's effect could be compared in both versions of the model.

This recursive link between field crops and inputs cost introduced in this study is similar to the recursive link between animal production and field crops in the BFAP output model. Both sub-sectors in the output model are recursively linked through feed equations. Thus, a rise in the commodity price augments the feed (input) cost for animal production. As a result of a lower ratio of output price to input costs, animal production subsequently subsides. The fall in production consequently brings about a fall in the feed demand. The fall in the demand, therefore, results in lower feed consumption and domestic use of the commodity that may ultimately affect the domestic commodity prices.

Figure 4.3 illustrates the main variables that are useful to compute the main target variables of the model, which are gross value added and net farming income. The gross value added is obtained by deducting intermediate input expenditure from gross income and adding own construction and change in livestock inventory to the difference. In this model, change in livestock inventory is assumed to have a negligible effect on the gross value added, as evidenced by its average value over the past decades, which is close to zero. These variables, which are useful in computing the gross value added, are given in the top block of Figure 4.3. Similarly, four expenditure variables are deducted from the gross value added to produce net farming income. These variables are labour remuneration, interest paid, rent paid and depreciation of the sector's asset values.

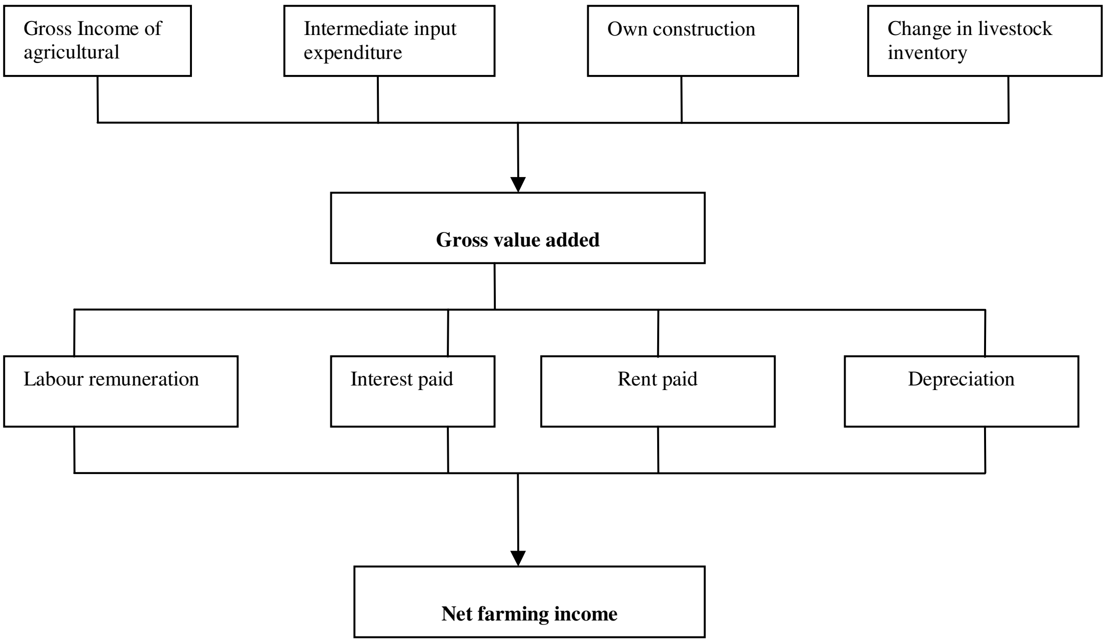


Figure 4.3: A schematic view of the main variables required to estimate the target variables.

4.3 List of Variables

Table 4.1 lists and describes the construction and the source of all the endogenous and exogenous variables used in the model.

Table 4.1: List of endogenous and exogenous variables in the model

VARIABLE ACRONYM	VARIABLE NAME AND DESCRIPTION	SOURCE AND METHOD
	ENDOGENOUS VARIABLES	
FUELP	Fuel price index	DAFF
RFUELP	Real fuel price index	(FULP/PPI)*100
FUELEXP	Fuel expenditure	DAFF
RFUELEXP	Real fuel expenditure	(FUELEXP/PPI)
RFUELD	Real fuel demand	(FUELP/FUELP)*100
FERTP	Fertiliser price index	DAFF
RFERTP	Real fertiliser price index	(FERTP/PPI)*100
AFERTP	Aggregate fertiliser price	GRAINSA
RAFERTP	Real aggregate fertiliser price	(AFERTP/PPI)*100
FERTEXP	Fertiliser expenditure	DAFF
RFERTEXP	Real fertiliser expenditure	(FERTEXP/PPI)*100
FEEDP	Feed price index	DAFF
RFEEDP	Real feed price index	(FEEDP/PPI)*100
FEEDC	Feed cost	DAFF
RFEEDC	Real feed cost	(FEEDCST/PPI)*100
FEEDEXP	Feed expenditure	DAFF
RFEEDEXP	Real feed expenditure	(FEEDEXP/PPI)*100
RFEEDD	Real feed demand	(FEEDEXP/FEEDP)*100
MREXP	Maintenance and repairs expenditure	DAFF
RMREXP	Real maintenance and repairs expenditure	(MREXP/PPI)*100
RMRD	Real maintenance and repairs demand	(MREXP/MRP)*100
FSEXP	Farm services expenditure	DAFF
RFSEXP	Real farm services expenditure	(FSEXP/PPI)*100
INTEXP	Intermediate input expenditure	DAFF
RINTEXP	Real intermediate input expenditure	(INTEXP/PPI)*100
PFC	Price of field crops	DAFF
RPFC	Real price of field crops	(PFC/CPI)*100
GINCFC	Gross income: field crops	BFAP
RGINCFC	Real gross income: field crops	(GINCFC/CPI)*100
GINCANI	Gross income of animal products	BFAP
RGINCANI	Real gross income of animal products	(GINCNI/CPI)*100
GINC	Gross income: agricultural sector	DAFF
RGINC	Real gross income: agricultural sector	(GINC/CPI)*100
OCON	Own construction	DAFF
ROCON	Real own construction	(OCONS/PPI)*100
GVA	Gross value added of agricultural sector	DAFF
RGVA	Real gross value added of agricultural sector	RGINC-RINTEXP+ROCON+CLI
LREMU	Labour remuneration	DAFF
RLREMU	Real labour remuneration	(LREMU/CPI)*100
INTPAID	Interest paid	DAFF
RINTPAID	Real interest paid	(INTPAID/CPI)*100
RENPAID	Rent paid	DAFF

VARIABLE ACRONYM	VARIABLE NAME AND DESCRIPTION	SOURCE AND METHOD
RRENPAID	Real rent paid	(RENPAID/CPI)*100
AREA	Total field crop area planted[1]	BFAP
NAREA	Nitrogen share weighted area (field crops)[2]	DAFF
PAREA	Phosphorous share weighted area (field crops)[3]	DAFF
KAREA	Potassium share weighted area (field crops)[4]	DAFF
NCONSFC	Nitrogen consumption by field crops	DAFF
PCONSFC	Phosphorous consumption by field crops	DAFF
KCONSFC	Potassium consumption by field crops	DAFF
FERTEXPFC	Fertiliser expenditure by field crops	NCONSFC+PCONSFC+ KCONSFC
RFERTEXPFC	Real fertiliser expenditure by field crops	(FERTEXPFC/PPI)*100
NP	Nitrogen price[5]	GrainSA
RNP	Real nitrogen price	(NPR/PPI)*100
PP	Phosphorous price[6]	GrainSA
RPR	Real phosphorous price	(PPR/PPI)*100
KP	Potassium price[7]	GrainSA
RKP	Real potassium price	(KP/PPI)*100
GCFIX	Gross capital formation: fixed improvement	DAFF
RGCFIXD	Real demand of gross capital formation: fixed improvement	(GCFIX/PFIX)*100
GCFMTI	Gross capital formation: machinery, tractors, implements	DAFF
RGCFMTID	Real demand of gross capital formation: machinery, tractors and implements	(GCFMTI/PMTI)*100
DEBT	Total debt value of agricultural sector	DAFF
RDEBT	Real total debt of agricultural sector	(DEBT/CPI)*100
DEPR	Depreciation: total asset	DAFF
RDEPR	Real depreciation: total asset	(DEPR/CPI)*100
DEPRFIX	Depreciation: fixed improvement	DAFF
RDEPREFIX	Real depreciation: fixed improvement	(DEPRFIX/CPI)*100
DEPRMTI	Depreciation: machinery, tractors and	DAFF

[1] Field crops comprises maize, wheat, sorghum, barely, sunflower, soybeans and sugarcane.
[2] The share of nitrogen consumption by field crops according to the survey by Fertiliser Society of South Africa (FSSA) (2005) is as follows: 54.2 % maize, 7.7 % wheat, 11.8 % sugarcane, 2.5 % sunflower, 0.3 % soybean, 6.5 % lucerne and pastures and 16.4 % horticulture and fruit.
[3] The share of phosphorous consumption by field crops according to the survey by Fertiliser Society of South Africa (FSSA) (2005) is as follows: 38 % maize, 9.4 % wheat, 12.5 % sugarcane, 5.7 % sunflower, 0.5 % soybean, 13.5 % lucerne and pastures and 18.2 % horticulture and fruit.

[4] The share of potassium consumption by field crops according to the survey by Fertiliser Society of South Africa (FSSA) (2005) is as follows: 13.6 % maize, 2.4 % wheat, 43.2 % sugar cane, 0.8 % sunflower, 0.8 % soybean, 5.6 % Lucerne and pastures and 32.8 % horticulture and fruit.
[5] Urea price is used as a proxy for the Nitrogen price.
[6] MAP price is used as a proxy for the Phosphorous price.
[7] Potassium (Kaliumchloried, GROF) price is used as a proxy for the Potassium price.

VARIABLE ACRONYM	VARIABLE NAME AND DESCRIPTION	SOURCE AND METHOD
	implements	
RDEPRMTI	Real depreciation: machinery, tractors and implements	(DEPRMTI/CPI)*100
ASSET	Total asset value of agricultural sector	DAFF
RASSET	Real total asset value of agricultural sector	(ASSET/CPI)*100
ASSETFIX	Asset value of fixed improvement	DAFF
RASSETFIX	Real asset value of fixed improvement	(ASSETFIX/CPI)*100
ASSETMTI	Asset value of machinery, tractors and implements	DAFF
RASSETMTI	Real asset value of machinery, tractors and implements	(ASSETMTI/CPI)*100
NFINC	Net farming income	DAFF
RNFINC	Real net farming income	RGVA-RLREMU-RINTPAID-RRENPAID-RDEPR
AVOL	Animal volume index	BFAP
EXOGENOUS VARIABLES		
OIL	U.S. refiners acquisition oil price	Global insight
ROIL	Real US refiners acquisition oil price	(OIL/PPI)*100
GDPDEF	GDP deflator	FAPRI
GROWTH	GDP growth	Reserve Bank
INT	Average annual prime rate	Reserve Bank
EXC	Exchange rate	Reserve Bank
PPI	Producer price index	Reserve Bank
CPI	Consumer price index	Reserve Bank
INT	Prime interest rate	Reserve Bank
INFL	Inflation	$((CPI-CPI_{(-1)})/(CPI)_{(-1)})*100$
RINT	Real interest rate	INT – INFL
WNP	World nitrogen price[8]	GrainSA
WPP	World phosphorous price[9]	GrainSA
WKP	World potassium price[10]	GrainSA
FEMPT	Labour employed in agricultural sector[11]	DAFF
WAGE	Agricultural wage rate	LREMU/FEMPT
RWAGE	Real agricultural wage rate	(WAGE/CPI)*100
FIXP	Fixed improvement price index	DAFF
RFIXP	Real fixed improvement price index	(FIXP/PPI)*100
MTIP	Machinery, tractors and implements price index	DAFF
RMTIP	Real machinery tractors and implements price index	(MTIP/PPI)*100

[8] The price of urea, Eastern Europe, bulk is used as world Nitrogen price.
[9] The price of DAP, USA gulf is used as the Phosphate world price.
[10] The price of MOP, CIS, bulk is used as world Potassium price.
[11] The missing data on the time series was extrapolated using the average annual growth rate.

VARIABLE ACRONYM	VARIABLE NAME AND DESCRIPTION	SOURCE AND METHOD
MRP	Maintenance and repairs price index	DAFF
RMRP	Real maintenance and repairs price index	(MRP/PPI)*100
WNAREA	World Nitrogen share weighted area[12]	FAPRI and IFA
WPHAREA	World Phosphorous share weighted area[13]	FAPRI and IFA
WPOAREA	World Potassium share weighted area[14]	FAPRI and IFA

Endogenous variables are determined within the model and these are the variables of interest for assessing the various impacts of policy instruments. Exogenous variables, on the other hand, are determined outside of the model. They often include policy, trade and other macro variables. Once the input expenditure model that will be developed is fully integrated with the sectoral model, the impact of all the policy variables and exogenous factors used in the sectoral model (like trade policies, weather and world commodity prices) on the input expenditure, gross value added and net farming income of the sector could also be analysed.

As the gross value added (GVA) by the agricultural sector to the economy shows the value added by the sector on factor inputs in converting them into final outputs, it indicates the contribution of the sector to the economy. Likewise, net farming income (NFI) represents the money left to producers after paying all operating expenses. Hence, it indicates the financial sustainability of the operators. Thus, both of these variables are used as target variables to assess the effect of policies and exogenous factors on the sector.

4.4 Model Specification

To create a recursive linkage between the input and output models, the models for fuel and fertiliser prices, which are used as a proxy for the input costs in the area response

[12] Area harvested of major fertiliser consumer countries (China, India, EU, USA and Brazil) is used. Each area is weighted using the share of the country's fertiliser consumption to the world consumption. The data is sourced from IFA (2009b). For Nitrogen: China (31.5 %), India (14.4 %), USA (12.5 %), EU (11.2 %) and Brazil (2.4 %).
[13] For Phosphorous: China (30.5 %), India (14.5 %), USA (10.8 %), EU (8.1 %) and Brazil (8.2 %).
[14] For Potassium: China (21.4 %, India (8.6 %), USA (17.1 %), EU (13.2 %) and Brazil (12.7 %).

equation of the sectoral model, are specified in equations 4.1 and 4.2. These equations will enable the sectoral model to capture the impact of exogenous factors and macro variables that affect these prices in the sectoral output. Thus, they would be able to capture the effect of variables that simultaneously affect both input and output sides of the agricultural sector.

The model for the price transmission equation for the real fuel price index, which is used as a proxy in the area response equation of the output model, is specified as follows.

$$RFUELP = \alpha + \beta_1 \, OIL^* \, EXCH + \varepsilon \qquad (4.1)$$

From the price transmission equation given in 4.1, depreciation of exchange rate and rising world oil prices are expected to raise the domestic fuel price.

The price transmission equation for the domestic fertiliser price is specified as follows:

$$RFERTP_i = \alpha + \beta_1 \, RWFP_i * EXCH + \beta_3 \, RGINCFC\,(-1) + \varepsilon \qquad (4.2)$$

The world fertiliser price and the exchange rate play a significant role in the price transmission equation. Moreover, the gross income of field crops, which is a proxy for the cash flow of farmers before the planting season, is expected to play a role in prompting demand and hence increasing the prices charged by input providers. Thus, the recursive effect of the output market on input price is captured by the gross income of field crops in this equation. This is an observed phenomenon in South Africa due to the oligopolistic market structure, where market supply is dominated by few suppliers.

The real aggregate fertiliser price index, which was and exogenous in the output model, is endogenised by the following equation.

$$RFERTPX = \alpha + \beta_1 \, RAFERTP + \varepsilon \qquad (4.3)$$

RAFERTP refers to the real aggregate domestic fertiliser price for all fertilisers. It is constructed using a weight based on the consumption share. Thus, 70% is given to the nitrogen price and 15% each for potassium and phosphorous.

The above equations reveals how the output side (gross income) determines input prices by affecting the domestic demand for inputs. The area planted in the output model also subsequently determines the quantity of input demands, and thus input expenditure. Hence, the integration of input expenditures into the existing output model captures the recursive effect of the input side on the output side and vice versa. This recursive link will also be 'switched off' to compare the result of a shock on both versions of the integrated model to test the hypothesis of the study.

Total intermediate input expenditure is the sum of expenditures on feed, fuel, fertiliser, maintenance and repairs, farm services and others, which encompasses all expenditures on dips and sprays, electricity, land tax, licences, packing material, seeds and plants, insurance, water tax and others not specified. The above five inputs that will be estimated in this model comprise more than 74% of all the intermediate inputs expenditure in 2008. The remaining inputs classified under other expenditure (ROTHEREXP) are projected in the model to increase by the growth outlook of the inflation rate, area planted and animal production.

$$RINTEXP = RFEEDEXP + RFUELEXP + RFERTEXP + RMAREXP + RFASEXP + ROTHEREXP \qquad (4.4)$$

Input expenditure is the product of quantity demanded and its price. For the inputs where both quantity and price data are available, they are estimated separately and the expenditure is calculated by multiplying the quantity demanded and the price. If the data is only available as expenditure value, however, then it is deflated by its own price index to obtain a proxy for the quantity demanded (Maligaya and White, 1989) and the input price index is deflated by PPI to obtain the real price index. Thus, the real expenditure on the input is retrieved by multiplying the real quantity demand and the real price index.

The model for fuel demand is specified as follows.

$$RFUELD = \alpha - \beta_1 RFUELP + \beta_2 AREA + \beta_3 AVOL + \varepsilon \qquad (4.5)$$

The real fuel demand equation is specified as a function of its real price index, the agricultural area planted, which is a proxy for capturing the activities of field crops, and the volume of animal products, which is also used as a proxy for the activities of animal production. The fuel demand is expected to be positively influenced by the expansion of area planted and increased animal production. It is also expected to be inversely related to the increase in the real fuel price. The projected values of the real fuel price index will be obtained from the estimated equations specified in 4.1. The projected value of area planted and animal volume production index is obtained from the BFAP output model. The animal production volume index, which is used as a proxy for the activities of animal production is computed and projected using the production volume of milk, chicken, pork, eggs and beef. The data for these variables is sourced from BFAP output model.

The real expenditure on fuel by the agricultural sector is obtained by multiplying the real fuel price index estimated in equation 4.1 and real fuel demand estimated in equation 4.5.

Real feed demand by the agricultural sector is specified using the following equation.

$$RFEEDD = \alpha - \beta_1 RFEEDP + \beta_2 AVOL + \varepsilon \qquad (4.6)$$

Feed demand is expected to increase by the rise in the level of animal production, which is captured by animal volume index and deterred by the rise of feed price.

The price index of feed is estimated using the following equation.

$$RFEEDP = \alpha + \beta_1 RFEEDC + \varepsilon \qquad (4.7)$$

Feed price index is estimated as a function of real feed cost for animal production (RFCOST), which is obtained from sectoral model that calculates the feed cost for each animal product[15]. The representative feed cost for the sector is then computed by assigning various weights to each feed cost. Based on the aggregate feed expenditure, a 60% weight is given to poultry feed and 10% is given for cattle, dairy, eggs and pork. Since the feed cost equation is directly linked to the commodity prices, it captures all the policy variables in the sectoral model that influence its value. Hence, equation 4.7 links these effects to the real feed price index that will ultimately be used to compute the real feed demand and expenditure, which is obtained by multiplying the real feed demand, obtained from equation 4.6, and the real feed price index of equation 4.7.

The equation for real demand of materials and repairs is given in 4.8.

$$RMAREPD = \alpha + \beta_1 \, RGCF - \beta_2 \, RMRP + \varepsilon \qquad (4.8)$$

The real demand of maintenance and repairs is expected to be affected negatively by higher own price and positively by the rise of real gross capital formation in the agricultural sector, which is used as a proxy for the activities of the agricultural sector that mainly deal with implements, tractors, machinery and fixed improvement.

For the fertiliser demand by the field crops, the following model is specified.

$$FERTCONS_i = \alpha - \beta_1 \, RFERTP_i + \beta_2 \, WAREA_i + \beta_3 \, RFCP + \varepsilon \qquad (4.9)$$

Domestic fertiliser consumption is expected to be determined by its own price and the area planted. When producers expand area and fertiliser prices fall, the demand for fertilisers is expected to increase. Moreover, the rise in output price is expected to encourage more fertiliser consumption. The *i* in the equation refers to the three macro fertiliser nutrients, which are Nitrogen, Phosphorous and Potassium. The planted area included in the model is a weighted area of field crops by the share of fertiliser nutrient demanded.

[15] Feed cost for each animal product is computed as the weighted product of the inclusion rate of feed stocks in the feed and the respective price of the feed stock used by the animal product. Some of these feed stocks include: maize, wheat, fishmeal, cotton seed, soybean full fat, soybean cake, sunflower cake and sorghum.

The world fertiliser price model is specified as follows.

$$WFP_i = \alpha + \beta_1\ WAREA_i + \beta_2\ OIL + \varepsilon \qquad (4.10)$$

World fertiliser price is expected to be influenced by energy and transport costs (oil price) and the demand by major consumers for fertiliser. This is captured using a weighted area of domestic consumption share of total world fertiliser consumption by major fertiliser consumer counties. The world fertiliser price is expected to rise due to high energy cost and world fertiliser demand.

The total field crop fertiliser expenditure is obtained by multiplying the total field crops fertiliser demand and the real fertiliser price of each nutrient obtained from equations 4.2 and 4.9. Then, equation 4.11 is used to get the real total fertiliser expenditure of the agricultural sector.

$$RFERTEXPE = \alpha + \beta_1\ RFERTEXPFC + \varepsilon \qquad (4.11)$$

The real farm services expenditure equation is specified in equation 4.12.

$$RFASEXP = \alpha + \beta_1\ RGINC + \varepsilon \qquad (4.12)$$

Real Farm services expenditure, which recently has increased its share of total expenditure, is expected to be determined by the gross income of the agricultural sector.

Own construction is expected to be positively influenced by the gross capital formation of fixed improvement. Hence, it is specified as follows:

$$ROCONS = \alpha + \beta_1\ RGCFFI + \varepsilon \qquad (4.13)$$

The model for interest paid is specified in equation 4.14.

$$INTP = INT\ (DEBT) \qquad (4.14)$$

The main factors that influence the amount of interest payment by the farming sector are the total debt value and interest rate. The rise in the value of both determinants is expected to increase the amount of interest payment. The projected value of total debt value by the agricultural sector is obtained from equation 4.20. Once the interest payment is obtained from the above equation, it will be deflated by CPI to obtain the real interest paid by the agricultural sector.

For estimating the rent paid equation, the total area devoted for production is expected to be a major determinant variable. The larger the area planted, the higher the amount of rent paid by the producers. Moreover, gross income from agricultural sector is used to capture the profitability of the agricultural sector in determining rent paid by agricultural producers. Hence, the model is specified as follows:

$$RRENT = \alpha + \beta_1 AREA - \beta 2RGINC + \varepsilon \qquad (4.15)$$

Labour remuneration is the product of the real wage rate and the number of farm employees. The labour employed in the sector is specified as follows:

$$FEMPT = \alpha - \beta_1 RWAGE - \beta_2 TIME + \beta_2 GINC + \varepsilon \qquad (4.16)$$

Farm employment is expected to fall due to the rise in real wages. Moreover, as the economy progresses, it is expected that less labour will be engaged in the agricultural sector. The rise in the profitability of the agricultural sector (real gross income), however, is expected to create more employment. The average annual wage rate is obtained by dividing the total labour remuneration by total farm employment (Poonyth *et al.,* 2001) and it is projected to increase by the inflation rate.

Depreciation of the asset value of the agricultural sector is computed by the given annual depreciation rate used by DAFF, using the following formula.

$$RDEPRE = 0.02RAVFIX + 0.1RAVMTI \qquad (4.17)$$

The coefficients 0.02 (2%) and 0.1 (10%) are the annual depreciation rate applied for the asset value of fixed improvement and tractors, machinery and implements respectively.

