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.

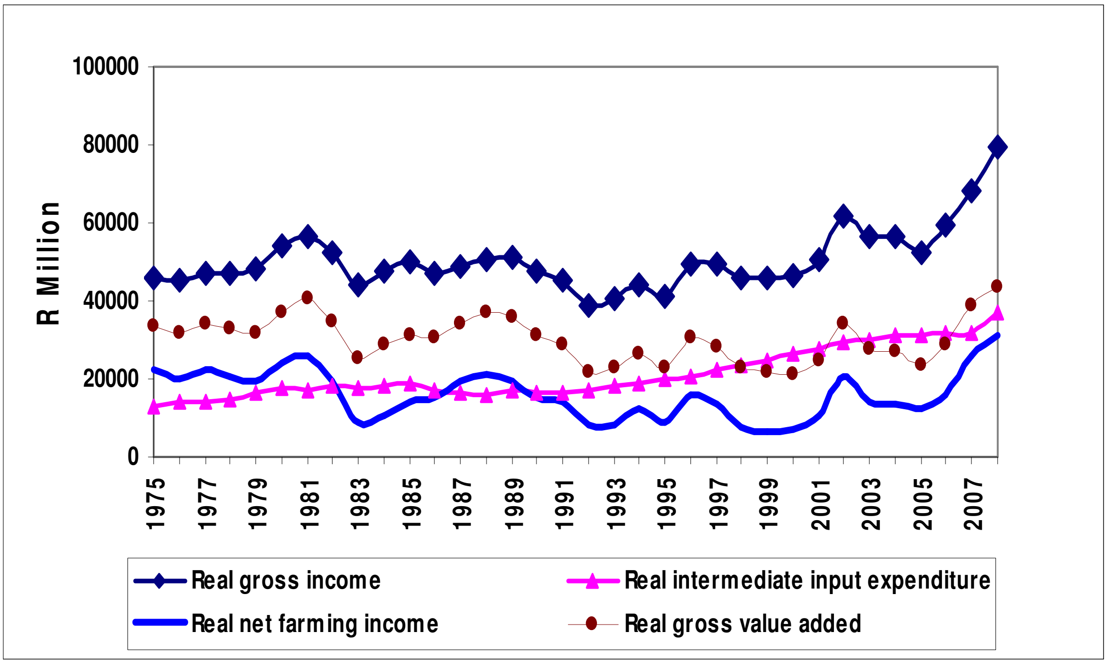

Figure 1.1: Agricultural gross income, value added, intermediate input expenditure and net farming income at constant 2000 prices.
Source: Adapted from DAFF (2009)

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.