The asset value is computed using the following formula:

$$RAV_i = RAV_i(-1) + RGCF_i - RDEPRE_i \tag{4.18}$$

The asset value of the agricultural sector is simply the depreciation value of the assets taken from the sum of the lagged asset value and the current gross capital formation. *i* in the equation refers to fixed improvement and machinery, tractors and implements. The asset value of land in the agricultural sector is adjusted by increasing the value by 6% semi-annually (the value currently applied by DAFF).

The model for gross capital formation of the agricultural sector is specified as follows:

$$RGCF_i = \alpha - \beta_1\, RINT - \beta_2\, RPi + \beta_2\, RGINC + \varepsilon \tag{4.19}$$

Gross capital formation is determined by the real income level of the sector, real interest rate and the price of the equipments. While the rise in income is expected to spur the capital formation, the increase in interest rate and price of equipment will deter it. *i* in the equation refers to the fixed improvement (FIX) and machinery, tractors and implements (MTI).

The model for total debt of the sector is specified by the following equation

$$RDEBT = \alpha + \beta_1\, RASSET + \beta_2\, RINT - \beta_2\, GROWTH + \varepsilon \tag{4.20}$$

The agricultural sector's debt is expected to be influenced by real interest rate and real asset value. The rise in interest rate and the asset value is expected to increase the amount of debt in the sector. The downturn of the economy, on the other hand, is expected to put more pressure on producers' ability to meet their obligation; hence, it increases the debt burden.

Once all the above behavioural equations are estimated, the following identity is used to calculate the real gross value added of the agricultural sector.

$$RGVA = RGINC - RINTEXP + ROCONS \qquad (4.21)$$

Once the expenditures on land, labour, capital and depreciation values have been estimated using the above equations, net farming income is calculated by subtracting these expenditures from the gross value added of the agricultural sector computed in equation 4.21. The formula for net farming income is given below.

$$RNFI = RGVA - RINTPAID - RLREMU - RRENPAID - RDEPRE \qquad (4.22)$$

4.5 Estimation Techniques

The estimation approach used in this study closely follows the FAPRI approach, which puts consultation of experts as its centre during the model building exercise (McQuinn and Binfield, 2002) and follows a general-to-specific methodology to estimate the specified equations (Binfield *et al.,* 2000). Hence, in this study, officials from the Department of Agriculture, Forestry and Fisheries have been consulted in formulating most of the model specifications and a similar methodology is used to estimate the individual equations.

Due to the limited span of data for most of the variables in the model, a parsimonious specification is used in estimating the models. Thus, most of the equations have a small number of explanatory variables, which are deemed important in explaining the dependent variable. In cases where the limited data set does not allow to undertake a general-to-specific methodology, a simple regression is used to estimate the relationship of the variables. Moreover, economic importance is given more weight than the statistical significance in explaining most of the dependent variables due to the short span of the data that precludes from obtaining statistical sound estimations.

Traditional econometric methodology uses the specified equation 4.23 to estimate the parameters. The relationship among the variables is derived mainly from economic theory. To examine the adequacy of the model, basic diagnostic tests like R^2, t statistic and Durbin-Watson are often applied.

$$y_t = \beta_1 + \beta_2 x_t + \mu_t \qquad (4.23)$$

If the models fail to pass the diagnostic tests, additional or alternative variables will be added until the adequacy of the model is accepted and passes all diagnostic tests. This methodology, though started with simpler model, could end up being much more complicated. Thus, it entails data mining, since all the possible estimations will be carried out until the acceptable model is obtained. Furthermore, prior beliefs will largely dictate the result of the estimation and it is impossible to judge the statistical significance of the reported final estimated equation (Roche, 2001). This methodology is known as simple-to-general methodology.

An alternative methodology, which was developed by Hendry, is known as the general-to-specific methodology. In this methodology various competing economic models are nested within the general model. If the actual data generation process (DGP) is equation 4.23, it could be reached by testing down procedures from the general-to-specific methodology as specified in equation 4.24. However, if equation 4.24 describes the actual DGP, estimating 4.23 will result in an inefficient and biased estimation. Moreover, it is often difficult to reach equation 4.24 if one starts with the model specification of equation 4.23. Hence, in the Hendry methodology, omitted variable bias is rarely found (Roche, 2001).

$$y_t = \beta_1 + \beta_2 y_{t-1} + \beta_3 x_t + \beta_4 x_{t-1} + \mu_t \qquad (4.24)$$

Economic theory in general determines which variables are to be included in the model; hence, the long-run equilibrium determinants of the dependent variable. The theory, however, has little to say about the short-run dynamics that are often captured by the lag structure and are largely determined by the data.

Some of the nested models within the general-to-specific, autoregressive distributive lag model specification of two variables given in 4.24 include:

The static regression – restriction on (4.24): $\beta_2 = \beta_4 = 0$

$$y_t = \beta_1 + \beta_3 x_t + \mu_t \tag{4.25}$$

The AR (1) process- restrictions $\beta_3 = \beta_4 = 0$

$$y_t = \beta_1 + \beta_2 y_{t-1} + \mu_t \tag{4.26}$$

The leading indicator equation- restriction on (4.24): $\beta_2 = \beta_3 = 0$

$$y_t = \beta_1 + \beta_4 x_{t-1} + \mu_t \tag{4.27}$$

The first difference equation – restrictions on (4.24): $\beta_2 = -1$ *and* $\beta_3 = \beta_4$

$$\Delta y_t = \beta_1 + \Delta \beta_3 x_t + \mu_t \tag{4.28}$$

The PDL (1) equation- restriction on (4.24): $\beta_2 = 0$

$$y_t = \beta_1 + \beta_3 x_t + \beta_4 x_{t-1} + \mu_t \tag{4.29}$$

The partial adjustment equation – restriction on (4.24): $\beta_4 = 0$

$$y_t = \beta_1 + \beta_2 y_{t-1} + \beta_3 x_t + \mu_t \tag{4.30}$$

The 'Dead-Start' lagged information model – restrictions on (4.24): $\beta_3 = 0$

$$y_t = \beta_1 + \beta_2 y_{t-1} + \beta_4 x_{t-1} + \mu_t \tag{4.31}$$

The proportional response model – restrictions on (4.24): $\beta_4 = - \beta_2$

$$y_t = \beta_1 + \beta_3 x_t + \beta_4 (x_{t-1} - y_{t-1}) + \mu_t \tag{4.32}$$

The error correction model (ECM) – restrictions on (4.24): $\beta_2 - 1 = -(\beta_3 + \beta_4)$

$$\Delta y_t = \beta_1 + (\beta_2 - 1)(x_{t-1} - y_{t-1}) + \beta_3 \ \Delta x_t + \mu_t \tag{4.33}$$

The static model with AR (1) errors – restrictions on (4.24): $\beta_4 = -\beta_2 \beta_3$

$$y_t = \beta_1 + \beta_3 x_t + \mu_t$$

$$\mu_t = \beta_2 \mu_{t-1} + \varepsilon_t \qquad \varepsilon_t \sim NIID(0, \sigma^2_\varepsilon)$$

$$y_t = \beta_1 + \beta_2 \mu_{t-1} + \beta_3 x_t + \beta_2 \beta_3 x_{t-1} + \varepsilon_t \tag{4.34}$$

The main steps to be followed in estimating each equation are the following (Roche, 2001):

- Plotting and analyzing the trend in the data and perform basic statistics;
- Estimating each equation using an ADL (1) model in the absence of theory suggesting a specific functional form;
- After estimating the equation, diagnostic tests determine the adequacy of the model;
- If some tests suggest a breaking trend, one might add trend and trend break dummy variables to the equation;
- If the final equation appears to be robust and if the parameters appear to be stable then the estimated equation can be reduced using t or F-tests.

After estimating the final equation, many misspecification tests should be performed to determine its adequacy.

4.6 Summary

This chapter applied the economic theory discussed in the previous chapter to specify an econometric model of all equations necessary to build the model for intermediate input expenditure and other aggregate variables. In addition, it presented a schematic view of the recursive link between input and output model, all the behavioural equations developed in the study, and the main aggregate variables needed to compute the target variables of the model. All data needed for building the model, with their source and constructions are also outlined. Most of the endogenous variables are sourced from DAFF and GrainSA and the exogenous variables are obtained mainly from FAPRI projections, Global Insight and the Reserve Bank.

To estimate the econometric equation, the Hendry methodology of general-to-specific was applied. This methodology is based on ADL (1) specification which nested various competing models. Thus, it is able to test these models in estimating each equation. Some of the nested models in ADL (1) specification include partial adjustment, the auto regressive (1) process, the leading indicator equation and the static regression. The econometric estimation results of all specified models are presented in the next chapter.

CHAPTER FIVE

ESTIMATION RESULTS OF INDIVIDUAL EQUATIONS

5.1 Introduction

In this chapter, each model specified in the previous chapter are estimated. In the following section, the statistical properties of the variables are examined. This is followed by the estimation results of all the individual equations, together with the diagnostic tests of the residuals of the equation. These tests examine violations of the underlying assumptions of the estimation techniques. Corrections are made for the violated assumptions to improve the adequacy of the model.

5.2 Statistical Properties of the Variables

The unit root test for variables with long span is conducted to examine the stationarity of the variables. As the Augmented Dickey Fuller (ADF) test suffers from low power, a recently developed Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test is used. Unlike most unit root tests, the null hypothesis of the KPSS test is the stationarity of the variables. For variables suspected to show a structural break, a Philips Perron test is used to examine the stationarity of the variable.

Table 5.1: Examining the stationarity of the data

Variable	Description	LM-Stat.
RFUELP	Real fuel price	0.34
RFUELEXP	Real fuel expenditure	0.20
RFERTP	Real fertiliser price	0.43
RFEEDP	Real feed price	0.24
RFEEDEXP	Real feed demand	0.64**
RMRP	Real maintenance and repairs price	0.59**
RINTPAID	Real interest paid	0.15
ROCON	Real own construction	0.62**
RRENPAID	Real rent paid	0.37
RGINC	Real gross income	0.22
RFIXP	Real fixed improvement price	0.63**
RGCFIX	Real gross capital formation: fixed	0.36

Variable	Description	LM-Stat.
	improvement	
RGCFMIT	Real gross capital formation: Machinery, implements and tractors	0.43
RDEBT	Real debt value	0.37
RFSEXP	Real farm services expenditure	0.7***
RMREXP	Real maintenance and repairs expenditure	0.59*
RMITP	Real price of machinery, implements and tractors	0.69**
RCLI	Real change in livestock inventory	0.07
RLREMU	Real labour remuneration	Philips-Perron structural break test (-4.44)
AREA	Total area planted	0.66**
RASSET	Real asset value	0.41
RFERTEXP	Real fertiliser expenditure	0.37

As shown in the above table, most of the variables in the model, including those that have a limited span due to data limitation, are stationary and when a non-stationary variable appears in the model and the residuals of the estimated equation fails to pass the diagnostic tests, it is addressed using the appropriate econometric techniques.

5.3 Intermediate Input Expenditure

Intermediate input expenditure estimated in the model consists of expenditure on fuel, feed, fertiliser, farm services and repairs and maintenance. These inputs represent more than 70% of the intermediate input expenditure. Both prices and quantity for fuel, feed and fertiliser expenditure are estimated. The expenditure value for each input is obtained by multiplying the price and quantity of inputs.

Each price equation specified in the model is used to link with the area response equation of the output model. Thus, the impact of all the factors that affect these prices on output will be captured through these price equations. Furthermore, most of the quantity of intermediate inputs are directly influenced by the factors from the output side, such as area planted, gross income and volume of production. Thus, the recursive impact of output components on input expenditure is reflected by its effect on the quantity demanded for inputs.

5.3.1 Fuel Demand

The demand for fuel in the agricultural sector is estimated using an Autoregressive Distributed Lag (ADL (1)) model specification and the results of various nested models are given in Table 5.2. Out of all estimated models, the partial adjustment model fits the data very well. As shown in the table, all variables are statistically significant and have the expected signs in equation 5.1C. The estimated model explains 83% of the variation in fuel demand, as shown by the adjusted R^2.

$$\underset{}{RFUELD} = \underset{(0.92)}{1371.15} - \underset{(-7.47)}{14.51RFUELP} + \underset{(4.13)}{0.27AREA} + \underset{(3.15)}{16.84AVOL} + \underset{(3.74)}{424.76D85} + \underset{(4.68)}{778.10D06} \quad (5.1C)$$

$$Adj.\ R^2 = 0.83 \qquad T = (1980\text{-}2007)$$

The expansion of both area planted and animal production drives up the demand for fuel in the sector. Conversely, a rise in the fuel price deters the demand. The computed elasticity of the variables shows that a ten percent increase in area planted and animal production will increase the fuel demand by 4.7 and 4.6% respectively. As expected, the own price elasticity is inelastic and a ten percent increase in price would only reduce the fuel demand by 3.42%. Hence, an increase in fuel price raises fuel expenditure by the sector.

Table 5.2: ADL (1) Models for real fuel demand

VARIABLE	5.1A	5.1B	5.1 C
CONSTANT	-100.15 (-0.06)	1,737.43 (1.38)	1,371.14 (1.61)
RFUELD(-1)	0.21 (0.97)	0.04 (0.24)	
RFUELP	-5.29 (-0.77)	-13.06 (-2.23)	-14.51 (-7.84)
RFUELP(-1)	-2.91 (-0.43)	-2.11 (-0.39)	
AREA	0.09 (0.71)	0.33 (2.84)	0.27 (4.39)
AREA(-1)	0.20 (1.5)	-0.09 (0.73)	
AVOL	12.23 (0.81)	21.77 (1.85)	16.83 (3.23)
AVOL(-1)	5.45 (0.33)	-7.61 (-0.57)	
D85		462.34 (2.08)	424.76 (2.64)
D06		867.43 (3.78)	778.10 (4.61)
R^2	0.63	0.79	0.83

Note: t-statistics are given in parentheses.

The diagnostic test performed on the residual of equation 5.1C shows that none of the classical assumptions of the OLS are violated.

Table 5.3: Misspecification tests for real fuel demand equation 5.1C

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	0.44	0.79
Serial Correlation	Ljung Box Q	Q(12)	10.78	0.54
	Breusch-Godfrey	$N*R^2(2)$	0.92	0.63
	Breusch-Godfrey	$N*R^2(1)$	0.92	0.33
Homoscedasticity	ARCH LM	$N*R^2(1)$	0.15	0.70
	ARCH LM	$N*R^2(2)$	0.26	0.87
	White	$N*R^2(1)$	4.45	0.81
Misspecification	Ramsey RESET	LR(1)	3.47	0.07
	Ramsey RESET	LR(2)	3.67	0.15
Parameter Stability	Recursive Estimates			

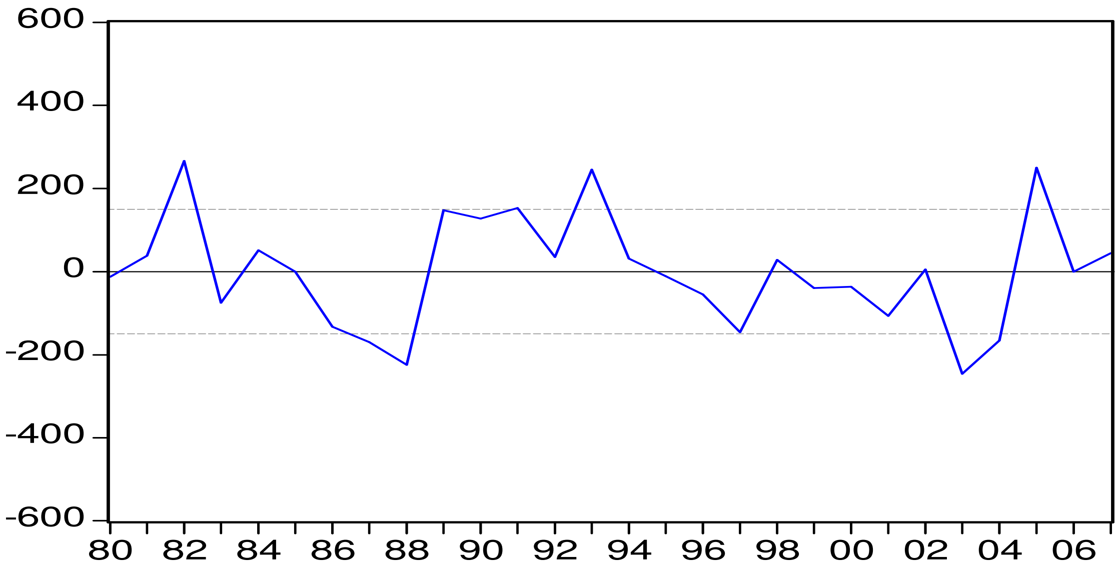


Figure 5.1 Residual graph for the real fuel demand equation 5.1C

5.3.2 Fuel Price

The result of the static model specified for the price transmission equation of the fuel price is given in equation 5.2. All variables are statistically significant with the expected signs. As expected, the domestic fuel price increases with the rise in the world crude oil price (USD) and depreciation of the exchange rate. The real domestic fuel price elasticity of crude oil price and exchange rate is 0.55. Hence, a ten percent increase in international oil price in local currency causes a 5.5% increase in domestic fuel price.

The fuel price equation plays a pivotal role in linking the input and output models. The variable cost used in the area response of the output model will now be linked with equation 5.2. Hence, the implications of all the determinant factors of fuel prices on the output side of the sector are captured and endogenised in the integrated model.

$$RFUELP = 46.75 + 0.27\ OIL^{*}\ EXC - 19.41D06 \quad (5.2)$$
$$(11.64)\ (10.25)\qquad (-3.98)$$

$Adj.R^2 = 97.2$ $\qquad T = (1991\text{-}2008)$

Table 5.4: Diagnostic tests for real fuel price equation 5.2

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	0.02	0.29
Serial Correlation	Ljung Box Q	Q(6)	3.11	0.99
	Breusch-Godfrey	$N*R^2(1)$	0.22	0.37
Homoscedasticity	ARCH LM	$N*R^2(1)$	1.52	0.38
	ARCH LM	$N*R^2(2)$	0.67	0.14
	White	$N*R^2(1)$	2.11	0.46
Misspecification	Ramsey RESET	LR(1)	2.88	0.23
	Ramsey RESET	LR(2)	2.39	0.12
Parameter Stability	Recursive Estimates			

Notes: *** 1% significant level, **: 5% significant level.

The diagnostic test performed on the residual of equation 5.2 shows that none of the classical assumptions of the OLS are violated.

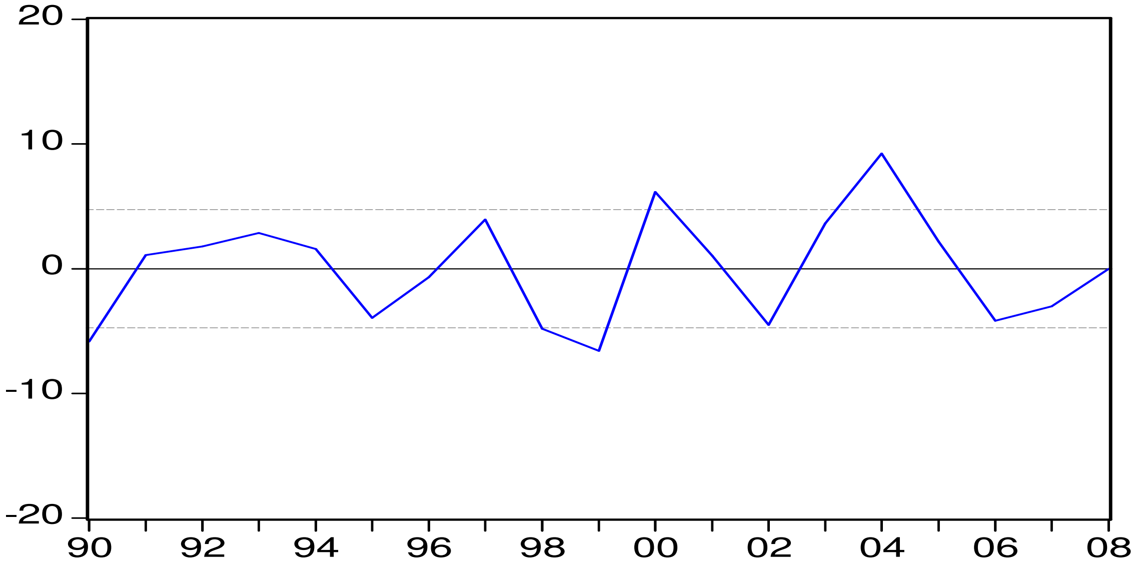


Figure 5.2: Residual graph of the real fuel price equation 5.2

5.3.3 Feed Demand

The results of ADL (1) model and various nested models of feed demand are given in Table 5.5. The results show that the partial adjustment model fits the data very well. All the variables are statistically significant and hold the expected sign. As expected, the rise in feed price affects the feed demand negatively and the expansion of animal production augments feed demand in the sector. The short run elasticities for feed price and animal production are -0.62 and 0.7 respectively. Thus, a ten percent increase in feed price and animal production would reduce the feed demand by 6.2 % and increase it by 7 % respectively.

As expected the long run elasticity of feed price and animal productions are higher than the short run. The long run own price and animal production elasticity are -1.53 and 1.71 respectively. Thus, any percentage increase in animal production and feed price would result in higher percentage increase in the feed demand. It, therefore, can be concluded that both animal production and feed price are important determinants of feed demand in the long run.

Table 5.5: ADL (1) Model for real feed demand

VARIABLE	5.3A	5.3B	5.3 C
CONSTANT	128.00 (0.08)	1219.00 (0.59)	1605.00 (1.09)
RFEEDD(-1)	0.89 (6.17)	0.69 (3.51)	0.59 (4.14)
RFEEDP	-54.30 (-5.01)	-23.24 (-2.01)	-30.82 (-3.69)
RFEEDP(-1)	51.60 (4.72)		
AVOL	73.56 (1.88)	29.09 (1.02)	37.41 (1.81)
AVOL(-1)	-66.34 (-1.52)		
D02			1949.29 (4.57)
R^2	0.87	0.74	0.87

Note: t-statistic is given in parenthesis

Like the other input demand models, the animal volume index variable from the output model is used in determining the feed demand of the agricultural sector. Thus, the integration of the feed demand model implies that all the factor incorporated in the sectoral model that determines the amount of animal production are also indirectly determine the feed demand of the sector. Similarly, the aggregate feed price index utilises the variable from the output model in estimating its value, which is discussed in the following section.

$$FEEDD = 1605 + 0.59RFEEDD\,(-1) - 30.82FEEDP + 37.41AVOL + 1949.3D02 \quad (5.3C)$$
$$(1.09) \quad (4.1) \qquad (-3.69) \qquad (1.81) \qquad (4.57)$$

$$Adj.R^2 = 0.95 \qquad T = (1985\text{-}2008)$$

The results of the diagnostic tests performed on the residual of equation 5.3C show that the all the classical assumptions are not violated.

Table 5.6: Misspecification tests of real feed demand equation 5.3C

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	1.43	0.48
Serial Correlation	Ljung Box Q	Q(12)	5.15	0.95
	Breusch-Godfrey	$N*R^2$ (2)	0.14	0.86
	Breusch-Godfrey	$N*R^2$ (1)	0.11	0.73
Homoscedasticity	ARCH LM	$N*R^2$ (1)	0.13	0.71
	ARCH LM	$N*R^2$ (2)	0.27	0.76
	White	$N*R^2$ (1)	1.25	0.33
Misspecification	Ramsey RESET	LR(1)	0.66	0.42
	Ramsey RESET	LR(2)	0.41	0.66
Parameter Stability	Recursive Estimates			

Notes: *** 1% significant level, **: 5% significant level

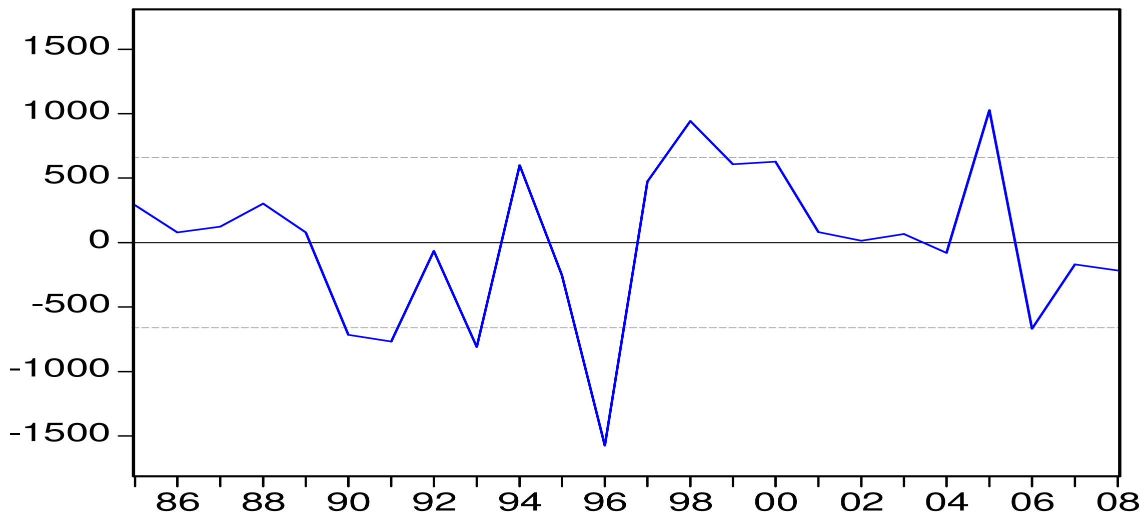


Figure 5.3: Residuals of real feed demand equation 5.3C

5.3.4 Real Feed Price

The result of the estimated model of real feed price is given in equation 5.4. The variable included in the model is statistically significant and display the expected signs. As expected the feed cost for animal production computed in the sectoral model well explains the aggregate feed price index of the agricultural sector. The elasticity of aggregate feed price to the cost of feed for animal production from the sectoral model is 0.65. Hence, a rise of 10% will increase the aggregate price index by 6.5%.

$$RFEEDP = \underset{(5.13)}{73.95} + \underset{(2.40)}{0.06}\ RTFEEDC \qquad (5.4)$$

$$Adj.R^2 = 0.54 \qquad T = (1990\text{-}2007)$$

This equation links the output model with the aggregate feed cost index, which is used also to determine the demand in equation 5.3C. Hence, the impact of all the variables that determine the feed cost in the output models, such as domestic commodity prices (which are also related to the world prices and exchange rate), are indirectly factored in determining feed expenditure by the agricultural sector.

Table 5.7: Misspecification tests for feed price equation

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	0.55	0.22
Serial Correlation	Ljung Box Q	Q(12)	3.21	0.99
	Breusch-Godfrey	$N{*}R^2(2)$	0.14	0.86
	Breusch-Godfrey	$N{*}R^2(1)$	0.00	0.96
Homoscedasticity	ARCH LM	$N{*}R^2(1)$	1.38	0.26
	ARCH LM	$N{*}R^2(2)$	0.73	0.49
	White	$N{*}R^2(1)$	1.14	0.84
Misspecification	Ramsey RESET	LR(1)	0.19	0.66
	Ramsey RESET	LR(2)	2.60	0.12
Parameter Stability	Recursive Estimates			

The diagnostic test performed on the residual of equation 5.4 shows that the classical assumptions of the OLS are not violated.

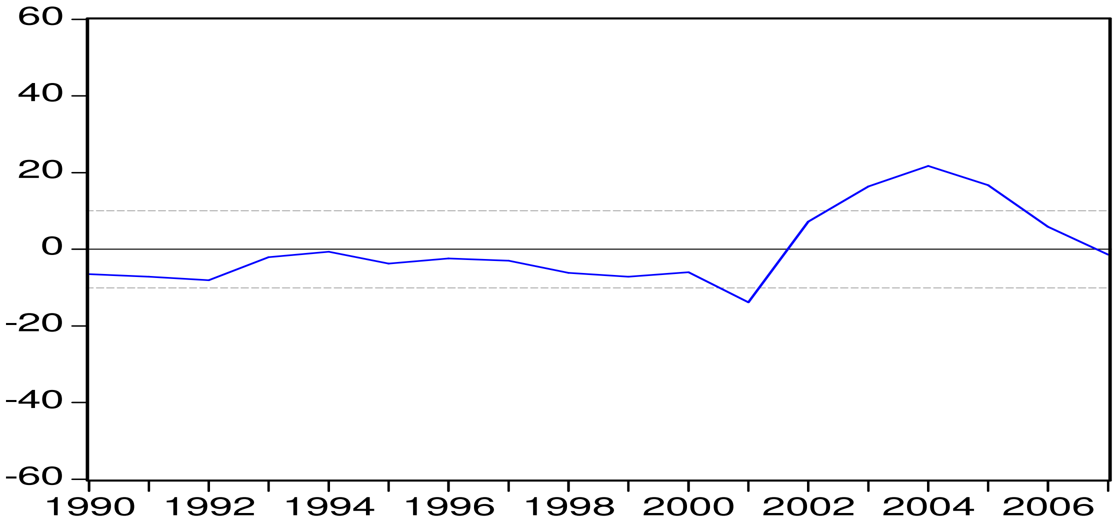


Figure 5.4: Residuals of real feed price equation

5.3.5 Real Maintenance and Repairs Demand

The results of the ADL (1) and the nested models for real maintenance and repairs demand are presented in Table 5.8. The results of various models show that the partial adjustment model fits the data very well. All the variables included in the model are statistically significant and display the expected signs. While the rise in the price of repairs and maintenance reduces the demand, the increase of the gross capital formation, which is used as a proxy for the activities in the sector, augments the demand. The Chow break point test, which shows a break in 1993, is also significant in the equation. The demand for maintenance and repairs is price inelastic. A ten percent increase of own price would reduce the demand by only 2.7%. The demand also increases by 1.1%, for a ten percent increase in gross capital formation.

Table 5.8: ADL (1) Model for real maintenance and repairs demand

VARIABLE	5.5A	5.5B	5.5C	5.5D	5.5E
CONSTANT	433.00 (1.04)	2,899.00 (7.30)	2,791.00 (19.19)	2,809.89 (19.27)	2,800.67 (18.10)
RMAREPD(-1)	0.80 (5.67)	-0.04 (-0.33)			
RGCF	0.07 (1.36)	0.03 (0.97)	0.03 (1.15)		0.07 (2.88)
RGCF(-1)	-0.09 (-1.58)	0.07 (1.74)	0.06 (1.9)	0.08 (3.39)	
RMRP	1.26 (0.18)	-10.34 (-2.7)	-8.53 (-4.8)	-8.33 (-4.67)	-7.42 (-4.15)
RMRP(-1)	0.59 (0.08)	1.53 (0.44)			
SHIFT93		508.37 (7.32)	488.45 (14.04)	504.00 (15.60)	469.95 (2.88)
R^2	0.66		0.92	0.92	0.91

Note: t-statistics are given in parentheses.

$$RMAREPD = \underset{(18.10)}{2800.67} + \underset{(4.15)}{0.07}\, RGCF - \underset{(2.88)}{7.42}\, RMRP\,(-1) + \underset{(13.22)}{469.95}\, SHIFT93 \qquad (5.5E)$$

$$Adj.\ R^2 = 0.91 \qquad T = (1985\text{-}2008)$$

The diagnostic tests performed on the residual of equation 5.3E shows that the classical assumptions of the OLS are not violated.

Table 5.9: Misspecification test for real maintenance and repairs demand equation 5.5E

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	0.43	0.80
Serial Correlation	Ljung Box Q	Q(12)	6.75	0.87
	Breusch-Godfrey	$N*R^2$ (2)	0.26	0.77
	Breusch-Godfrey	$N*R^2$ (1)	0.22	0.64
Homoscedasticity	ARCH LM	$N*R^2$ (1)	0.00	0.96
	ARCH LM	$N*R^2$ (2)	0.08	0.92
	White	$N*R^2$ (1)	0.62	0.68
Misspecification	Ramsey RESET	LR(1)	1.54	0.22
	Ramsey RESET	LR(2)	0.79	0.46
Parameter Stability	Recursive Estimates			

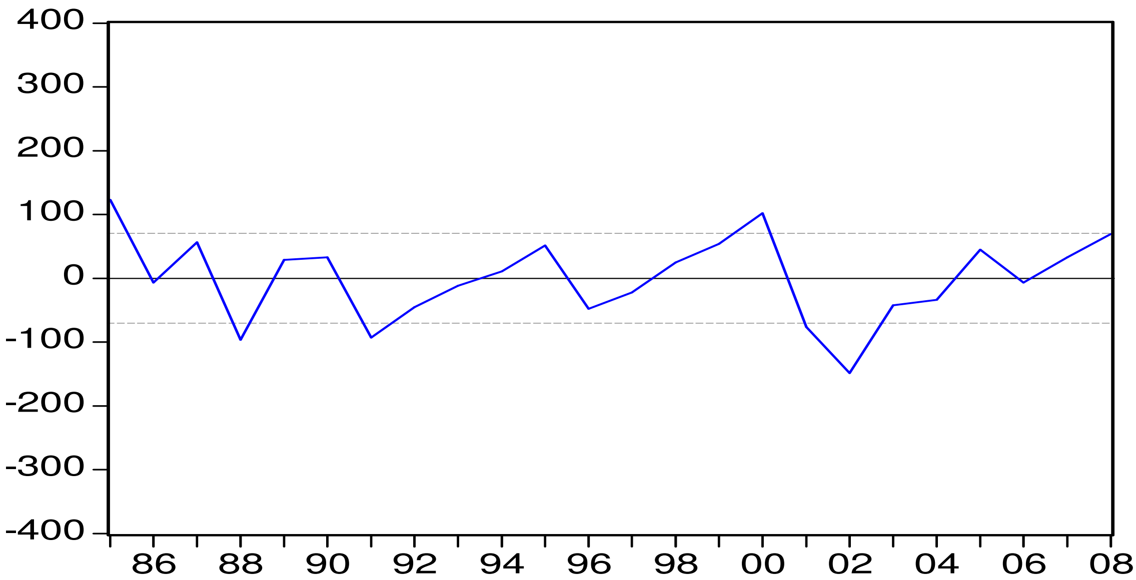


Figure 5.5: Residuals of real maintenance and repairs demand equation 5.5E

5.3.6 Real Farm Services Expenditure

The results of ADL (1) and various nested models for the estimated real farm services expenditure are given in Table 5.10. From the results, the autoregressive model with trend and lagged agricultural income fits the data well. The model explains 98% of the variation in the expenditure during the specified period of time.

Table 5.10: ADL (1) Model for real farm services expenditure

VARIABLE	5.6A	5.6B	5.6C
CONSTANT	272.83 (0.98)	-56, 641 (-2.10)	-60,153 (-2.31)
RFASEXP(-1)	1.08 (27.36)	0.87 (7.99)	0.84 (8.48)
RGINC	-0.007 (-1.01)	-0.004 (-0.62)	
RGINC(-1)	0.002 (0.21)	0.008 (0.99)	0.0053 (0.8)
TREND		28.48 (2.11)	30.22 (2.32)
R^2	0.98	0.98	0.98

Note: t-statistics are given in parentheses.

$$RFASEXP = -60\ 153 + 0.84RFASEXP(-1) + 30.22\ TIME + 0.005\ RGINC(-1)$$
$$(-2.31) \quad (8.48) \quad (2.32) \quad (0.8) \quad (5.6C)$$

$Adj.\ R^2 = 0.98$ $\qquad T = (1982\text{-}2008)$

Table 5.11: Misspecification tests for the real farm services expenditure equation 5.6D

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	24.03	0.00***
Serial Correlation	Ljung Box Q	Q(12)	9.33	0.67
	Breusch-Godfrey	$N*R^2(2)$	1.96	0.16
	Breusch-Godfrey	$N*R^2(1)$	1.93	0.18
Homoscedasticity	ARCH LM	$N*R^2(1)$	0.02	0.89
	ARCH LM	$N*R^2(2)$	0.02	0.97
	White	$N*R^2(1)$	1.59	0.21
Misspecification	Ramsey RESET	LR(1)	0.10	0.75
	Ramsey RESET	LR(2)	1.41	0.26
Parameter Stability	Recursive Estimates			

The diagnostic test performed on the residual shows that the classical assumptions, except the normality, of the OLS are not violated. As noted in Gujarati (1995), the OLS estimators are best linear unbiased estimators (BLUE), regardless of the assumption of normality.

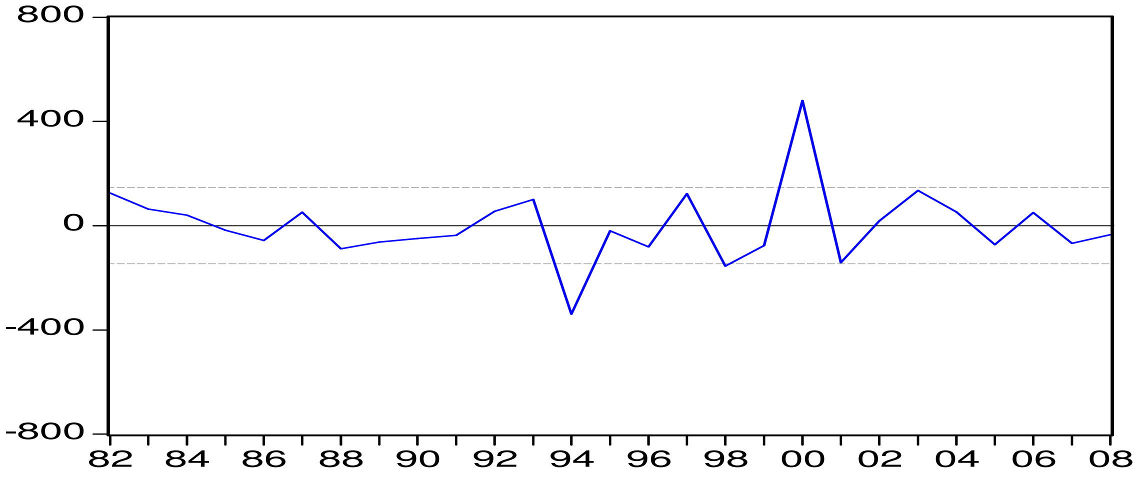


Figure 5.6: Residuals for the real farm services expenditure equation 5.6D

5.3.7 Nitrogen Consumption by Field Crops

The results of the estimated model of nitrogen consumption by field crops is given in equation 5.7. The result shows that nitrogen consumption soars with the increase in the nitrogen consumption share weighted area and a rise in field crop prices. A rise in nitrogen price, however, reduces consumption. The own price and weighted area elasticity show that a ten percent increase in the price will reduce consumption by 1.7% and an increase of the weighted area by ten percent will increase consumption by 5.6%. A 10% increase in field crop prices will also induce a 1.7% rise in nitrogen consumption.

$$NCONS = \underset{(-5.09)}{-15\,236\,305} - \underset{(-2.81)}{26.18}\,RUREAP + \underset{(5.36)}{103.51}\,NWAREA + \underset{(5.16)}{7684.08}\,TREND$$

$$+ \underset{(1.82)}{435.34}\,RPFC - \underset{(-2.75)}{40202.01}\,D02 \qquad (5.7)$$

$Adj.\ R^2 = 0.73$ $\qquad$ $T = (1995\text{-}2008)$

The diagnostic tests performed on the residual show that none of the classical assumptions are violated.

Table 5.12: Misspecification tests for nitrogen consumption equation 5.7

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	2.07	0.60
Serial Correlation	Ljung Box Q	Q(6)	3.55	0.59
	Breusch-Godfrey	$N*R^2(2)$	1.63	0.44
	Breusch-Godfrey	$N*R^2(1)$	1.37	0.24
Homoscedasticity	ARCH LM	$N*R^2(1)$	1.01	0.31
	ARCH LM	$N*R^2(2)$	2.44	0.29
	White	$N*R^2(1)$	2.09	0.46
Misspecification	Ramsey RESET	LR(1)	0.08	0.94
	Ramsey RESET	LR(2)	2.35	0.41
Parameter Stability	Recursive Estimates			

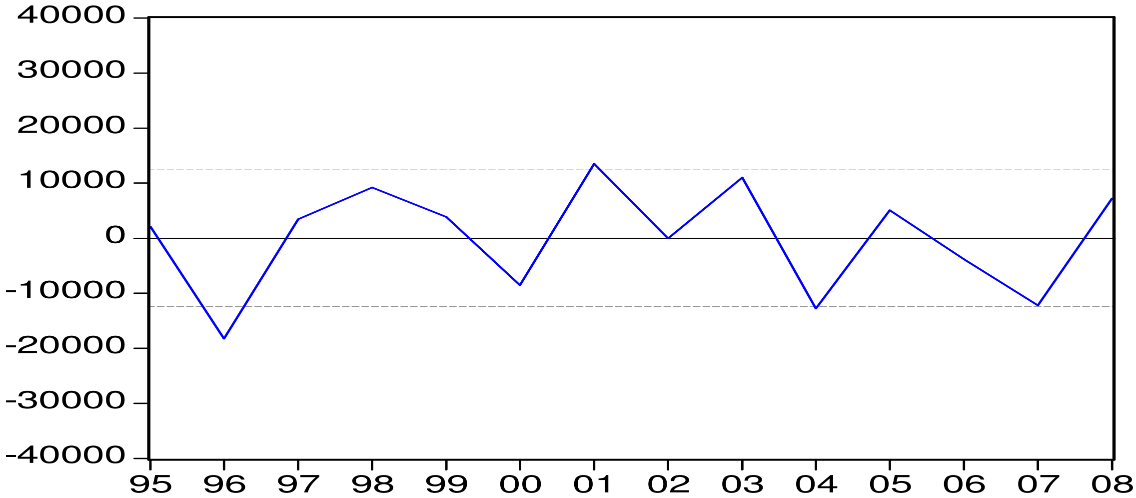


Figure 5.7: Residuals of nitrogen consumption by field crops equation 5.7

5.3.8 Phosphorous Consumption by Field Crops

The results of the estimated model of phosphorus consumption by field crops is given in equation 5.8. As expected, a rise in the phosphorous price reduces consumption and an increase in the phosphorous weighted area increases consumption. A ten percent increase in own price reduces phosphorous consumption by 1% and a ten percent increase in weighted area will increase consumption by 6.7%. Field crop price, however, was not found to have influence on the phosphorous consumption.

$$
\begin{array}{lllll}
PCONS = 24\,999.21 & -\ 1.38\ RPHOSP & +\ 33.17PAREA & -\ 7630.47D01 & (5.8) \\
\quad (3.23) & (-1.9) & (5.98) & (-2.11) & \\
Adj.\ R^2 = 0.79 & & & T = (1995\text{-}2008) &
\end{array}
$$

The diagnostic test performed on the residual of equation 5.8 shows that none of the classical assumptions of the OLS are violated.

Table 5.13: Misspecification tests for phosphorous consumption equation 5.8

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	1.87	0.38
Serial Correlation	Ljung Box Q	Q(6)	1.56	0.95
	Breusch-Godfrey	$N*R^2(2)$	0.38	0.34
	Breusch-Godfrey	$N*R^2(1)$	0.06	0.79
Homoscedasticity	ARCH LM	$N*R^2(1)$	0.02	0.24
	ARCH LM	$N*R^2(2)$	0.88	0.64
	White	$N*R^2(1)$	3.62	0.39
Misspecification	Ramsey RESET	LR(1)	0.39	0.53
	Ramsey RESET	LR(2)	0.54	0.76
Parameter Stability	Recursive Estimates			

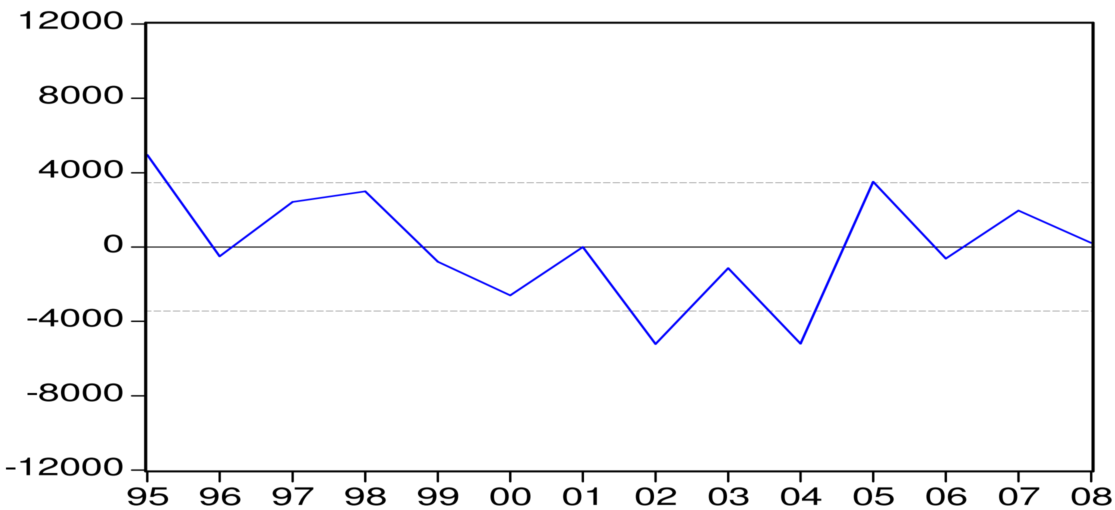


Figure 5.8: Residuals of phosphorous consumption by field crops equation 5.8

5.3.9 Potassium Consumption by Field Crops

The results of the estimated model for potassium consumption is given in equation 5.9. As expected, consumption is positively affected by the expansion of planted area and influenced negatively by the rise in its own price. The own price and field crops price elasticity of potassium consumption are -0.39 and 0.45 respectively. Thus, a ten percent increase in own price and field crop price would decrease the consumption by 3.9% and increase it by 4.5% respectively.

$$KCONS = \underset{(-1.37)}{-77599.59} + \underset{(2.41)}{337.96}SCAREA - \underset{(-1.8)}{15.89}RKP(-1) + \underset{(2.09)}{258.43}RFCP + \underset{(2.54)}{11604.88}D99 + \underset{(2.05)}{10368.66}D05 \quad (5.9)$$

$Adj.\ R^2 = 0.48$ $\qquad$ $T = (1992-2007)$

The diagnostic tests on the residual of equation 5.9 show that none of the classical assumptions are violated.

Table 5.14: Misspecification tests for potassium consumption equation 5.9

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	2.66	0.43
Serial Correlation	Ljung Box Q	Q(6)	1.96	0.92
	Breusch-Godfrey	$N*R^2(1)$	0.25	0.61
Homoscedasticity	ARCH LM	$N*R^2(1)$	0.67	0.21
	ARCH LM	$N*R^2(2)$	2.07	0.35
	White	$N*R^2(1)$	6.96	0.12
Misspecification	Ramsey RESET	LR(1)	1.53	0.21
	Ramsey RESET	LR(2)	2.07	0.35
Parameter Stability	Recursive Estimates			

Notes: *** 1% significant level, **: 5% significant level.