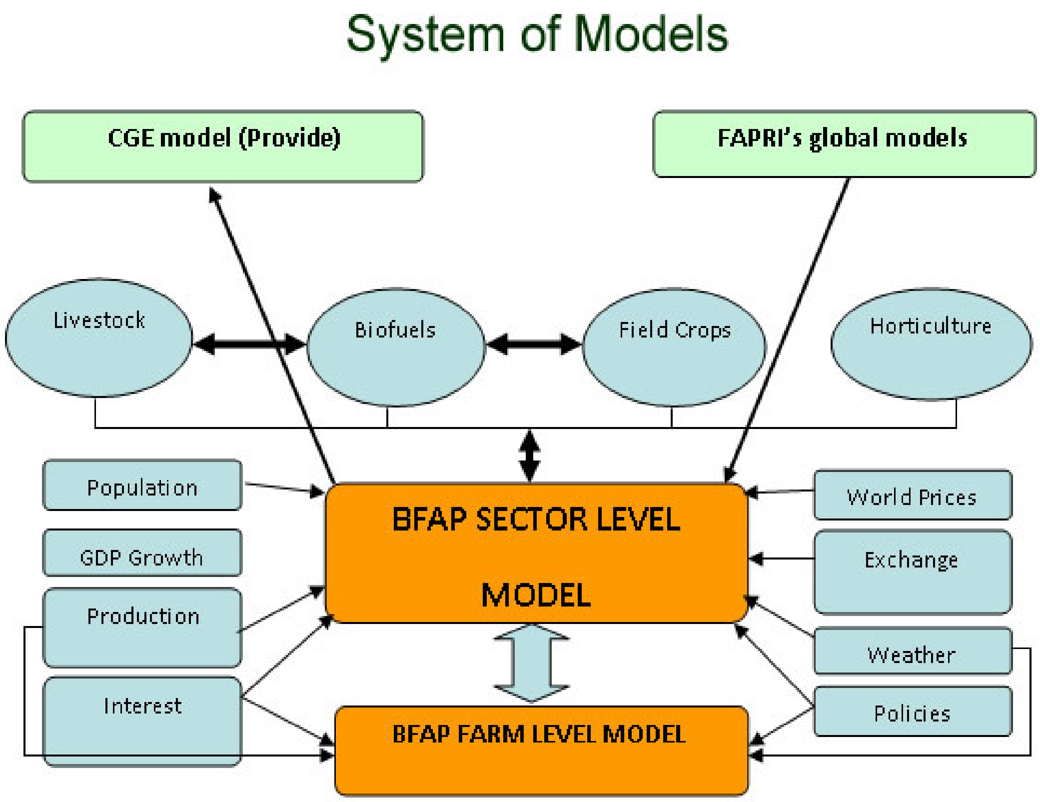

Figure 1.2: Basic structure of the BFAP system of models.
Source: BFAP (2010).

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.

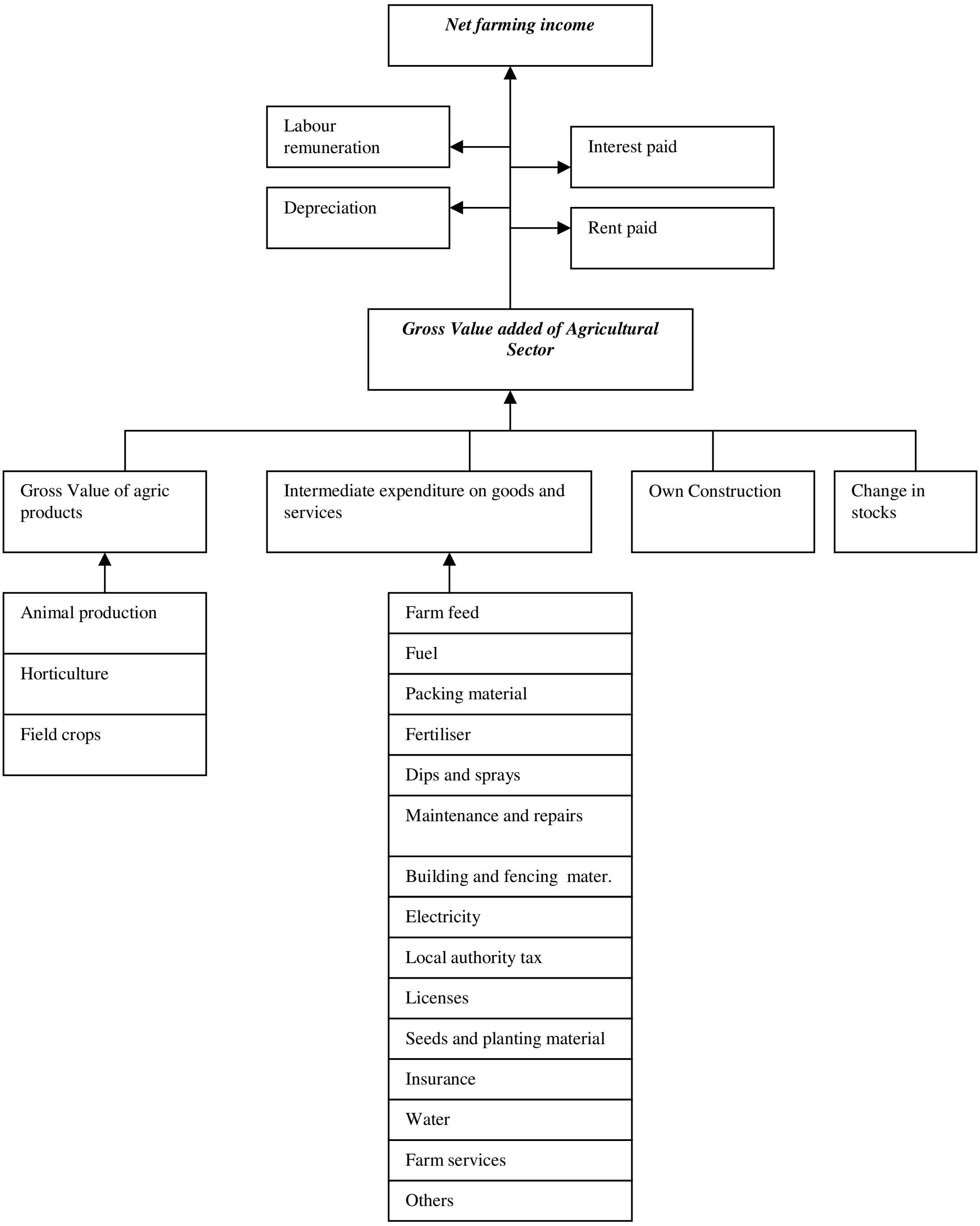

Figure 1.3: Graphical representation of the components of agricultural value added and net farming income

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).