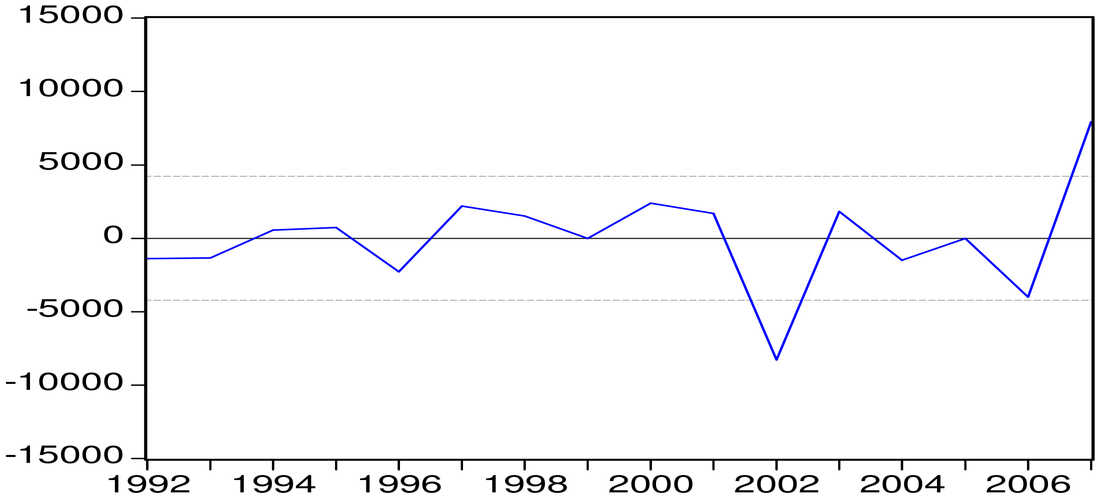


Figure 5.9: Residual of potassium consumption equation 5.9

5.3.10 Potassium Price

The result of the price transmission of domestic potassium price equation is presented in equation 5.10. A rise in the world price and depreciation of the exchange rate will increase the domestic potassium price. Moreover, the effect of the 'cash availability' of producers on domestic price is positive. Hence, it indicates input providers have the market power to charge more for inputs if they realised producers have obtained enough cash during the previous season. This behaviour is among the issues that have been investigated by the Competition Commission recently. The price elasticity for the transmission and cash availability are 0.56 and 0.24 respectively. Thus, a ten percent increase in world potassium price (in terms of Rand) and in gross income by field crops would cause the domestic price to increase by 5.6% and 2.4% respectively.

$$RPOTP = \underset{(3.01)}{415.14} + \underset{(30.34)}{1.34}\, RWPP*EXCH + \underset{(3.58)}{0.034}RGINCFC\,(-1) \qquad (5.10)$$

$Adj.\ R^2 = 0.98$ $\qquad T = (1995 - 2008)$

None of the classical assumptions of OLS are violated, as shown in the diagnostic tests of the residual given in Table 5.15.

Table 5.15: Misspecification tests for real potassium price equation

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	0.25	0.87
Serial Correlation	Ljung Box Q	Q(6)	1.58	0.95
	Breusch-Godfrey	$N*R^2(1)$	0.33	0.56
Homoscedasticity	ARCH LM	$N*R^2(1)$	1.41	0.23
	ARCH LM	$N*R^2(2)$	1.73	0.42
	White	$N*R^2(1)$	2.90	0.57
Misspecification	Ramsey RESET	LR(1)	1.05	0.30
	Ramsey RESET	LR(2)	1.26	0.53
Parameter Stability	Recursive Estimates			

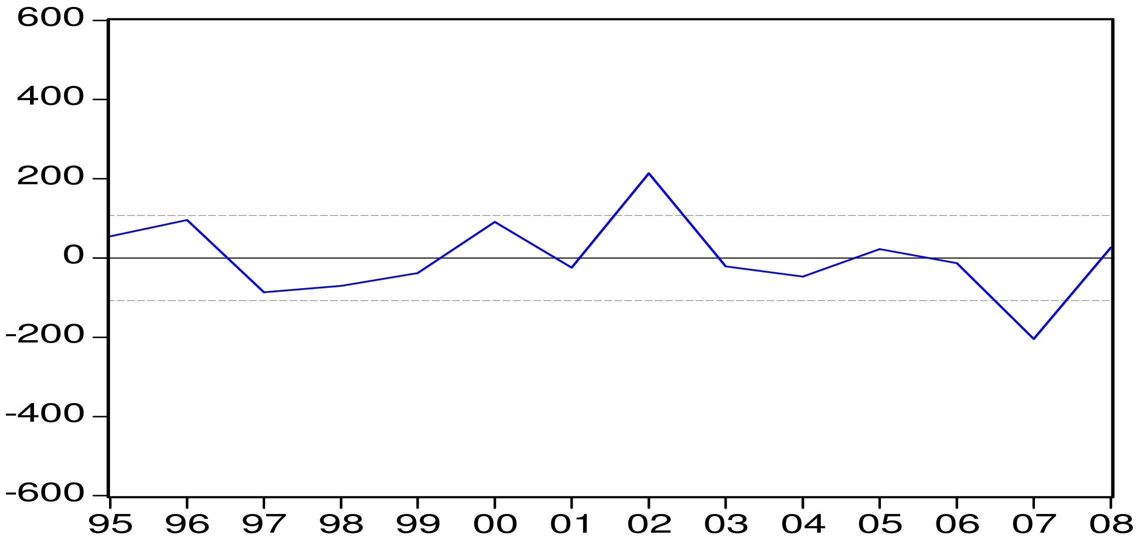


Figure 5.10: Residuals for real potassium price equation

5.3.11 Phosphorous Price

The estimation results of the model specified for the price transmission of domestic phosphorous price equations is given in equation 5.11. The rise of world price, depreciation of the Rand and cash availability of producers increases the domestic price. Thus, similar to the domestic potassium fertiliser prices, the result shows the input suppliers' response to higher income by setting domestic prices higher, which could be attributed to the market structure of fertiliser producers in the country. The price transmission elasticity is higher than the other fertiliser prices. A 10% increase in world price would cause a 7.7% rise in phosphorous price. Moreover, an increase by 10% in 'cash availability' would cause a simultaneous 1.7% increase in the domestic phosphorous price.

$$RPHOSP = \underset{(0.79)}{146.46} + \underset{(33.3)}{1.48}\ RPHWP*EXC + \underset{(2.77)}{0.03}\ RGINCFC(-1) \qquad (5.11)$$

$$Adj.R^2 = 0.99 \qquad T = (1996 - 2008)$$

The diagnostic test performed in the residual of equation 5.11 shows that most of the classical assumptions of OLS are not violated.

Table 5.16: Misspecification test for phosphorous price equation

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	0.56	0.75
Serial Correlation	Ljung Box Q	Q(6)	6.13	0.40
	Breusch-Godfrey	$N*R^2(1)$	2.58	0.11
Homoscedasticity	ARCH LM	$N*R^2(1)$	0.00	0.96
	ARCH LM	$N*R^2(2)$	1.75	0.41
	White	$N*R^2(1)$	7.07	0.13
Misspecification	Ramsey RESET	LR(1)	3.84	0.05**
	Ramsey RESET	LR(2)	4.00	0.13
Parameter Stability	Recursive Estimates			

Notes: *** 1% significant level, **: 5% significant level

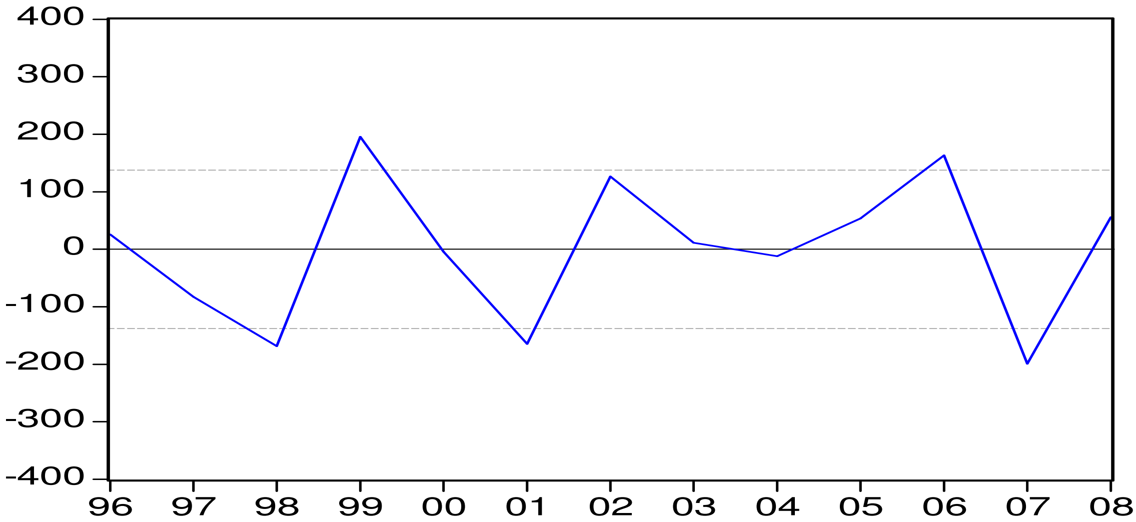


Figure 5.11: Residuals of real phosphorous equation

5.3.12 Nitrogen Price

The estimation result of the specified model for the price transmission of domestic nitrogen price equation is given in equation 5.12. As expected, a rise in world price or depreciation of exchange rate increases the domestic price. Moreover, the cash availability of farmers, though statistically insignificant, shows a positive effect on the domestic price, which suggests that input prices are set higher in response to cash availability. The elasticity of the price transmission from the world price (in terms of Rand) is 0.59 and from 'cash availability' is 0.114. Thus, a 10% increase in world price (in terms of Rand) and cash availability will cause the domestic price to increase by 6 and 1.14% respectively.

$$RNP = 589.60 + 1.31\ RWNP*EXCH + 0.012\ RGINCFC(-1) \qquad (5.12)$$
$$(3.06) \qquad (15.52) \qquad\qquad (1.3)$$
$$Adj.\ R^2 = 0.96 \qquad T = (1995 - 2008)$$

The diagnostic test on the residual of equation 5.12 shows that the classical assumptions are not violated.

Table 5.17: Misspecification test for real nitrogen price equation

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	2.18	0.33
Serial Correlation	Ljung Box Q	Q(6)	1.2	0.97
	Breusch-Godfrey	$N^*R^2(2)$	3.41	0.18
	Breusch-Godfrey	$N^*R^2(1)$	1.76	0.18
Homoscedasticity	ARCH LM	$N^*R^2(1)$	0.20	0.65
	ARCH LM	$N^*R^2(2)$	1.03	0.59
	White	$N^*R^2(1)$	2.52	0.64
Misspecification	Ramsey RESET	LR(1)	2.79	0.10
	Ramsey RESET	LR(2)	5.96	0.05**
Parameter Stability	Recursive Estimates			

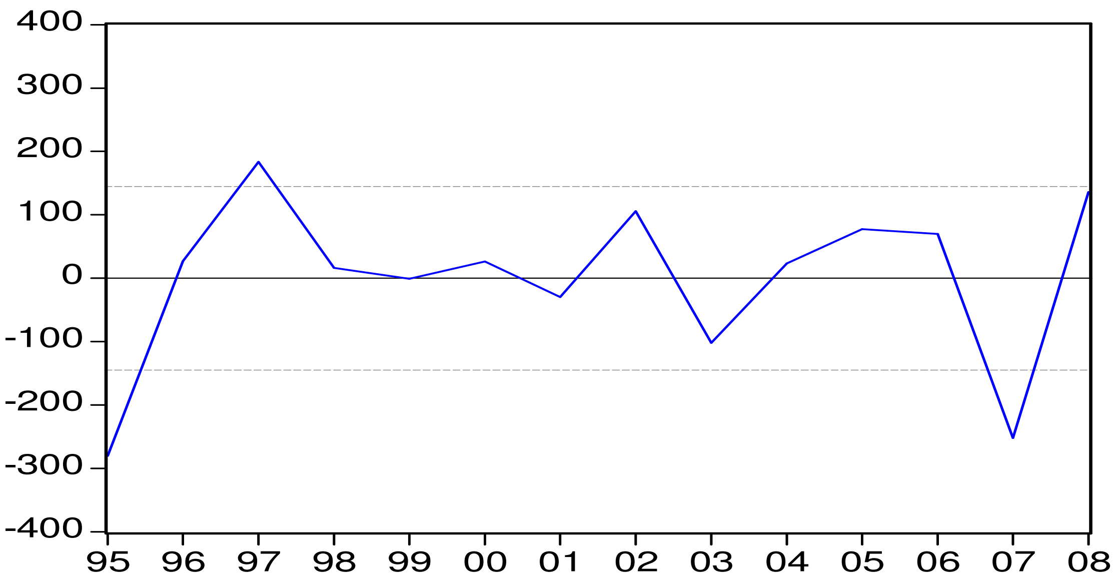


Figure 5.12: Residuals for real nitrogen price equation

5.3.13 Real Fertiliser Price

The result of the estimated model for real aggregate fertiliser price index is given in equation 5.13. As expected, the aggregate price for all fertilisers, which was constructed using a weight based on the consumption share for each fertilisers displays the expected signs and is highly significant. In addition, the elasticity of the aggregate price index to the actual constructed aggregate fertiliser price is close to unity.

$$RFERTINDEX = \underset{(4.87)}{22.87} + \underset{(19.65)}{0.04}AFERTP \qquad (5.13)$$

$$Adj.\ R^2 = 0.96 \qquad T = 1991\text{-}2008$$

The diagnostic test on the residual of equation 5.16 shows that the classical assumptions are not violated.

Table 5.18: Misspecification tests for real fertiliser price equation

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	0.56	0.75
Serial Correlation	Ljung Box Q	Q(6)	4.35	0.62
	Breusch-Godfrey	$N*R^2(1)$	1.21	0.27
Homoscedasticity	ARCH LM	$N*R^2(1)$	0.03	0.86
	ARCH LM	$N*R^2(2)$	1.13	0.57
	White	$N*R^2(1)$	5.29	0.07
Misspecification	Ramsey RESET	LR(1)	0.59	0.44
	Ramsey RESET	LR(2)	0.77	0.67
Parameter Stability	Recursive Estimates			

This equation is also among the input prices equation that links the input model with the output model. The area response equation used in the output model uses fertiliser prices (a proxy for variable costs) as its determinant. The model specified in this equation will be linked with the area response equation in the output model. Thus, all the effects of the determinants of each fertiliser price (world price, exchange rate and cash availability) on the output sector are captured and endogenised in the integrated model.

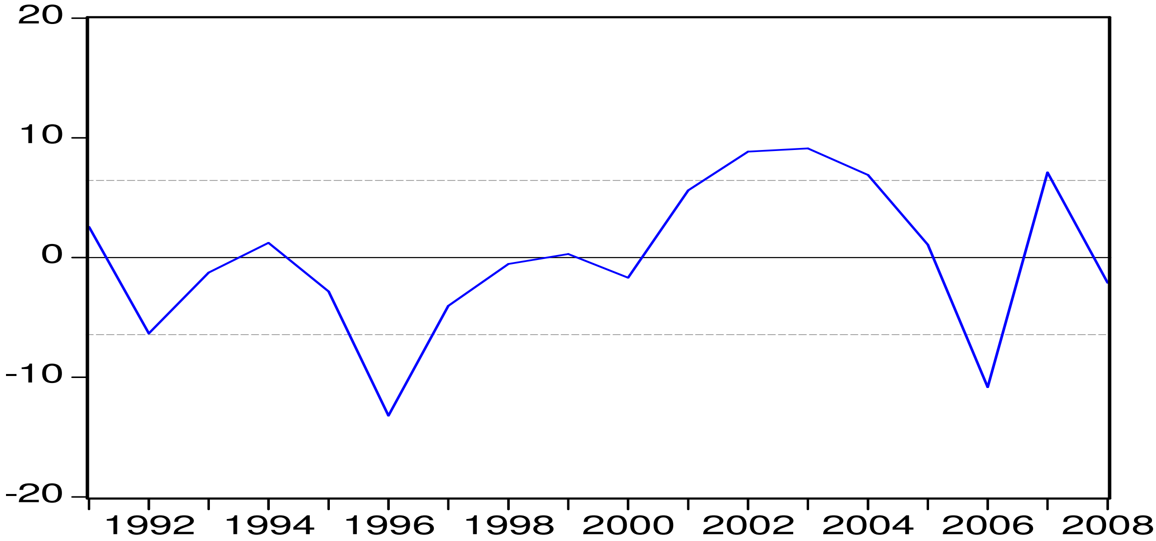


Figure 5.13: Residuals of fertiliser price equation

5.3.14 World Fertiliser Price

Due to the lack of a projected world fertiliser prices, its forecasted value is estimated using world oil prices and area allocated by major world fertiliser consumer countries (China, India, EU, USA and Brazil) as its determinants. Area allocated for each commodity is weighted according to the fertiliser consumption share of each country. The data for the weight is obtained from IFA and the projections of area planted for each commodity in each country are obtained form the projections of FAPRI. A recent study by Chen *et al.,* (2010) also found that crude oil price significantly determines world fertiliser prices.

The result of the world fertiliser price estimations are given in equations 5.14 – 5.16. Due to the limited span of dataset, only economically significant variables are used to evaluate the model. The variables included in the model show the expected signs and all the equations have adjusted R^2 more than 0.79. Hence, it would be adequate to use the model for projecting world fertiliser prices.

Potassium price equation:

$$WKP = -1630.66 + 0.04WKAREA + 6.03\ OIL - 191.20D07 \qquad (5.14)$$
$$(-1.55) \quad (1.46) \quad (4.3) \quad (-1.96)$$
$$Adj.\ R^2 = 0.79 \qquad T = (1999\text{ -}2008)$$

Nitrogen price equation:

$$WNP = -65.44 + 5.48\ OIL + 0.00056\ WNAREA \qquad (5.15)$$
$$(-0.2) \quad (11.56) \quad (0.08)$$
$$Adj.R^2 = 0.95 \qquad T = (1999\text{ -}2008)$$

Phosphorous price equation:

$$WPHP = -894.15 + 9.08\ OIL + 0.018\ WPHAREA - 216.49\ D06 \qquad (5.16)$$
$$(-0.83) \quad (5.38) \quad (0.73) \quad (-3.2)$$
$$Adj.\ R^2 = 0.83 \qquad T = (1999\text{ -}2008)$$

5.3.15 Total Fertiliser Expenditure

Once the individual prices and quantities of each fertiliser group are estimated, the following formula is used to calculate the fertiliser expenditure by major field crops.

$$RFERTEXPFC = (NCONSU*RNP) + (PCONSU*RPHP) + (KCONS*RKP) \qquad (5.17)$$

Then, the fertiliser expenditure by the agricultural sector as reported in DAFF is estimated using the estimated field crop fertiliser consumption. Equation 5.18 displays the result of the estimation. The variable in the model is statistically significant and shows the expected signs. As expected, the elasticity of the total fertiliser expenditure by the sector to the field crops fertiliser expenditure is close to one.

$$RFERTEXPE = 306.63 + 2.65\ RFEXPFC - 810.57D05 \qquad (5.18)$$
$$(1.05) \quad (7.45) \quad (-3.48)$$
$$Adj.\ R^2 = 0.77 \qquad T = (1991\text{ -}2007)$$

The diagnostic tests on the residual of equation 5.18 show that none of the classical assumptions of OLS are violated.

Table 5.19: Misspecification tests for total fertiliser consumption equation

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	4.52	0.11
Serial Correlation	Ljung Box Q	Q(6)	0.33	0.99
	Breusch-Godfrey	$N*R^2(2)$	1.63	0.23
	Breusch-Godfrey	$N*R^2(1)$	0.61	0.45
Homoscedasticity	ARCH LM	$N*R^2(1)$	1.09	0.31
	ARCH LM	$N*R^2(2)$	0.58	0.57
	White	$N*R^2(1)$	2.64	0.11
Misspecification	Ramsey RESET	LR(1)	0.33	0.57
	Ramsey RESET	LR(2)	1.21	0.33
Parameter Stability	Recursive Estimates			

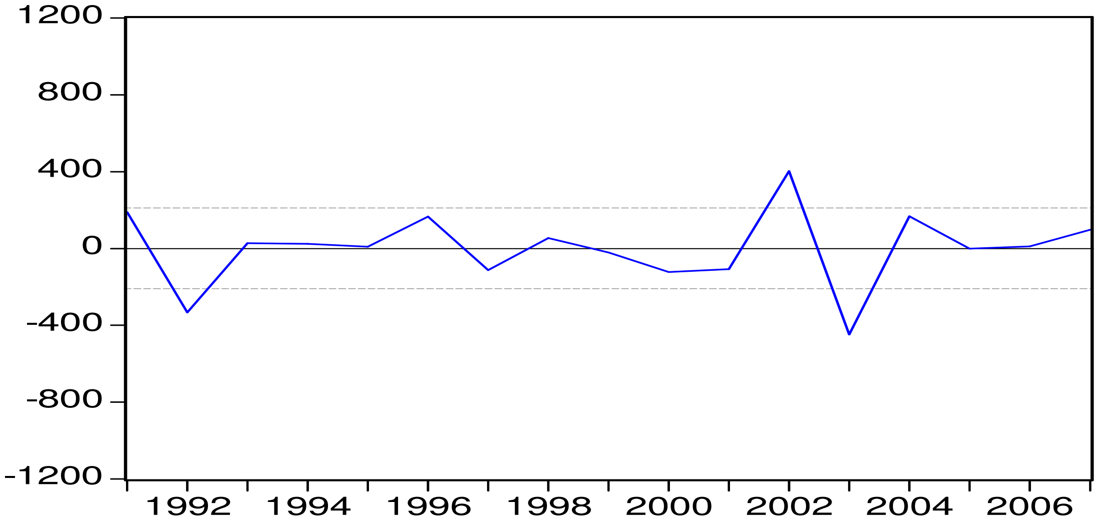


Figure 5.14: Residual of aggregate fertiliser expenditure

5.4 Real Own Construction

The results of ADL (1) and nested models of real own construction are given in Table 5.20. Of all the models estimated, the partial adjustment model with time trend fits the data very well. All the variables included in the model are statistically significant and show the expected signs. As expected, real gross capital formation of fixed improvements

(RGCFFIX) influences the value of own construction positively. The short- and long-run elasticity of RCCFFIX are 0.5 and 0.62 respectively. Thus, a 10% increase in RGCFFIX would increase own construction by 5% in the short run and 6.2% in the long run.

Table 5.20: ADL (1) Model for real own construction

VARIABLE	5.19A	5.19B	5.19C
CONSTANT	27.72 (0.43)	-23,205.7 (-2.90)	-25,815.18 (-4.14)
ROCONS(-1)	1.03 (40.71)	0.72 (6.56)	0.684 (7.77)
RGCFFIX	0.23 (2.42)	0.23 (2.73)	0.20 (3.48)
RGCFFIX(-1)	-0.24 (-2.6)	-0.056 (-0.54)	
TREND			12.90 (3.48)
R^2	0.98	0.98	0.98
	T = (1975-2008)		

Note: t-statistics are given in parentheses.

$$ROCONS = \underset{(-4.14)}{-25815.18} + \underset{(7.77)}{0.684}ROCONS(-1) + \underset{(3.48)}{0.2}\,RGCFFIX + \underset{(3.48)}{12.9}\,TREND \qquad (5.19C)$$

$$Adj.R^2 = 0.98 \qquad\qquad T = (1975-2008)$$

The classical assumptions of OLS are not violated, as shown in the diagnostic tests of equation 5.19C. As noted in Gujarati (1995), the OLS estimators are BLUE, regardless of the assumption of normality.

Table 5.21: Misspecification tests for real own construction equation 5.19C

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	11.87	0.002***
Serial Correlation	Ljung Box Q	Q(12)	4.66	0.97
	Breusch-Godfrey	$N*R^2(2)$	0.07	0.93
	Breusch-Godfrey	$N*R^2(1)$	0.00	0.97
Homoscedasticity	ARCH LM	$N*R^2(1)$	0.06	0.81
	ARCH LM	$N*R^2(2)$	0.16	0.85
	White	$N*R^2(1)$	1.85	0.13
Misspecification	Ramsey RESET	LR(1)	0.00	0.97
Parameter Stability	Recursive Estimates			

Notes: ***: 1% significant level; **: 5% significant level

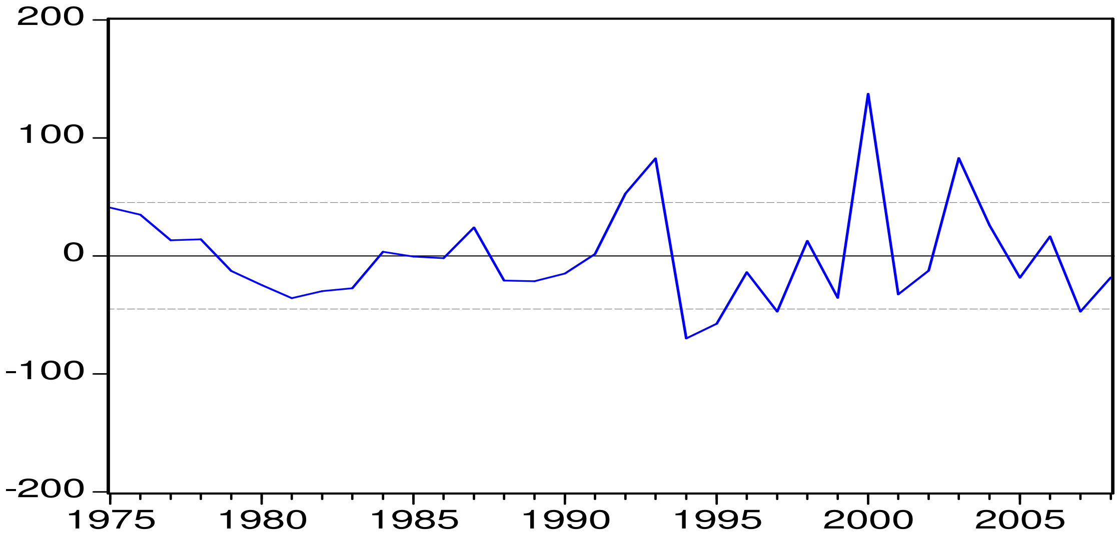


Figure 5:15: Residuals of real own construction equation 5.19C

5.5 Real Gross Capital Formation in Fixed Improvement

The results of ADL (1) and various nested models for the gross capital formation of fixed improvement are given in Table 5.22. The result shows that a partial adjustment model with lagged interest rate fits the data very well. All the variables included in the model are statistically significant and they explain 90% of variation in the capital formation during the estimated period. As expected, the rise in real interest rate and the price of fixed improvement deter the gross capital formation of fixed improvement. The real gross income, however, is found insignificant but holds the expected sign. The Chow break point test, which shows a structural break in 1993, is also significant in the equation. The short and long run elasticities of the real interest rate are -0.04 and -0.31 respectively. Thus, a rise of real interest rate by 10% would decrease the capital formation in the short run by 0.4 and in the long run by 3.1%. The own price elasticity in the short and long run is -0.31 and -1.46 respectively. Thus, gross capital formation of fixed improvement is highly responsive to its own price in the long run.

Table 5.22: ADL (1) Model for the real gross capital formation: fixed improvement

VARIABLE	5.20A	5.20B	5.20C
CONSTANT	186.98 (0.51)	623.32 (2.00)	946.44 (3.49)
RGCFFIX(-1)	0.911 (9.00)	0.85 (11.10)	0.77 (11.28)
RINT	8.77 (1.33)	0.58 (0.10)	
RINT(-1)	-7.48 (-1.10)	-11.15 (-2.03)	-11.24 (-2.30)
RPFIX	-10.49 (-1.55)	-14.31 (-3.07)	-6.74 (-2.40)
RPFIX(-1)	12.38 (1.77)	10.9 (1.99)	
RGINC	0.0035 (0.69)	-0.0012 (-0.34)	0.0016 (0.5)
RGINC(-1)	-0.008 (-1.22)		
SHIFT93		209.75 (3.76)	227.95 (4.32)
R^2	0.86	0.91	0.90

Note: t-statistics are given in parentheses.

$$RGCFFIX = \underset{(3.5)}{946.44} + \underset{(11.28)}{0.77}\, RGCFIX(-1) - \underset{(-2.3)}{11.24}\, RINT(-1) - \underset{(-2.4)}{6.74}\, PFIX +$$

$$\underset{(0.5)}{0.0016}\, RGINC + \underset{(4.32)}{227.95}\, SH93 \qquad (5.20C)$$

$$R^2 = 0.91 \qquad T = (1980 - 2008)$$

The diagnostic test on the residual of equation 5.20C shows a non-violation of all the classical OLS assumptions, except normality. As noted in Gujarati (1993), the OLS estimators are BLUE, regardless of the assumption of normality.

Table 5.23: Misspecification tests for real gross capital formation: fixed improvement equation 5.20C

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	23.48	0.00***
Serial Correlation	Ljung Box Q	Q(12)	12.17	0.43
	Breusch-Godfrey	$N*R^2$(2)	5.32	0.07
	Breusch-Godfrey	$N*R^2$(1)	0.19	0.66
Homoscedasticity	ARCH LM	$N*R^2$(1)	0.015	0.90
	ARCH LM	$N*R^2$(2)	0.13	0.93
	White	$N*R^2$(1)	13.11	0.07
Misspecification	Ramsey RESET	LR(1)	3.82	0.05**
	Ramsey RESET	LR(2)	10.57	0.00***
Parameter Stability	Recursive Estimates			

Notes: ***: 1% significant level, **: 5% significant level.

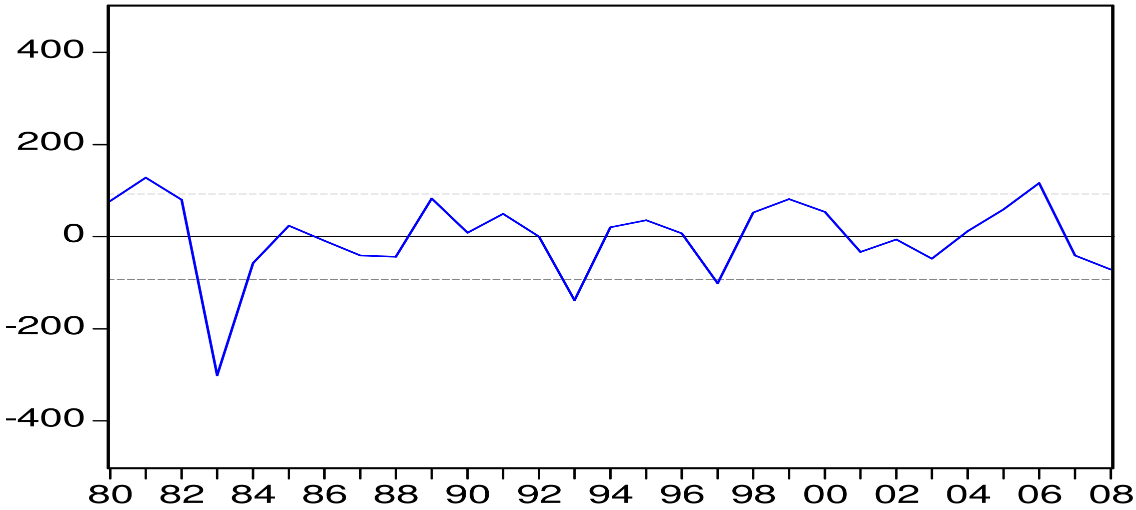


Figure 5.16: Residuals of real gross capital information: fixed improvement

5.6 Real Gross Capital Formation in Machinery Tractors and Implements

The results of the ADL (1) and nested models of real gross capital formation for machinery, tractors and implements (RGCFMTI) estimation are given in Table 5.24. Of all estimated models, the partial adjustment model fits the data very well. The gross income of the sector, however, is found significant in the equation, unlike in the capital formation of fixed improvement equation. As expected, the increase in real price of machinery, tractors and implements (RPMTI) reduces the RGCFMTI and the rise in gross income augments RGCFMTI. The rise in interest rate also deters the gross capital formation, though it is statistically insignificant in the equation. The short and long run own price elasticities are -0.55 and -1.10 respectively. Similarly, the short and long run income elasticities of RGCFMTI are 0.62 and 1.24 respectively. Thus, RGCFMTI is elastic in the long run for both own price and income elasticities. For interest rate elasticity of the gross capital formation in the short and long run is -0.03 and -0.06 respectively. Thus, the result of the model shows that the profitability of the agricultural sector and the price of the equipments play a key role in determining investment in machineries, tractors and implements than the cost of financing the purchase.

Table 5.24: ADL (1) Model for the real gross capital formation: MTI

VARIABLE	5.21A	5.21B	5.21C	5.21D
CONSTANT	1,643.62 (1.08)	1,408.00 (1.61)	1,466.00(1.58)	1,466.62 (1.61)
RGCFMTI(-1)	0.72 (4.12)	0.63 (6.24)	0.49 (6.23)	0.49 (6.42)
RINT	-14.1 (-0.31)	7.04 (0.26)		
RINT(-1)	-55.25 (-1.24)	-31.77 (-1.22)	-19.86 (-0.92)	-19.87 (-0.94)
RPMTI	-35.26 (-1.15)	-19.49 (1.09)	-21.46 (-1.12)	-21.51 (-2.37)
RPMTI(-1)	27.56 (0.89)	-31.77 (-1.22)	-0.05 (-0.003)	
RGINC	0.10 (3.56)	0.07 (4.37)	0.04 (3.41)	0.04 (3.56)
RGINC(-1)	-0.09 (-2.01)	-0.06 (-2.36)		
D8081		2,666.00 (7.00)	2,779.00 (6.84)	2,779.00 (6.99)
R^2	0.81	0.92	0.93	0.93

Note: t-statistics are given in parentheses.

$$RGCFT = 1466.62 + \underset{(6.42)}{0.497\,RGCFT(-1)} - \underset{(-0.94)}{19.87\,RINT(-1)} - \underset{(-2.37)}{21.51\,RPMTI} +$$

$$\underset{(3.56)}{0.044RGINC} + \underset{(6.99)}{2779D8081} \quad (5.21D)$$

$Adj.\ R^2 = 0.93$ $\qquad T = (1976 - 2008)$

The diagnostic test on the classical assumptions of OLS on the residual of equation 5.21D shows that they are not violated.

Table 5.25 Misspecification tests for real gross capital formation: machinery, tractors and implements equation 5.21D

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	0.63	0.72
Serial Correlation	Ljung Box Q	Q(12)	8.47	0.75
	Breusch-Godfrey	$N*R^2(2)$	0.99	0.38
	Breusch-Godfrey	$N*R^2(1)$	0.12	0.73
Homoscedasticity	ARCH LM	$N*R^2(1)$	0.38	0.54
	ARCH LM	$N*R^2(2)$	0.16	0.85
	White	$N*R^2(1)$	1.07	0.42
Misspecification	Ramsey RESET	LR(1)	0.03	0.85
	Ramsey RESET	LR(2)	0.31	0.74
Parameter Stability	Recursive Estimates			

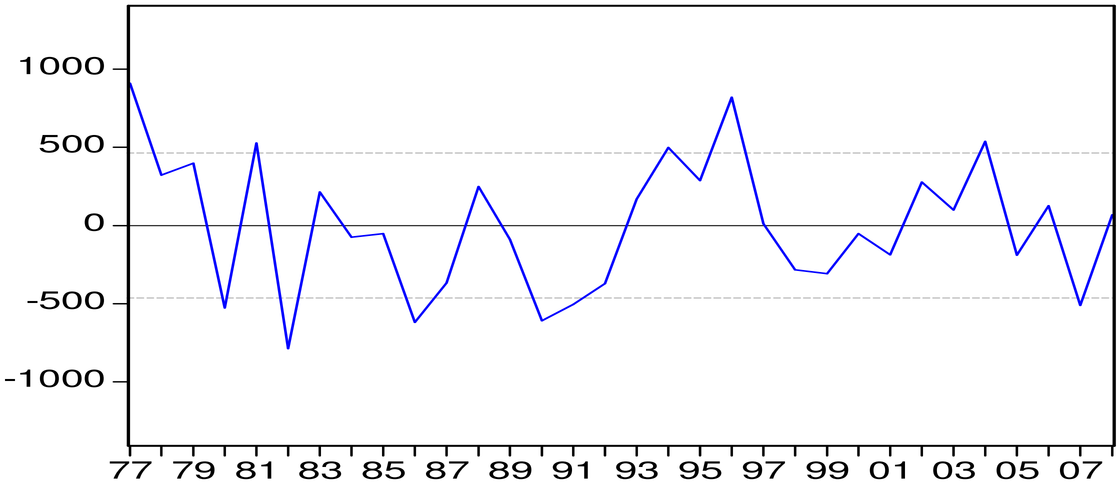


Figure 5.17: Residuals of real gross capital formation: machinery, tractors and implements equation 5.21D

5.7 Real Rent Paid

The results of the ADL (1) and nested models equation for real rent paid are given in Table 5.26. For the estimated models, the partial adjustment model fits the data very well. The short run area elasticity of rent paid is 0.3. Thus, a 10% increase in planted area would result in a 3% increase in real rent paid. In the long run, however, the elasticity remains unitary. Similarly, the elasticity of rent paid to field crop prices is 0.4. Hence, a 10 % increase in field crop prices will trigger a 4% rise in rent paid.

Table 5.26: ADL (1) Model for the real rent paid

VARIABLE	5.22A	5.22B	5.22C
CONSTANT	-204.03 (-2.35)	-.208.77 (-0.64)	- 10.54 (-0.25)
RRENTP(-1)	0.83 (5.31)	0.76 (4.56)	0.68 (6.24)
AREA	0.04 (1.30)	0.02 (0.64)	0.02 (1.83)
AREA(-1)	0.01 (0.56)	0.02 (0.72)	
PFC/CPI	1.78 (2.53)	0.72 (1.25)	0.89 (2.37)
PFC(-1)/CPI(-1)	-2.11 (-2.28)		
R^2	0.93	0.92	0.93

Note: t-statistics are given in parentheses.

$$RRENTP = -10.54 + 0.68\ RRENTP(-1) + 0.02\ AREA - 0.89 RPFC \qquad (5.22C)$$
$$\qquad (-0.25) \quad (6.24) \qquad\qquad (1.83) \qquad (2.37)$$

$R^2 = 0.93$ $\qquad\qquad T = (1979 - 2007)$

The classical assumptions of OLS, except homoscedasticity, are not violated. Hence, White heteroscedasticity-consistent variances and standard errors are used to address the problem. The re-estimated model shows that all the variables still remain significant in the equation.

Table 5.27: Misspecification tests for real rent paid equation 5.22C

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	1.02	0.53
Serial Correlation	Ljung Box Q	Q(12)	9.92	0.62
	Breusch-Godfrey	$N*R^2(2)$	0.14	0.93
	Breusch-Godfrey	$N*R^2(1)$	0.03	0.85
Homoscedasticity	ARCH LM	$N*R^2(1)$	3.26	0.07
	ARCH LM	$N*R^2(2)$	6.95	0.03**
	White	$N*R^2(1)$	10.45	0.06
Misspecification	Ramsey RESET	LR(1)	0.77	0.38
	Ramsey RESET	LR(2)	1.75	0.49
Parameter Stability	Recursive Estimates			

Notes: ***: 1% significant level, **: 5% significant level.

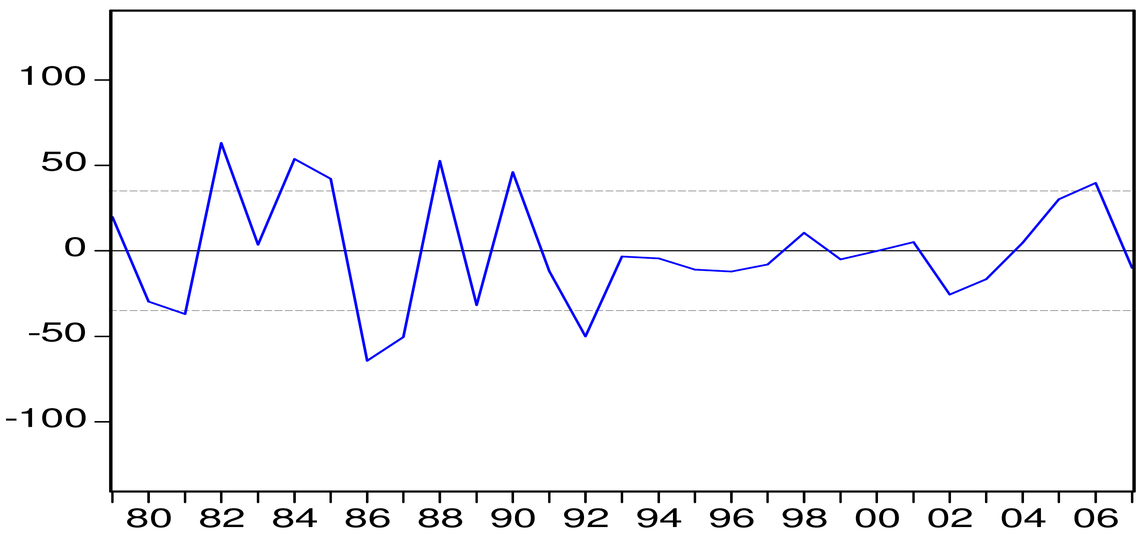


Figure 5.18: Residuals for real rent paid equation 5.22C

5.8 Real Interest Paid

The main lender institutions for the agricultural producers are commercial banks, agricultural cooperatives, Land Bank, Department of Agriculture, Forestry and Fisheries and other financial institutions. In 2009, the loan from commercial banks to the agricultural sector accounts for 69% of the debt followed by cooperatives (14%) and private persons (6%). By giving a weight to each of the interest rate charged by these lender institutions, the DAFF estimates the average cost of borrowing by the agricultural sector.

Interest paid by the agricultural sector is estimated by multiplying the nominal average cost of borrowing and total debt level. The projection of the prime rate by Reserve Bank is used to project the average cost of borrowing by the agricultural sector. The nominal value is then deflated by the projected CPI to produce the real interest paid by the agricultural sector.

5.9 Real Total Debt

The results of the estimated ADL (1) and nested models of real total debt are given in Table 5.28. The data is fitted very well by the partial adjustment model. Most of the variables included in the model are statistically significant and display the expected signs. The rise in the asset value and real interest rate increases the debt value. The short-run elasticity for interest rate and asset is respectively 0.06 and 0.15. Thus, a 10% increase in asset value and interest rate would respectively increase the debt value by 1.5 and 0.6% respectively. In the long run, the asset elasticity is almost unitary and the interest rate elasticity is 0.40. Thus, accumulation of new assets by agricultural producers through gross capital formation plays a greater role in increasing the debt level than the interest rate. The estimated result also shows that a downturn in economic growth puts pressure on the debt level of the sector, even though it is statistically insignificant.

Table 5.28: ADL (1) Model for the real total debt

VARIABLE	5.23A	5.23B	5.23C
CONSTANT	-3,089.69 (-0.45)	-3,807.17 (-0.59)	-1, 776.67 (-0.50)
RDEBT(-1)	0.82 (5.2)	0.84 (5.97)	0.84 (13.02)
RASSET	0.11 (0.29)	0.17 (2.05)	0.13 (3.27)
RASSET(-1)	0.05 (0.13)		
RINT	196.60.55 (0.93)	292.12 (2.00)	214.35 (2.59)
RINT(-1)	130.38 (0.78)		
GROWTH	-9776.87 (-0.29)	-6639.13 (-0.24)	-998.32 (-0.06)
GROWTH(-1)	-11217.60(-0.40)	-13388.17 (-0.51)	
D02			-4,221.81 (-5.42)
R^2	0.81	0.83	0.93
	T = (1990-2008)		

Note: t-statistics are given in parentheses.

$$RTDEBT = \underset{(-0.58)}{-1\,776.67} + \underset{(13.07)}{0.83}\ RTDEBT\,(-1) + \underset{(3.86)}{0.16}\ RASSET + \underset{(2.17)}{237.75}\ RINT\ –$$

$$\underset{(-0.06)}{998.32}GROWTH - \underset{(-5.42)}{4241.10}D02 \qquad (5.23C)$$

$Adj.R^2 = 0.94$ $\qquad$ $T = (1990 -2008)$

The diagnostic tests on the residual of the equation shows that the classical assumptions of OLS are not violated.

Table 5.29: Misspecification tests for real total debt for equation 5.23C

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	0.53	0.74
Serial Correlation	Ljung Box Q	Q(6)	7.87	0.25
	Breusch-Godfrey	$N*R^2(2)$	3.49	0.15
	Breusch-Godfrey	$N*R^2(1)$	3.44	0.06
Homoscedasticity	ARCH LM	$N*R^2(1)$	0.68	0.44
	ARCH LM	$N*R^2(2)$	1.71	0.42
	White	$N*R^2(1)$	9.40	0.28
Misspecification	Ramsey RESET	LR(1)	0.12	0.72
	Ramsey RESET	LR(2)	1.04	0.59
Parameter Stability	Recursive Estimates			

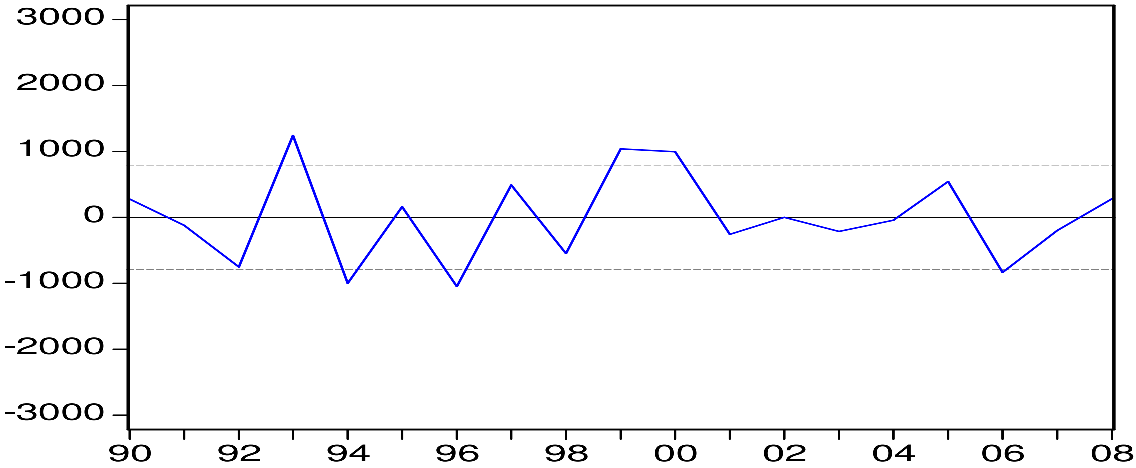


Figure 5.19: Residuals of real total debt equation 2.23C

5.10 Farm Employment

The results of ADL (1) and the nested models of the farm employment equation are given in Table 5.30. The static model with time trend fitted the data very well. The wage and trend variables included are statistically significant and show the expected signs. As expected, the rise in real wage deters farm employment. Similarly, as the economy of the country progresses, fewer people are engaged in farming activities. An increase in the profitability of the agricultural sector, however, generates employment, though it is statistically insignificant. The estimated wage elasticity of employment is 0.58. Thus, a 10% increase in real wage induces a 5.8% decline in farm jobs.

Table 5.30: ADL (1) Model for farm employment

VARIABLE	5.24A	5.24B	5.24C
CONSTANT	9136.41 (1.42)	15 102.00 (2.10)	17,073.00 (2.44)
LABOUR(-1)	0.31 (1.03)	0.04 (0.44)	
RWAGE	-0.06 (-5.85)	-0.06 (-6.52)	-0.06 (-7.85)
RWAGE(-1)	0.02 (0.88)		
RGINC	0.001 (1.01)	0.002 (1.44)	0.002 (1.47)
RGINC(-1)	-0.001 (-0.72)		
TIME	-4.07 (-1.30)	-6.89 (-1.89)	-7.86 (-2.20)
Adj. R^2	0.96	0.96	0.97

Note: t-statistics are given in parentheses.

$$FEMPT = 17\,073.00 - 0.06\ RWAGE - 7.86\ TIME + 0.002\ RGINC \qquad (5.24C)$$
$$\qquad (2.44) \quad (-7.85) \qquad (-2.2) \qquad (1.47)$$

$$Adj.\ R^2 = 0.96 \qquad T = (1988 - 2007)$$

The diagnostic test on the residual of equation 5.24C shows that the classical assumptions of OLS are not violated.

Table 5.31: Misspecification tests for farm employment equation 5.24C

Purpose of Test	Test	d.f	Test Statistic	Probability
Normality	Jarque-Bera	JB(2)	0.77	0.69
Serial Correlation	Ljung Box Q	Q(6)	3.76	0.77
	Breusch-Godfrey	$N^*R^2(2)$	1.15	0.56
	Breusch-Godfrey	$N^*R^2(1)$	0.72	0.39
Homoscedasticity	ARCH LM	$N^*R^2(1)$	3.15	0.07
	ARCH LM	$N^*R^2(2)$	3.83	0.70
	White	$N^*R^2(1)$	8.43	0.07
Misspecification	Ramsey RESET	LR(1)	0.76	0.38
	Ramsey RESET	LR(2)	0.79	0.67
Parameter Stability	Recursive Estimates			

employment model

Notes: *** 1% significant level, **: 5% significant level.

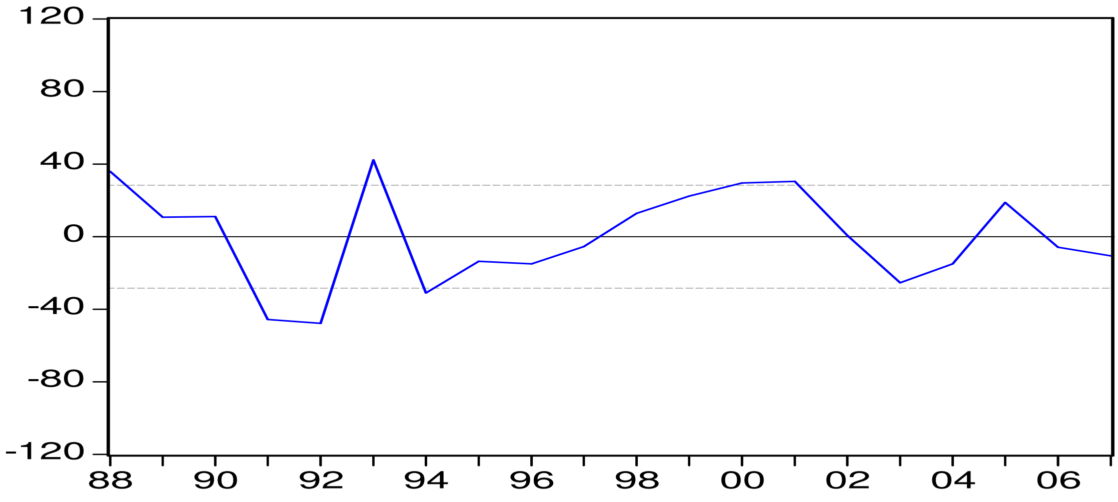


Figure 5.20: Residuals for farm employment equation

5.11 Summary

This chapter presented the estimation results of individual models specified in the previous chapter. Diagnostic tests were conducted on all the residuals of the estimated model to examine a violation of the underlying assumptions. These include correlograms of residuals, a normality test, a serial correlation Lagrange Multiplier (LM) test, an autoregressive conditional heteroskedasticity (ARCH) LM test, and White's heteroskedasticity test. Most of the violations are corrected using the appropriate techniques.

White's heteroskedasticity consistent coefficient covariance is used to address the violation of homoscedasticity assumption. Moreover, the presence of serial correlation in the model is addressed using the Chochrane-Orcutt iterative procedure. In general, most of the diagnostic tests on the estimated models display no violation of the basic assumption, and the goodness of fit measured using adjusted R^2 for most models lies above 85%, indicating a satisfactory result. In addition, the diagnostic tests for most of the equations reveal the absence of econometric problems associated with the presence of few non-stationarity variables in the models. The next chapter will be devoted to a comprehensive assessment and validation of the model.

CHAPTER SIX

MODEL EVALUATION

6.1 Introduction

Economic models should undergo various tests to evaluate to what extent they replicate real-world phenomena before employing them for forecasting and policy analysis purposes. Various techniques, which comprise graphical as well as statistical methods, are often used to evaluate the adequacy of the model in replicating the actual values.

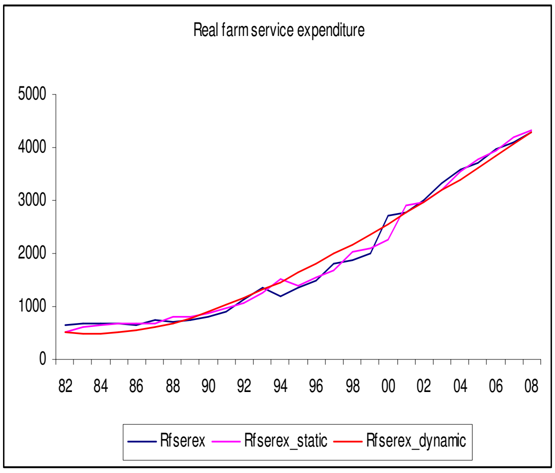
Once the model is validated and found adequate in tracking the actual values, it can be used to analyse several '*what if?*' policy questions or simulations for the agricultural sector. As mentioned in previous chapters, the incorporation of the input model into the multi-market output model enables the integrated model to evaluate the net effect of policies on gross value added and net farming income by assessing their impact on both agricultural gross income and input expenditures. Furthermore, the incorporation of other aggregate variables, like gross capital formation, asset values and total debt of the sector, would enable the model to generate several financial and economic indicators that would not have been possible with the mere integration of input expenditures into the output model.

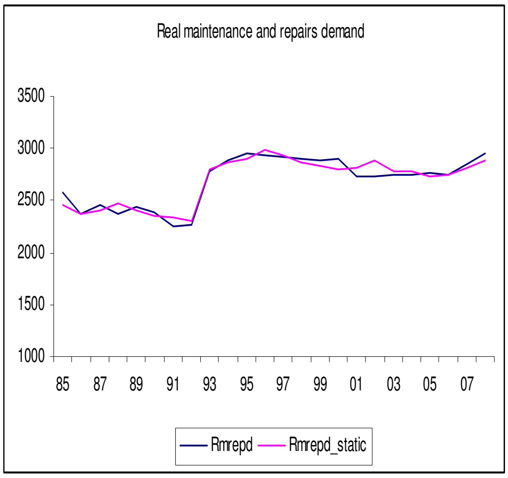
The next two sections of this chapter present an assessment of the model's performance in tracking past trends using a graphical view and various statistical techniques.

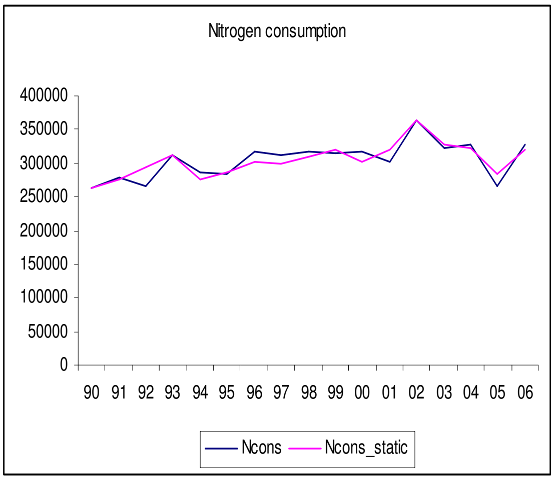
6.2 Graphical Evaluation of the Model

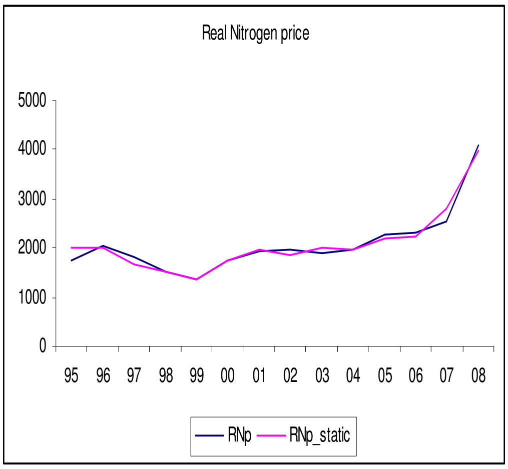
One of the straightforward assessments of the forecast ability of the model is made by looking at graphs of the actual and estimated values of the model. There are two approaches to evaluating the model graphically. These are static and dynamic forecasting. Static forecasting is a one-step ahead forecast, which uses the actual values of both endogenous and exogenous variables. Dynamic forecasting, however, is a multi-step forecast, since it takes the estimated values of the lagged dependent variables to forecast the current value. Thus, any error term occurring in one period will be carried throughout the whole period. Dynamic forecasting can only be formed if the model incorporates lagged dependent variables. The actual, static and dynamic versions of the models for the estimated endogenous variables are presented in Figure 6.1.

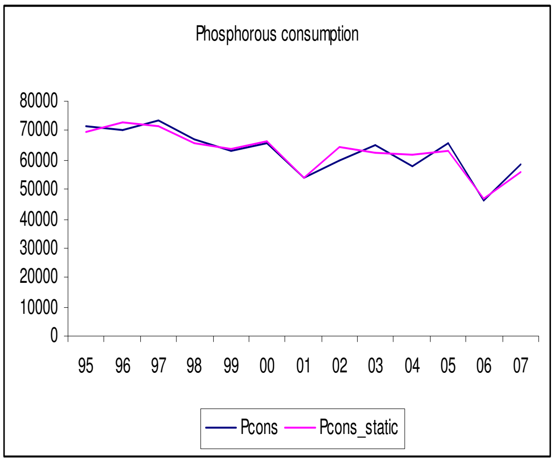
Figure 6.1: The actual and fitted (static and dynamic) graphs of all endogenous variables in the model.

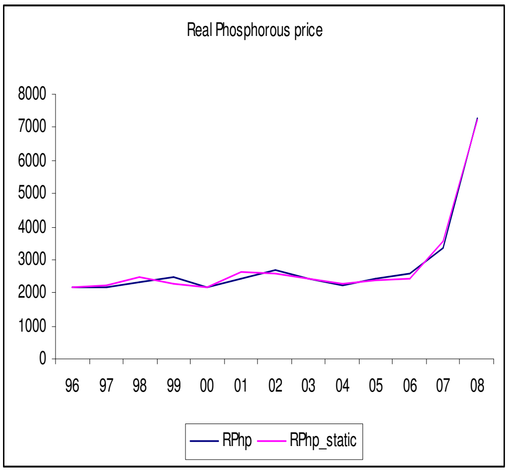

Real farm service expenditure
5000
4000
3000
2000
1000
0
82 84 86 88 90 92 94 96 98 00 02 04 06 08
Rfserex
Rfserex_static
Rfserex_dynamic

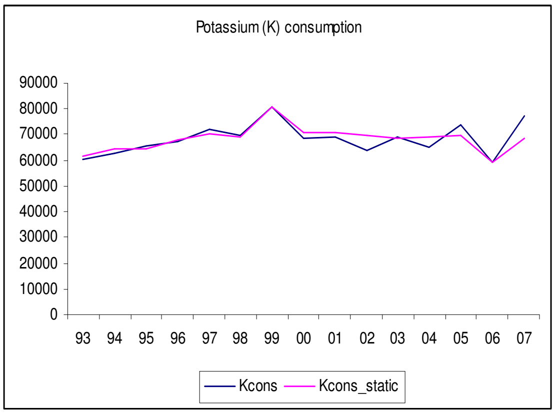

Real maintenance and repairs demand
3500
3000
2500
2000
1500
1000
85 87 89 91 93 95 97 99 01 03 05 07
Rmrepd
Rmrepd_static

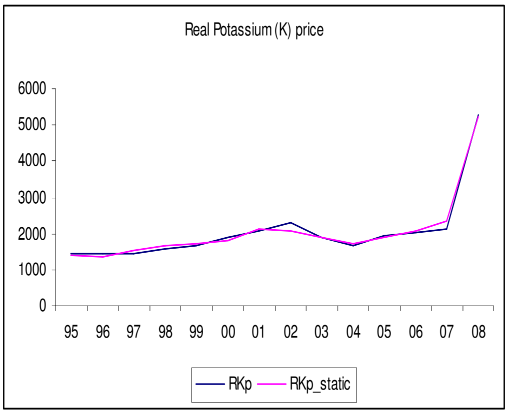

Nitrogen consumption
400000
350000
300000
250000
200000
150000
100000
50000
0
90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06
Ncons
Ncons_static

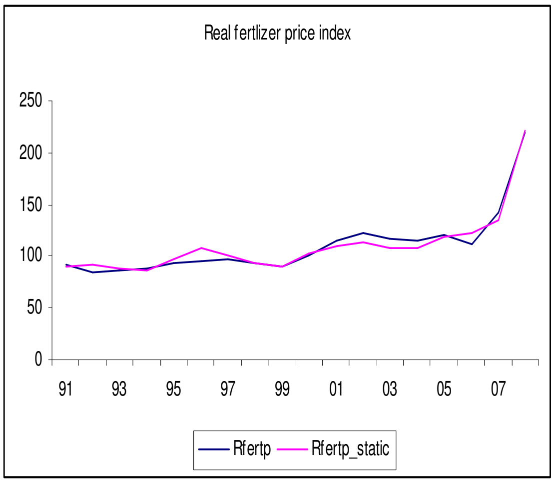

Real Nitrogen price
5000
4000
3000
2000
1000
0
95 96 97 98 99 00 01 02 03 04 05 06 07 08
RNp
RNp_static

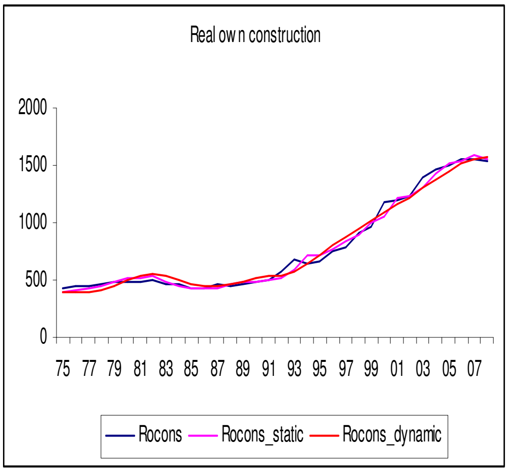

Phosphorous consumption
80000
70000
60000
50000
40000
30000
20000
10000
0
95 96 97 98 99 00 01 02 03 04 05 06 07
Pcons
Pcons_static

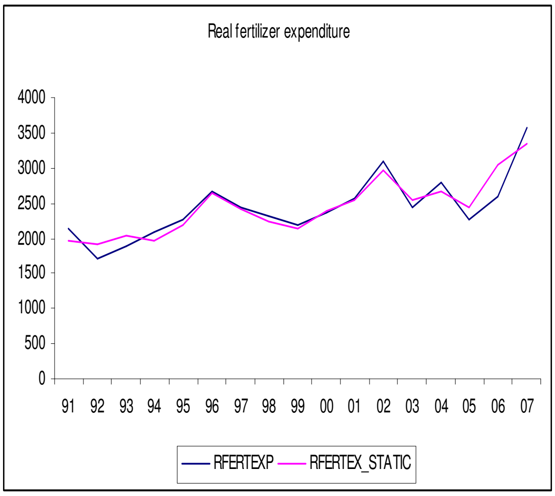

Real Phosphorous price
8000
7000
6000
5000
4000
3000
2000
1000
0
96 97 98 99 00 01 02 03 04 05 06 07 08
RPhp
RPhp_static

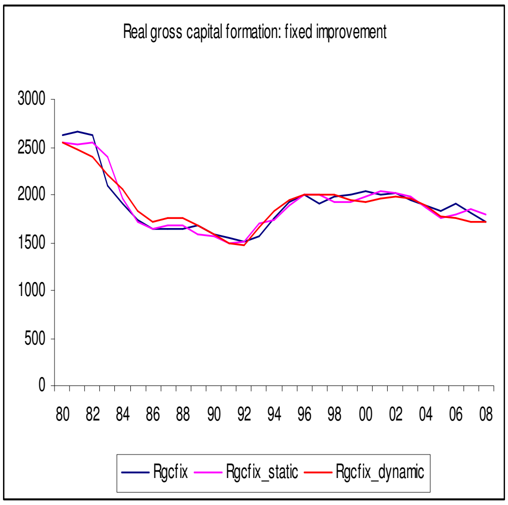

Potassium (K) consumption
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
93 94 95 96 97 98 99 00 01 02 03 04 05 06 07
Kcons
Kcons_static

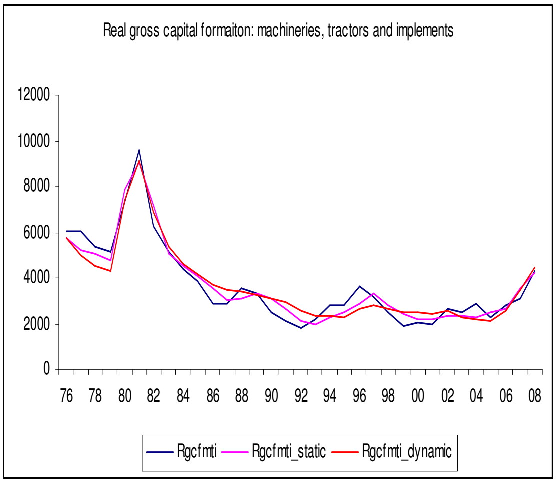

Real Potassium (K) price
6000
5000
4000
3000
2000
1000
0
95 96 97 98 99 00 01 02 03 04 05 06 07 08
RKp
RKp_static


Real fertlizer price index
250
200
150
100
50
0
91 93 95 97 99 01 03 05 07
Rfertp
Rfertp_static

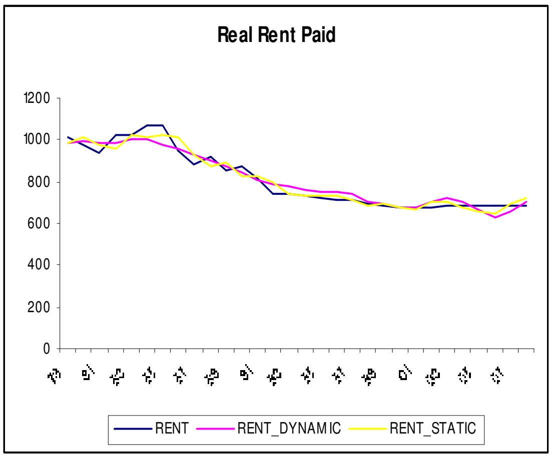

Real own construction
2000
1500
1000
500
0
75 77 79 81 83 85 87 89 91 93 95 97 99 01 03 05 07
Rocons
Rocons_static
Rocons_dynamic

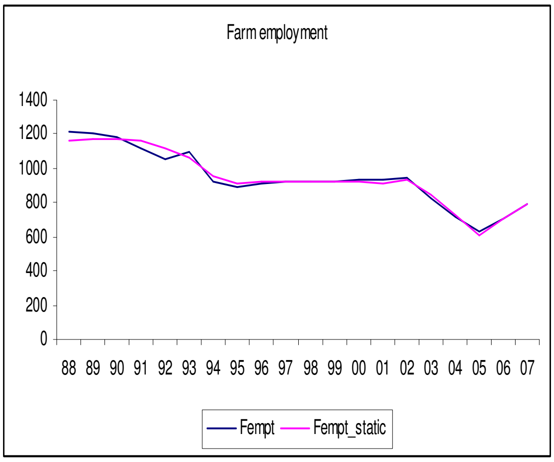

Real fertilizer expenditure
4000
3500
3000
2500
2000
1500
1000
500
0
91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07
RFERTEXP
RFERTEX_STATIC


Real gross capital formation: fixed improvement
3000
2500
2000
1500
1000
500
0
80 82 84 86 88 90 92 94 96 98 00 02 04 06 08
Rgcfix
Rgcfix_static
Rgcfix_dynamic


Real gross capital formaiton: machineries, tractors and implements
12000
10000
8000
6000
4000
2000
0
76 78 80 82 84 86 88 90 92 94 96 98 00 02 04 06 08
Rgcfmti
Rgcfmti_static
Rgcfmti_dynamic


Real debt
40000
35000
30000
25000
20000
15000
10000
5000
0
90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08
Rdebt
Rdebt_static
Rdebt_dynamic


Real Rent Paid
1200
1000
800
600
400
200
0
RENT
RENT_DYNAMIC
RENT_STATIC


Farm employment
1400
1200
1000
800
600
400
200
0
88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07
Fempt
Fempt_static

The view of all actual and fitted graphs shows a generally good performance of the model in tracking past trends and turning points for most endogenous variables.

6.3 Statistical Evaluation of the Model

Statistical methods that examine the forecasting ability of the model largely assess the forecast error value, computed as the deviation of the forecast value from the actual value. Thus, if the model produces a low error value, its forecasting ability is regarded as relatively good and hence it can be used for forecasting and policy analyses.

Based on the forecast error term, the following four statistical techniques are often applied to evaluate the forecasting ability of the model (Pindyck and Rubinfeld, 1998).

$$MAE = \frac{1}{T}\sum_{t=1}^{T}\left|\hat{Y}_t - Y_t\right| \qquad (6.1)$$

Mean Average Error (MAE) given in equation 6.1 is simply computed as the average value of the absolute value of the error terms occurring in each period. The Mean Average Percentage Error (MAPE), on the other hand, measures the error in terms of the percentage of the actual value. The formula to compute MAPE is given in equation 6.2.

$$MAPE = \frac{1}{T}\sum_{t=1}^{T}\left|\frac{\hat{Y}_t - Y_t}{Y_t}\right| \qquad (6.2)$$

The other statistical technique measures the square root of the square of the error terms to evaluate the forecasting ability of the model. In this method, unlike the mean average error (MAE), large errors weigh more, thus it penalises large deviations. The square root of the mean square error (RMSE) is computed using the following formula.

$$RMSE = \sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(\hat{Y}_t - Y_t\right)^2} \qquad (6.3)$$

Like the MAPE, Theil has also developed a scale invariant forecast error measurement called the Theil Inequality Coefficient (U). The formula used to compute U is given in equation 6.4. The numerator of the formula is simply the root mean square of errors. The denominator, however, causes the value of U to fall between 0 and 1. A coefficient close to zero shows that the forecasting ability of the model is relatively good and a value close to one implies the model is inadequate to be used for forecasting purpose.

$$U = \frac{\sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(\hat{Y}_t - Y_t\right)^2}}{\sqrt{\frac{1}{T}\sum_{t=1}^{T}\left(\hat{Y}t\right)^2}\sqrt{\frac{1}{T}\sum_{t=1}^{T}(Y_t)^2}} \qquad (6.4)$$

The value of the RAMSE, MAE, MAPE and U for the 25 endogenous equations is given in Table 6.1.

Table 6.1: Dynamic and static simulation accuracy of stochastic variables

Variable name	Acronym	Root Mean Square Error (RMSE)	Mean Absolute Error (MAE)	Mean Absolute Percentage Error (MAPE)	Theil Inequality Coefficient (U)
Real fuel demand	RFUELD	132.70	101.60	2.9332	0.0189
Real fuel price index	RFUELP	7.52	5.86	6.71	0.0421
Real feed demand	RFEEDD	263.62	223.95	4.95	0.0240
Real feed price index	RFEEDP	3.77	3.23	2.97	0.0174
Real maintenance and repairs demand	RMREPD	64.14	52.6	1.98	0.0119
Real farm services expenditure	RFSEREX	172.23	141.44	11.31	0.0381
Nitrogen consumption by field crops	NCONS	1,1806	8,965.93	3.04	0.019
Phosphorous consumption by field crops	PCONS	2,395.19	2,072.99	3.303	0.018
Potassium consumption by field crops	KCONS	3,348.92	2,330.57	3.369	0.0244
Real Nitrogen price	RNP	128.14	94.99	4.52	0.0294
Real Phosphorous price	RPHP	120.78	97.10	3.697	0.0193
Real Potassium price	RPP	94.96	72.04	3.88	0.021
Real fertiliser price index	RFP	6.08	4.75	4.41	0.02
Real total fertiliser expenditure	RFERTEX	164.58	127.42	5.37	0.033
Real own construction	ROCONS	51.30	44.28	6.66	0.029
Real gross capital formation: fixed improvement	RGCFIX	94.83	75.46	3.88	0.0247
Real gross capital formation: machinery,	RGCFMTI	522.55	441.97	14.19	0.064

Variable name	Acronym	Root Mean Square Error (RMSE)	Mean Absolute Error (MAE)	Mean Absolute Percentage Error (MAPE)	Theil Inequality Coefficient (U)
tractors and implements					
Real rent paid	RRENT	46.19	37.81	5.17	0.029
Real total debt	RDEBT	612.20	511.49	1.819	0.0105
Farm employment	FEMPT	27.56	21.30	2.15	0.014

As shown in Table 6.1, most of the forecast error measurements using Theil's Inequality Coefficient produce a U value approaching zero. Moreover, the Mean Absolute Percentage Error is below ten percent for most of the variables. Thus, from the statistical tests it can be concluded that the model performs reasonably well and therefore can be used for policy analysis and forecasting.

6.4 Summary

This chapter presented model validations conducted using graphical and statistical techniques. The graphic approach uses a static and dynamic forecasting to evaluate the forecast ability of the model. Generally, the view shows that it tracked past trends and turning points for most of endogenous variables well. The statistical method also applied Root Mean Square Error (RMSE), Mean Absolute Error (MAE), Mean Absolute Percentage Error (MAPE) and Theil Inequality Coefficient (U) to assess the model's performance. The results of these forecast error measurements indicate that the model has generally replicated the actual values well. Hence, it can be used for policy analysis and forecasting purposes.

CHAPTER SEVEN

BASELINE PROJECTIONS, MODEL COMPARISION AND SCENARIO ANALYSIS

7.1 Introduction

In this chapter, the objectives and hypotheses of the study are addressed by generating baseline projections, comparing recursively linked and unlinked models and performing policy analysis on the model, which integrated the intermediate input expenditures and other aggregate variables into the existing BFAP output model. The integrated model is thus able to comprehensively assess the net effect of all exogenous factors that affect the agricultural sector.

The endogenisation of domestic input prices in the integrated model also helps to evaluate the net impact of exogenous variables, such as the exchange rate, which affect both input and output prices, since it assesses the effect on both input expenditures and gross income of the sector. As gross value added and net farming income account for the changes in both gross income and input expenditures of the agricultural sector, they are used as the main target variables in the integrated model to evaluate the net impact of policies. Though domestic input prices are factored in influencing the area planted decision in the BFAP output model, they are not endogenised in the model. Hence, evaluating the net impact of exogenous variables, such as oil price, world fertiliser prices, exchange rate movements and higher domestic input demand that affects input prices are not possible.

The main hypothesis of the study is also tested by comparing the integrated model that recursively linked the output and input side of the agricultural sector and endogenises input costs with a model that does not capture the recursive link and treat input prices as exogenous. The recursively linked model takes into account the dynamic effects of a change in output side to input side of the agricultural sector and vice versa. The two models are compared to evaluate their ability in replicating the dynamics experienced by the sector when exogenous shocks are introduced into the model.

Using the integrated model, a baseline outlook for the main aggregate variables such as gross value added and net farming income is also generated for the medium term (2010-2015). In addition, several financial and economic performance indicators of the agricultural sector are projected to address the second objective of the study. The previous BFAP output model could project a baseline only for variables from the output side of the agricultural sector, such as commodity prices, area planted, production volume and thus only the gross income for the agricultural sector.

This chapter is organised into four sections. The following section provides the baseline projection for the main aggregate variables and the financial and economic performance indicators of the agricultural sector. The second section compares the recursively linked and unlinked models to assess the effects of various shocks of exogenous variables on the target variables. The third section evaluates the net implication of exchange rate depreciation that affects both agricultural input and output prices on the agricultural sector. A summary of the chapter is given in section four.

7.2 Baseline Projection of the Agricultural Sector

A baseline projection refers to the outlook of the endogenous variables under the *status quo* assumptions of exogenous variables. Thus, it is mainly used as a benchmark to evaluate the effect of changes in the exogenous variables on the endogenous variables. The previous BFAP output model was able to project the commodity/animal product prices, the production volume of field crops and animal products, and the total area planted. Hence, at the aggregate level, the model was able to project the gross income of the agricultural sector by multiplying the quantity produced and their respective prices. The integrated model developed in this thesis is now able to compute various key aggregate variables of the agricultural sector by applying some basic accounting relationships since it incorporates all input expenditure into the existing BFAP output model.

Among the key aggregate variables, the gross value added of the agricultural sector, which shows the contribution of the sector to the economy, is computed by deducting intermediate input expenditure from the gross income of the agricultural sector and own construction. Net farming income, on the other hand, is the profit accrued to producers after depreciation, labour remuneration, rent and interest payment are deducted from the gross value added. The medium term (2010-2015) outlook for these and other aggregate variables of the agricultural sector is projected using the integrated model.

7.2.1 Baseline Projection of Main Aggregate Variables

The forecast values of the selected exogenous variables of the model used for producing the baseline are given in Table 7.1.

Table 7.1: Projected values of selected exogenous variables

Exogenous Variable	2010	2011	2012	2013	2014	2015
Exchange rate (R/USD)	7.44	7.80	8.14	8.47	8.80	9.09
Average annual prime rate (%)	11.10	12.00	12.50	13.00	13.00	13.00
Oil price (USD)	79.60	90.00	80.77	86.43	86.00	80.65
Inflation (%)	6.8%	6.6%	6.3%	6.3%	5.7%	6%
Yellow maize, US No.2, FOB, Gulf ($/t)	170.57	169.75	176.38	177.72	183.81	186.81
Wheat, US No2 HRW, FOB, Gulf ($/t)	210.77	206.57	215.40	225.53	229.47	228.81
Sorghum, US No 2, FOB, Gulf ($/t)	159.34	159.50	165.90	168.79	174.31	177.72
Cheese, FOB, N. Europe ($/t)	2,432.8	2,618.8	2,747.7	2,802.4	2,879.1	2,969.4
Chicken, US 12-city wholesale ($/t)	1,467.9	1,820.6	1,846.3	1,873.5	1,907.7	1,937.7
WMP, FOB, N. Europe ($/t)	1,988.4	2,183.6	2,225.3	2,283.3	2,365.2	2,462.4

Source: Adapted from BFAP model (2010).

The integrated model developed here was for the first time used in the BFAP 2008 outlook to project gross value added and net farm income of the agricultural sector. It projected that gross value added and net farming income will increase by 17 and 21% respectively from 2007 to 2008. The actual data from DAFF (2009) released in 2009 reveals that both variables have increased by 13 and 21% respectively. Similarly the model has projected the actual decline of real gross value added and net farming income in 2009. Thus, the integrated model generally performs a satisfactory outlook in tracking the trend of these target variables.

The baseline projection for the main aggregate variables of the agricultural sector is given in Table 7.2. The projection for the planted area is obtained by aggregating the projections of area planted for white maize, yellow maize, sorghum, barley, canola, sunflower and soybean, which have already been produced by the BFAP output model. The aggregate projection for the total area planted shows a decline in 2011. Thereafter, it displays an increasing trend until 2015.

The real gross income is projected by multiplying the projection of each commodity (animal product) prices and the respective volume of production. The production volume for field crops is obtained by multiplying the projections of each crop's area planted and yield, which is estimated under the normal weather assumption. Since the field crops and the animal product sector represent more than 70% of the total gross value of the agricultural sector, the growth trend of the gross income from the BFAP output model is used to extrapolate the total gross income of the agricultural sector.

Table 7.2: Baseline projections of real values of main aggregate variables (constant 2000 prices)

Variable (1000 Ha/Million Rand)	2010	2011	2012	2013	2014	2015
Total Area	4,642	4,145	4,377	4,387	4,446	4,511
Gross income	68,836	69,682	71,371	72,627	74,036	76,298
Own construction	2,113	2,063	2,029	2,006	1,993	1,989
Intermediate input expenditure	33,384	33,624	34,459	35,602	36,385	36,876
Fuel expenditure	3,814	3,757	3,784	3,873	3,913	3,885
Fertiliser expenditure	3,411	3,761	3,976	4,114	4,137	4,033
Feed expenditure	7,195	7,908	8,107	8,369	8,506	8,594
Gross value added	37,374	37,905	39,176	39,134	39,546	41,514
Interest paid	3,256	3,680	4,014	4,371	4,573	4,755
Depreciation	2,647	2,814	2,959	3,087	3,220	3,330
Labour remuneration	7,426	7,370	7,332	7,284	7,240	7,214
Rent paid	328	345	367	385	400	414
Net farming income	24,442	24,662	25,200	24,984	25,438	27,038

The baseline projections for the real gross income depict an annual average growth rate of 2.08% during the baseline period. The moderate growth rate for the sector's income is largely due to the small growth rate displayed by field crops. During the baseline period, the gross income from animal products and field crops is projected to grow by an annual average rate of 2.7 and 0.8% respectively.

Intermediate input expenditure of the agricultural sector also shows an increasing trend and it is projected to grow at an annual average rate of 2% during the baseline period. The intermediate input expenditure is composed of expenditures on fuel, fertiliser, feed, maintenance and repairs, farm services and other expenditures. The growth in expenditure is largely driven by the cost of fuel and fertiliser, which are projected to increase due to the projected depreciation of the exchange rate and higher oil and world fertiliser prices. The projected rise in animal production also plays a role in increasing the intermediate input expenditure by raising the feed expenditure of the sector.

Own construction of the sector also shows marginal decline during the baseline period, spurred by little growth in the gross capital formation of fixed improvement of the sector. The gross value added of the agricultural sector, which is calculated using the accounting relationship of intermediate input expenditure taken away from gross income and own construction, largely reflects the growth displayed by these three components. Thus, it is projected to grow at an annual average growth rate of 2.12% during the baseline period. The modest growth of the gross value added is due to the relatively similar growth rate of intermediate input expenditure and gross income of agricultural sector.

Labour remuneration is expected to decline, though marginally, during the baseline period. Rent paid is projected to show a gentle rising trend following the growth in the planted area. Similarly, interest paid is projected to depict an increasing trend because of the projected rise in real total debt value and real interest rate. The total debt of the agricultural sector is expected to grow as a result of the rise in the asset value of the sector, which is spurred by the growth in the gross capital formation of the sector. Depreciation of the assets by the agricultural sector, therefore, shows an increasing trend following the rise in the total asset values.

The net effects of the changes in the expenditures on labour, land, capital and the depreciation of assets on agricultural producers is captured by the net farming income of the sector, which is computed by subtracting these expenditures from the gross value added. Its projection shows a modest growth due to the projected higher growth of these input expenditures compared to the gross value added of the sector. Thus, during the baseline period, net farming income is expected to grow at an annual average growth rate of 1.7%.

7.2.2 Baseline Projection of Financial and Economic Indicators

Using the projections of the main aggregate variables, the financial and economic indicators that are projected for the agricultural sector are given in Table 7.3. To produce the projections of these financial indicators, the asset and debt values of the agricultural sector have been projected in the model. The asset value is estimated by adding the net capital formation to the lagged asset value. The three assets in the sector are land, fixed improvements and machinery, tractors and implements. The gross capital formation of the latter two assets is determined by the profitability of the agricultural sector and the cost of the materials, which includes interest rate and own prices. On the other hand, total debt of the sector has been estimated using the asset value of the sector and the interest rate.

Once these two major indicators of assets and liabilities of the sector are projected, together with the net farming income, they are used to compute and project key economic and financial performance indicators for the agricultural sector. Thus, while the inclusion of input expenditures is enough to produce a comprehensive baseline for the main aggregate variables, the incorporation of assets and liabilities of the sector is vital to project the economic and financial performance indicators of the sector.

The projected financial and economic indicators show that the cash flow (measured as a percentage of gross income) depicts a declining trend. Farmers' cash flow is the actual cash remaining after paying all actual expenditures, thus it excludes own construction and depreciation. Since these excluded values are trending upward, their reduction from the gross income dampen the amount of actual cash flow to producers. Similarly, the net return on assets and equity is projected to decline until 2014 due to a modest growth of net farming income and the projected rising trend of asset and equity values. A comparison of the net returns on assets and equity with the average cost of borrowing (opportunity cost) shows that the net return on assets and equity is projected to exceed the cost of borrowing during the baseline period. Thus, compared to the previous decade, the sector's economic performance is expected to be improved during the baseline period.

Table 7.3: Baseline projections for the financial and economic indicators of the agricultural sector

Indicators	2010	2011	2012	2013	2014	2015
Cash flow (as % of gross income)	35.5	35.4	35.3	34.4	34.4	35.4
Net return on asset (%)	14.6	14.1	14.1	13.2	12.7	13.3
Net return on equity (%)	19.1	18.4	18.5	17.3	16.7	17.5
Average cost of borrowing (%)	10.4	11.3	11.8	12.3	12.3	12.3
Real total debt (Million Rand)	31,372	32,624	34,075	35,597	37,240	38,724
Real total asset value (Million Rand)	134,156	139,069	144,139	149,138	154,880	160,307
Leverage ratio	0.31	0.31	0.31	0.31	0.32	0.32
Debt burden (%)	23.4	23.5	23.6	23.9	24.0	24.2

Derived by the projected rise of real interest rate and the asset value of the agricultural sector, the real total debt is projected to show an increasing trend. The asset value is also expected to increase because of the projected rise in the gross capital formation and land value. The leverage ratio, which indicates the share of external debt that is used to finance growth and calculated as the ratio of the debt level to total equity, is projected to remain at a relatively constant ratio of 0.31 during the baseline period.

Similarly, the debt burden, which is computed as the percentage share of debt to the total asset value, is projected to increase marginally but remain below 24.2% during the baseline period due to the parallel rise of both the asset and debt values of the sector. Hence, the baseline outlook of the financial and economic performance indicators of the sector show that in general there will be a modest improvement in the financial and economic position of the South African agricultural sector in the medium term under *status quo* assumptions.

7.3 Comparison of the Recursively Linked and Unlinked Models

To test the hypothesis of the study that argues the effect of input cost shocks converges slowly in the recursively linked input and output side of the agricultural sector two versions of the integrated model are used. The first version is the one where both sides of the sector are recursively linked and the second version is where the recursive link is 'switched off'. Hence, in the latter version the recursive effects of any changes in the input side of the agricultural sector to the output side or vice versa are subdued.

For the recursively unlinked model, the effect on the gross value added and net farming income is computed by taking the value of gross income and planted area from the output model and obtaining the input expenditures from the input model. Then, using the basic accounting relationship, gross value added and net farming income of the sector are computed. For the recursively linked model, however, the accounting relationship is established on the model so that it automatically generates the effects on the key target variables.

The result of the exogenous shocks that will be introduced on both versions of the models is compared with the baseline projections of the integrated model given in the above section. The baseline results of both versions will remain the same due to the fact that full information of projected variables is used by both output and input models to produce all the target variables in both versions of the model. Thus, the experiment will evaluate the respective impacts of the shocks that will be introduced in both models on the baseline projections of the target variables. The hypothesis of the study states that embracing the recursive effect of the agricultural inputs side to the output side and vice versa lessens and lengthens the effect of the shock introduced into the model, as the recursive effects of both sides is taken into account. Ignoring the recursive effect, however, would only analyse the impact on the first year without considering its further dynamic and recursive implications.

Generally, the integrated model that incorporates input and output sides also appropriately evaluates the effect of policies on the sector by assessing their simultaneous impact on both inputs and outputs. Economic policies that may result in a fall of area planted, for example, may entail a change in the gross income. However, its effect on the agricultural sector would not be severe if the simultaneous reduction effect of the area on input expenditures is taken into account. Conversely, the effect of policies that increase area planted would be overestimated if the simultaneous impact of the rise of area production on intermediate input expenditure is not taken into account.

To test the hypothesis of the study, two exogenous shocks are introduced in the recursively linked and unlinked models. These are shocks on increasing world fertiliser and crude oil prices. These shocks also evaluate the impact of input costs on the agricultural sector using the integrated model, which is able to analyse these effects due to the endogenisation of the domestic input prices in the model.

7.3.1 A shock of 50% increase in World Fertiliser Price

The results of a single shock of a fifty percent increase in world fertiliser price introduced on both recursively linked and unlinked models in 2010 are given in Table 7.4 and 7.5 respectively. As shown in the tables, the impact largely increases the intermediate input expenditures due to the rise in the cost of the fertiliser input. However, there is a fall in the area planted and gross income due to impact of the current input prices on the winter area planted. As a result, both gross value added and net farming income of the sector falls in the recursively linked model in 2010.

Following the year of the shock, however, the area planted and the gross income in the recursively linked model fell in 2011 due to the recursive impact of the rise in input costs on the summer area planted. The gross income fell due to the fall in the percentage of production, which exceeded the rise in the price for most of the field crops (see Appendix A). However, since the input expenditure fell following the decline in area planted in 2011, the recursively linked model shows little change in the gross value added and net farming income of the sector in 2011. The rise in output prices in 2011 also causes an increase in the area planted and the gross income in 2012 and following small change in the intermediate input expenditure, the gross value added and net farming income shows a slight increase. Thereafter the effect of the shock on the gross value added and net farming income slowly converges in a cyclical pattern until the effect eventually disappears (see Figure 7.1 and 7.2).

For the recursively unlinked model, however, the effect of the shock was a rise in the input expenditure, which induced a fall in the gross value added and net farming income in 2010. The shock did not impact the area response, as domestic input prices are exogenous in the model. Furthermore, due to the lack of the recursive effect of the shock on the output side, the subsequent impact of the shock disappears in 2011 and thereafter. Thus, using the recursively linked model, the effect of the rise in world fertiliser price on the gross value added and net farming income shows a presence of a positive impact of the effect which is slowly dwindling than a once off plummeting effect implied by the recursively unlinked model.

Table 7.4: Results of the recursively linked model for the shock of a 50% rise in the world fertiliser price in 2010

Variable	2010	2011	2012	2013	2014	2015
Area planted	-0.21%	-2.03%	0.34%	0.03%	0.06%	-0.03%
Gross income	-0.06%	-0.29%	0.17%	0.00%	0.07%	-0.06%
Intermediate input expenditure	2.06%	-0.64%	-0.05%	0.09%	-0.04%	0.02%
Gross value added	-1.84%	0.03%	0.36%	-0.08%	0.17%	-0.12%
Net farming income	-3.42%	0.09%	0.82%	-0.17%	0.48%	-0.32%

Table 7.5: Results of the recursively unlinked model for the shock of a 50% in the world fertiliser price in 2010

Variable	2010	2011	2012	2013	2014	2015
Area planted	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Gross income	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Intermediate input expenditure	2.14%	0.00%	0.00%	0.00%	0.00%	0.00%
Gross value added	-1.79%	0.00%	0.00%	0.00%	0.00%	0.00%
Net farming income	-3.32%	0.00%	0.00%	0.00%	0.00%	0.00%

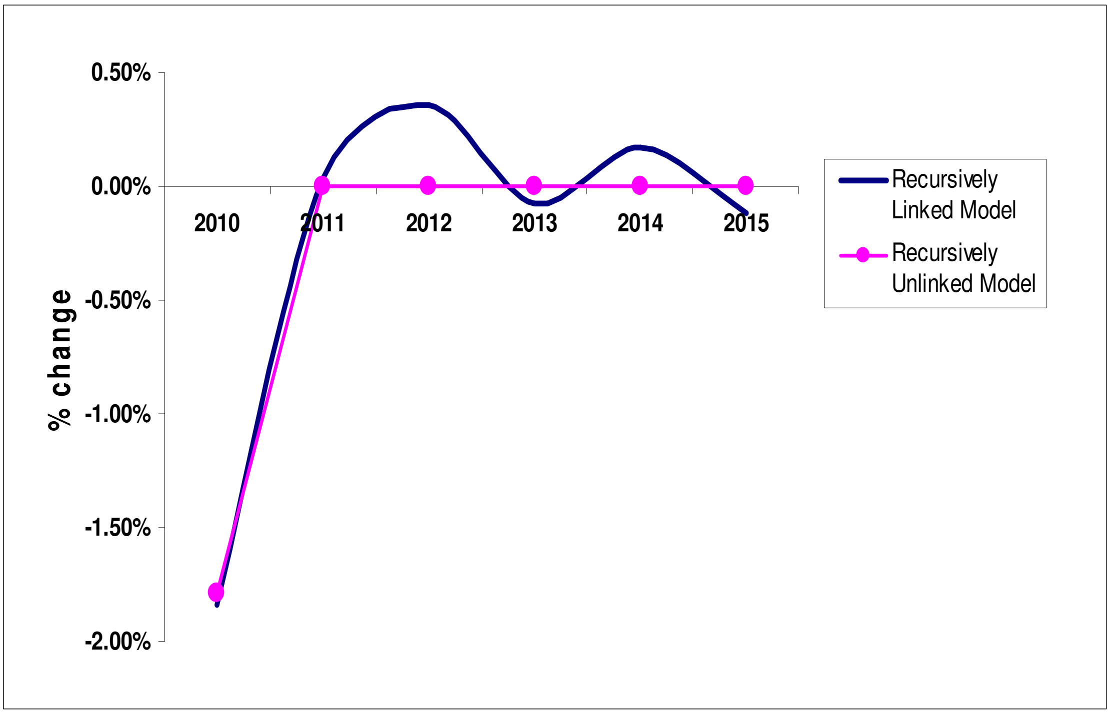


Figure 7.1: The impact of a 50% shock in the world fertiliser price on the gross value added of the agricultural sector.

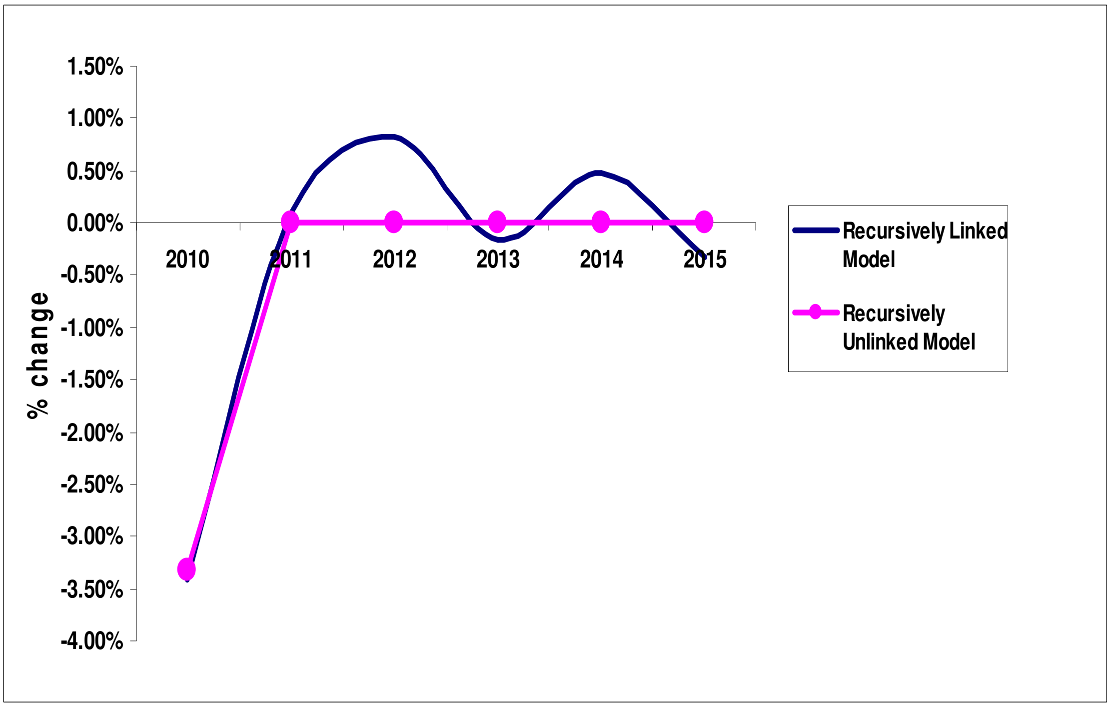


Figure 7.2: The impact of a 50% shock in the world fertiliser price on the net farming income.

7.3.2 A Shock of 50% Increase in Crude Oil Price

The results of the impact of a single fifty percent increase in crude oil price introduced in 2010 on the agricultural sector using the recursively linked and unlinked models are presented in Table 5.4 and 5.5 respectively. The impact of the shock entails a fall of the gross value added and net farming income due to the rise in input expenditure. Unlike the effect of the shock in world fertiliser price, however, the crude oil price shock showed a marginal increase in the gross income of both versions of the model in 2010. This is because the shock raised the domestic prices of some commodities by increasing the transport cost, which is captured in both models.

In 2011, the unlinked model shows a marginal increase in the area planted and the gross income due to an increase in output prices in 2010, but the area planted and gross income fall in the recursively linked model since it takes into account the full effect of the change in fuel prices during 2010, when the summer planting area decision was made for 2011. Similar to the above scenario, the gross income falls because the percentage of production has exceeded the rise in price for most of the field crops (see Appendix B).

The reduction in input expenditure following the decline in area planted, however, augments the gross value added and net farming income. In 2012, the gross value added and net farming income also grows after the effect of the change in gross income and input expenditures are taken into account. Gross income rises in 2012 due to the rise in the area planted following the rise in price in 2011. Thereafter, the impact of the shock on the gross value added and net farming income slowly converges in a cyclical pattern until it slowly disappears (see Figure 7.3 and 7.4). Thus, the effect of the rise in the crude oil price on the agricultural sector may not be a once-off fall in the gross value added and net farming income when the recursive effect is fully taken into account. If the impact of oil price on world commodity price were included, the positive effect on the agricultural sector would also be more than the result obtained in this scenario.

Table 7.6: Results of the recursively linked model for the shock of a 50% rise in the crude oil price in 2010

Variable	2010	2011	2012	2013	2014	2015
Area planted	-0.29%	-2.51%	0.74%	-0.07%	0.12%	-0.06%
Gross income	0.24%	-0.06%	0.25%	-0.03%	0.11%	-0.09%
Intermediate input expenditure	2.75%	-0.75%	-0.01%	0.07%	-0.07%	0.03%
Gross value added	-1.86%	0.56%	0.46%	-0.11%	0.26%	-0.19%
Net farming income	-3.46%	1.17%	1.02%	-0.28%	0.70%	-0.58%

Table 7.7: Results of the recursively unlinked model for the shock of a 50% rise in the crude oil price in 2010

Variable	2010	2011	2012	2013	2014	2015
Area planted	0.00%	0.38%	0.07%	0.00%	0.00%	0.00%
Gross income	0.34%	0.18%	0.02%	0.00%	0.00%	0.00%
Intermediate input expenditure	2.83%	0.00%	0.00%	0.00%	0.00%	0.00%
Gross value added	-1.77%	0.34%	0.04%	0.00%	0.00%	0.00%
Net farming income	-3.29%	0.70%	0.10%	0.00%	0.00%	0.00%

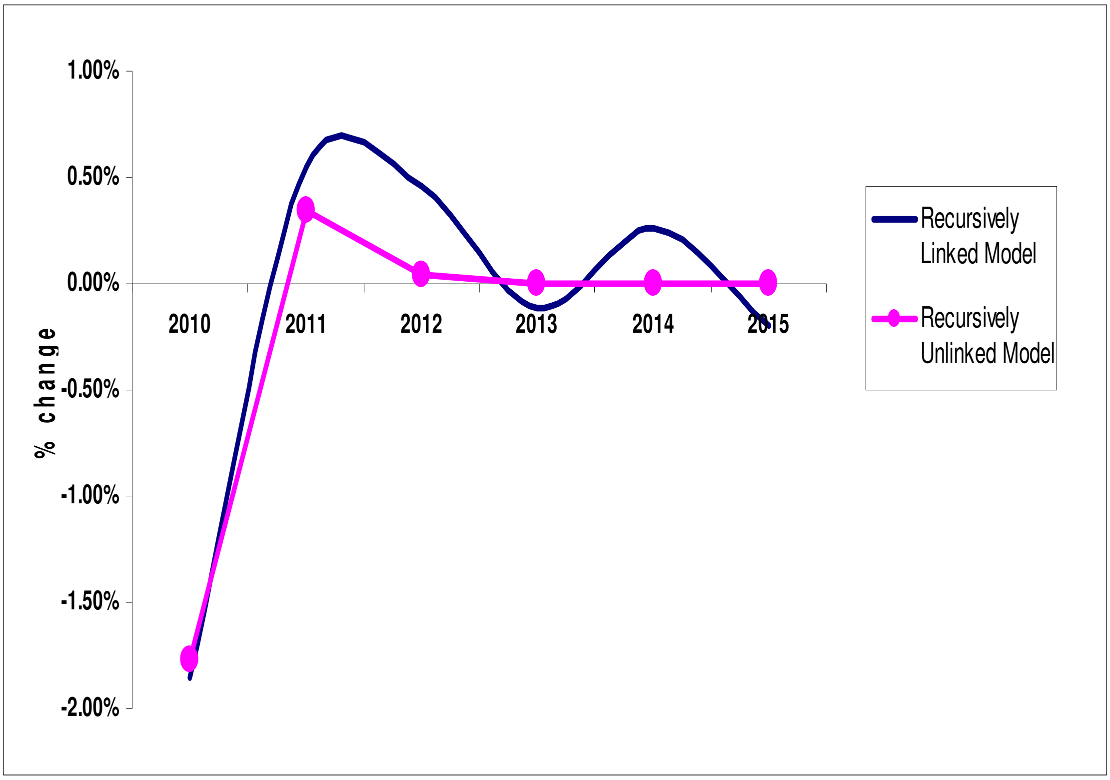


Figure 7.3: The impact of a 50% increase in the crude oil price on gross value added of agricultural sector

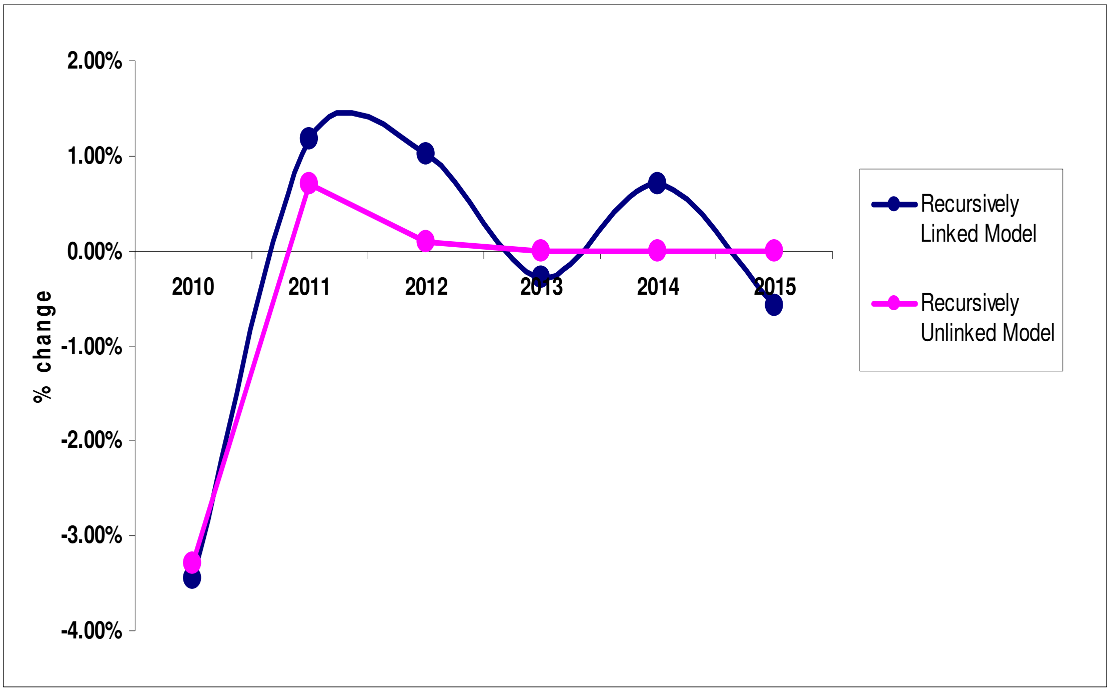


Figure 7.4: The impact of a 50% shock in the crude oil price on net farming income

7.4 Applying the Recursively Linked Model for Analysing the Impact of Exchange Rate Depreciation on the Agricultural Sector

Since in the previous BFAP output model domestic input prices were exogenous, the impact of change in input prices that might occur due to a change in exogenous variables such as world fertiliser prices, crude oil price, changes in exchange rate and growing domestic input demand could not be analysed. The recursively linked integrated model, however, links the domestic input prices with world markets, macro variables and domestic demand, and is therefore suitable for analysing the impact of exogenous factors that affect both output and input prices of the agricultural sector. Hence, the net impact of exchange rate depreciation on the sector is evaluated to assess the factors that affect both input and output prices simultaneously.

The results of a single shock of 50% exchange rate depreciation introduced in 2010 on the recursively linked model are given in Table 7.8. As shown in the table, the model showed little change in the area planted in 2010, since current prices and costs affect only the winter area planted. However, the exchange rate depreciation affects largely the gross income and input expenditure in 2010. Intermediate input expenditure rises by 5.6% due to the increase in the prices of fuel, fertiliser and feed. The rise is relatively modest as the depreciation of the exchange rate does not affect much the current planted area and not all agricultural input costs that may be affected are incorporated in the model.

The gross income also shows an increment of 24%, induced by the rise in output prices. Thus, the net effect of the shock increases the gross value added and net farming income by 39 and 72% respectively. The net farming income increases more due to the fact that most of the expenditures like depreciation, labour remuneration, rent and interest payments will remain unaffected for 2010. A significant increment of net farming income is also observed in 2001, when the 41% depreciation of the exchange rate induces a 50% rise in net farming income.

During 2011, however, area planted increases by 11% as the result of the lagged higher returns. Gross income, therefore, increases, by 3.5%. The modest rise in gross income is due to the price inelastic demand of agricultural products, which lowers the prices due to the rise in production. Following the rise in planted area, intermediate input expenditure also increases. Hence, the gross value added and net farming income will rise respectively by 5.3 and 10.3% in 2011. After 2012, the effect of the exchange rate shock will follow a cyclical pattern where the rise in gross value added and net farming income is followed by a fall until the total effect of the shock slowly disappears.

Table 7.8: Results of the recursively linked model for the shock of a 50% depreciation in exchange rate in 2010

Variable	2010	2011	2012	2013	2014	2015
Area planted	0.30 %	11.17 %	-1.49 %	0.41 %	-0.13 %	0.08 %
Gross income	24.39 %	3.50 %	-0.57 %	0.71 %	-0.51 %	0.43 %
Intermediate input expenditure	5.49 %	1.10 %	-1.63 %	-1.01 %	-0.27 %	-0.48 %
Gross value added	38.98 %	5.35 %	0.40 %	2.25 %	-0.68 %	1.22 %
Net farming income	72.50 %	10.36 %	-0.47 %	3.68 %	-4.20 %	0.92 %

7.5 Summary

This chapter addresses the main objectives of the study by providing baseline projections for the main aggregate variables and for the financial and economic performance indicators of the agricultural sector. Moreover, it tests the main hypothesis of the study, which states that the impact of input cost shocks on the agricultural sector is lengthened and converged slowly when the agricultural input and output sides are recursively linked by comparing the results of exogenous shocks introduced in the two versions of the integrated model. While the first version recursively links the agricultural input and output sides, the second version of the model 'switches off' the link.

The baseline projections for the main aggregate variables and the financial and economic performance indicators of the agricultural sector based on the projected values of exogenous variables show that the sector's gross income, intermediate input expenditure and gross value added will grow at an annual average growth rate of roughly 2%. Net farming income, however, shows a modest growth of 1.7% due to a higher rise in input expenditure compared to the growth of gross income. In addition, most of the financial and economic indicators show a modest improvement except the debt burden that shows little growth and leverage ratio, which remain relatively constant at 0.31 respectively.

Comparing the results of exogenous shocks introduced in the recursively linked and unlinked versions of the integrated model shows that the effect of exogenous shocks on the recursively unlinked model quickly die after the year of the shock due to the lack of a recursive effect between the output and the input sides. For the recursively linked model, however, the effect slowly converges in a cyclical pattern until it disappears due to the consideration for the recursive effect between the input and output side. Thus, the effect of increasing input cost may not be only a fall in gross value added and net farming income, as shown by the recursively unlinked model, but also a growth in subsequent years when the recursive effect of the impact is fully accounted for.

Using the recursively linked integrated model, the effect of exchange rate depreciation that affects the price of input and output simultaneously is evaluated. The result of a fifty percent shock introduced in the model reveals that the devaluation augments the gross income due to the increase in domestic prices for most agricultural products. Similarly, it increases input expenditure as a result of the rise in the cost of fuel and fertiliser. Due to the overwhelming rise in gross income, however, the net impact shows a significant rise of gross value added and net farming income in 2010. The rise in area planted in the subsequent year also induces a rise in gross income. However, the expansion of area planted and animal production also augments the input expenditure. Thus, the net effect on the gross value added and net farming income during 2011 remains positive because of the relatively higher growth of gross income *vis-à-vis* the input expenditure. After 2012, however, the impact converges slowly until the effect eventually disappears.

CHAPTER EIGHT

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

8.1 Summary

This study integrated a detailed model of agricultural input expenditures into the existing South African multi-market partial equilibrium model in order to evaluate the net impact of economic policies that especially affect input costs in the agricultural sector. Evaluating such impact by integrating inputs and other key aggregate variables with the output model and endogenising input costs would enrich the results of standard partial equilibrium models by enabling them to generate several economic and financial indicators to conduct a comprehensive assessment of the net effects of economic policies on the agricultural sector.

The main focus of most partial equilibrium models is the output side of the agricultural sector. Thus, sufficient attention has only been paid to incorporating inputs in a few of these models. Moreover, in most partial equilibrium models, the recursive linkage of the input and output sides of the sector and endogenising of input costs is overlooked in analysing the net impact of policies that affect both sides of the sector. Hence, the main objective of the study was to address both issues by extending the existing South African multi-market model to comprehensively evaluate the net impact of economic policies on the agricultural sector.

Since using few indicators to evaluate and assess the performance of the sector often provides little insight, applying several financial and economic indicators sheds more insights on the impact of economic policies on the sector, as this captures the effect from various angles. To obtain these indicators, however, it is crucial to integrate agricultural inputs into a multi-market output model and to incorporate the key aggregate variables of the agricultural sector (like asset value, debt level and gross capital formation of the sector).

Since the data used for the variables in the model is on aggregate level and the main objective of the research is for the purpose of policy analysis and projections, a single-equation method is used in the study. The approach is based on Hendry's methodology, where the data generation process starts from the general ADL (1) model specification, which allows testing of various nested and rival models. Thus, this method avoids data mining problems associated with the simple-to-general method and it allows the short-run dynamics of the model to be determined by the data.

The estimated input expenditures and other aggregate variable models are used to project the baseline for the agricultural sector, based on *status quo* assumptions for the exogenous variables, after passing many statistical diagnostic tests and model validation procedures. The baseline projections of the main aggregate variables of the agricultural sector showed a modest growth for the gross income, intermediate input expenditure and gross value added of the agricultural sector. The growth of real net farming income is relatively low during the baseline period, due to a relatively modest growth of gross income compared to all input expenditures. However, compared to previous decades, a modest improvement in the economic and financial position of the agricultural sector is projected during the baseline period.

From the comparative results of the impact of exogenous shocks on the agricultural sector using the recursively linked and unlinked models, it is revealed that an integrated model that recursively links the input and output sides of the agricultural sector and endogenises input costs subdues and lengthens the effect of shocks slowly and cyclically, due to the consideration it gives to the recursive effect from the output side to the input side and vice versa. The impact of a fifty percent devaluation of the exchange rate is also examined to evaluate the net impact of a variable that simultaneously affects both input and output prices. The result of the experiment indicates that the increase in gross income by far exceeds the rise in the expenditure effect. Thus, the net effect on gross value added and net farming income is very positive. Hence, this scenario showed that the net impact would have been overestimated if the simultaneous impact of the depreciation on input expenditure is not taken into account in the model. Similarly, the effect on the sector would have been concluded to be detrimental if the impact is evaluated only on input costs and expenditures.

8.2 Conclusions

Since the growth of the gross value added and net farming income do not exactly match the growth of the gross income due to the incorporation of input expenditures, economic and sectoral policy analyses that are based only on the gross income could reach a misleading conclusion. Moreover, since economic policies and exogenous factors that affect the gross value (output and prices) of agricultural sector could also affect input expenditures (inputs and costs) of the sector simultaneously and recursively, incorporating the impact of these policies on both outputs and inputs is essential to uncover their net effect on the sector.

Hence, this study extended the partial equilibrium sectoral model developed by Bureau for Food and Agricultural Policy (BFAP) by integrating input expenditures and other components of aggregate variables and endogenising input costs into the model in order to improve its ability to comprehensively assess the full impact of policy changes and exogenous shocks. Thus, the developed integrated model is now able to project a baseline for the gross value added, net farming income and several financial and economic performance indicators of the agricultural sector. Stated differently, the integrated model has extended the economic policies impact assessment on the South African agricultural sector, which was limited only on gross income (production, area planted and prices) to input expenditures, gross value added and net farming income of the sector. In addition, the integrated model has further extended the analysis to evaluate the financial and economic position of agricultural sector by assessing the implication of the policy on the asset and debt values of the sector.

The integrated model has also recursively linked the input and output side of the sector and endogenised input costs. Hence, the dynamic effects of policies on the agricultural sector are well captured due to the recursive linkage. Moreover, the model is now able to analyse the net effect of policies and exogenous factors that simultaneously affect both input and output prices.

Comparing the results of exogenous shocks introduced on the recursively linked and unlinked versions of the integrated model shows that the effect of exogenous shocks on the recursively unlinked model quickly die after the year of the shock due to the lack of the recursive effect between the output and the input side. For the recursively linked model, however, the effect is lengthened and slowly converged in a cyclical pattern until it disappears due to the account for the recursive effect between the input and output side of the agricultural sector.

In conclusion, this study shows that a partial equilibrium model that integrates input expenditures into the output side of the agricultural sector will be able to generate baseline projections for key aggregate variables. Moreover, incorporating other main aggregate variables into the partial equilibrium model enables the model to produce several indicators that can be used to evaluate the economic and financial position of the agricultural sector. Endogenising domestic input costs in the partial equilibrium model also enables the model to comprehensively analyse the net impact of exogenous factors that simultaneously affect both sides of the agricultural sector. From the results of several shocks and policy scenarios, it can also be concluded that a recursively linked output and input models of agricultural sector replicates the dynamics of the agricultural sector better than the unlinked one.

The model developed in this study, therefore, improves the result of the standard partial equilibrium models by producing a comprehensive assessment of the effects of policies than obtained by models that have few/no inputs components, assess the effects separately, or treat input costs as exogenous to the model. Moreover, by simultaneously encompassing the impact of policies on both output and input sides of the agricultural sector, the integrated model serves as a powerful tool to investigate the effects of various economic policy analyses and answers several ‘what if’ questions. Ignoring the dynamic and recursive interaction within the sector in evaluating the implication of economic policies often leads to a biased conclusion.

8.3 Limitations of the Study and Areas of Further Research

This study attempts to provide a modelling framework that could be used to comprehensively analyse the net impact of economic policies on the South African agricultural sector by integrating agricultural input expenditures into a multi-market commodity model. The modelling framework, however, could be further refined in the following aspects.

- Dealing with aggregated data often conceals the difference in the impact of economic policies across sub-sectors and at a commodity or animal product level. Therefore, it is recommended that disaggregating the input expenditure component and assessing the net farm income at a lower aggregation level would be able to capture the diverse implications of these policies on each sub-sector and product level.

- This study also assumes that the rise in input costs will affect all commodities equally. In reality, however, there is a wide difference in input utilisation by each commodity. The inclusion of variable input cost composition for each commodity, therefore, would give more accurate policy impacts at a commodity level and it would also make it possible to project the profitability trend of the commodity production.

- Incorporating several variable input costs for each commodity would also make the recursive effect of the input side to the output side of the agricultural sector more pronounced than the findings of the study, which used only fuel and fertiliser costs as a proxy.

- Embracing the possible yield effects of the rise in input costs would also enhance the analysis of the impact of these costs on the agricultural sector.

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APPENDIX A : The effect of a 50% world fertiliser cost on commodity prices and production

	2010	2011	2012	2013	2014	2015
White maize production	0.00%	-2.46%	-0.33%	0.73%	0.02%	0.02%
White maize producer price	0.00%	0.31%	1.36%	0.01%	0.01%	0.05%
Yellow maize production	0.00%	-2.46%	2.02%	-0.68%	0.32%	-0.18%
Yellow maize producer price	0.00%	3.33%	-1.32%	0.74%	-0.35%	0.27%
Wheat summer area harvested	0.00%	-2.46%	-0.57%	-0.15%	-0.13%	0.02%
Wheat winter area harvested	-2.37%	0.00%	0.00%	0.00%	0.00%	0.00%
Wheat production	-1.04%	-1.45%	-0.33%	-0.09%	-0.08%	0.01%
Wheat producer price	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Barley production	-1.48%	-0.89%	-0.05%	0.00%	-0.02%	0.01%
Barley producer price	0.07%	0.04%	0.00%	0.00%	0.00%	0.00%
Canola production	-2.37%	0.10%	0.01%	-0.01%	0.00%	0.00%
Canola producer price	0.19%	0.00%	0.00%	0.00%	0.00%	0.00%
Sorghum production	0.00%	-2.46%	0.27%	-0.11%	-0.06%	-0.02%
Sorghum producer price	0.00%	0.66%	-0.08%	0.06%	-0.01%	0.02%
Sunflower production	0.00%	-2.46%	0.00%	-0.07%	-0.07%	0.03%
Sunflower producer price	0.00%	0.60%	-0.02%	0.01%	0.02%	-0.01%
Soybean production	0.00%	-2.41%	0.37%	0.01%	0.05%	-0.04%
Soybean producer price	0.00%	0.88%	-0.21%	-0.06%	-0.07%	-0.02%
Sugarcane production	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Sugarcane average price	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

APPENDIX B: The effect of a 50 % world crude oil price on commodity prices and production

	2010	2011	2012	2013	2014	2015
White maize production	0.00%	-3.55%	0.51%	0.56%	0.10%	0.00%
White maize producer price	0.17%	2.05%	0.91%	0.22%	-0.05%	0.09%
Yellow maize production	0.00%	-3.80%	2.89%	-0.97%	0.52%	-0.30%
Yellow maize producer price	0.05%	5.45%	-1.97%	1.16%	-0.60%	0.46%
Wheat summer area harvested	0.00%	0.13%	-0.85%	-0.08%	-0.19%	0.05%
Wheat winter area harvested	-3.23%	2.17%	0.12%	0.01%	0.00%	0.00%
Wheat production	-1.42%	0.97%	-0.45%	-0.04%	-0.12%	0.03%
Wheat producer price	5.08%	0.00%	0.00%	0.00%	0.00%	0.00%
Barley production	-2.02%	-0.98%	-0.26%	0.01%	-0.03%	0.01%
Barley producer price	2.18%	0.05%	0.01%	0.00%	0.00%	0.00%
Canola production	-3.23%	-0.50%	-0.07%	-0.01%	0.00%	0.00%
Canola producer price	0.25%	0.04%	0.00%	0.01%	-0.01%	0.01%
Sorghum production	0.00%	-2.47%	0.13%	-0.19%	-0.10%	-0.06%
Sorghum producer price	0.03%	0.79%	-0.09%	0.10%	-0.01%	0.04%
Sunflower production	0.00%	-3.87%	-0.33%	0.02%	-0.14%	0.06%
Sunflower producer price	-0.03%	0.94%	0.05%	-0.02%	0.03%	-0.02%
Soybean production	0.15%	-3.04%	0.76%	-0.13%	0.09%	-0.08%
Soybean producer price	2.57%	0.95%	-0.45%	-0.10%	-0.16%	-0.07%
Sugarcane production	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Sugarcane average price	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%