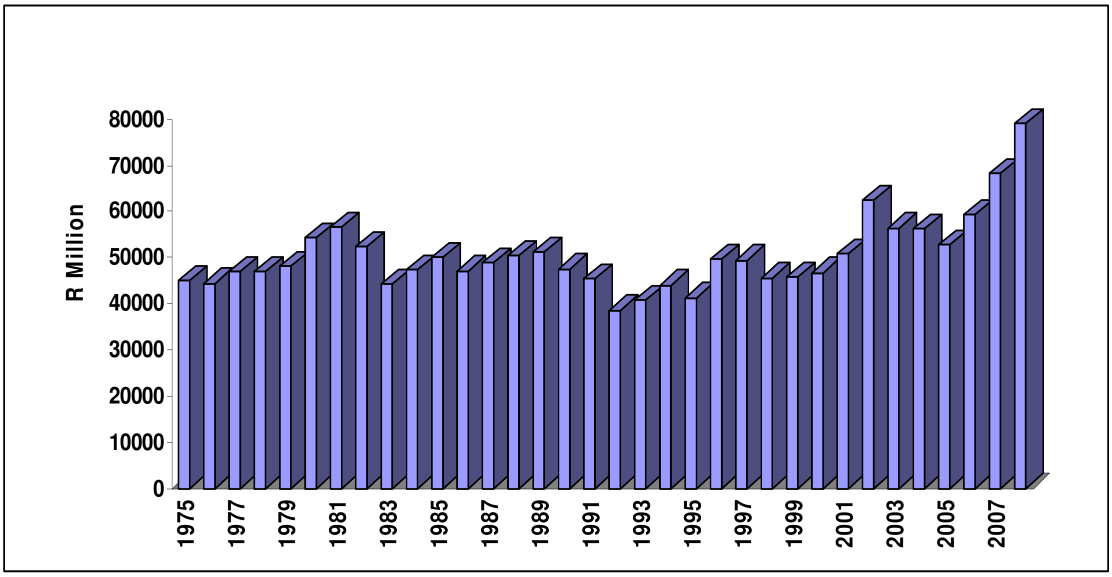

Figure 2.1: Gross value of the agricultural sector: deflated by CPI (2000=100).
Source: Adapted from DAFF (2009).

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.

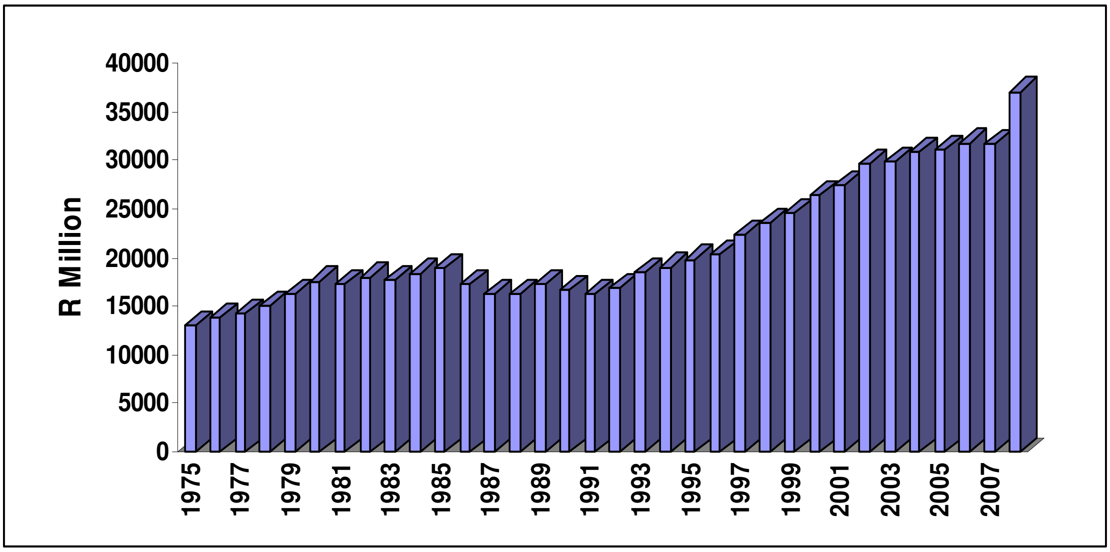

Figure 2.2: Intermediate input expenditure deflated by PPI (2000=100).
Source: Adapted from DAFF (2009)

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.

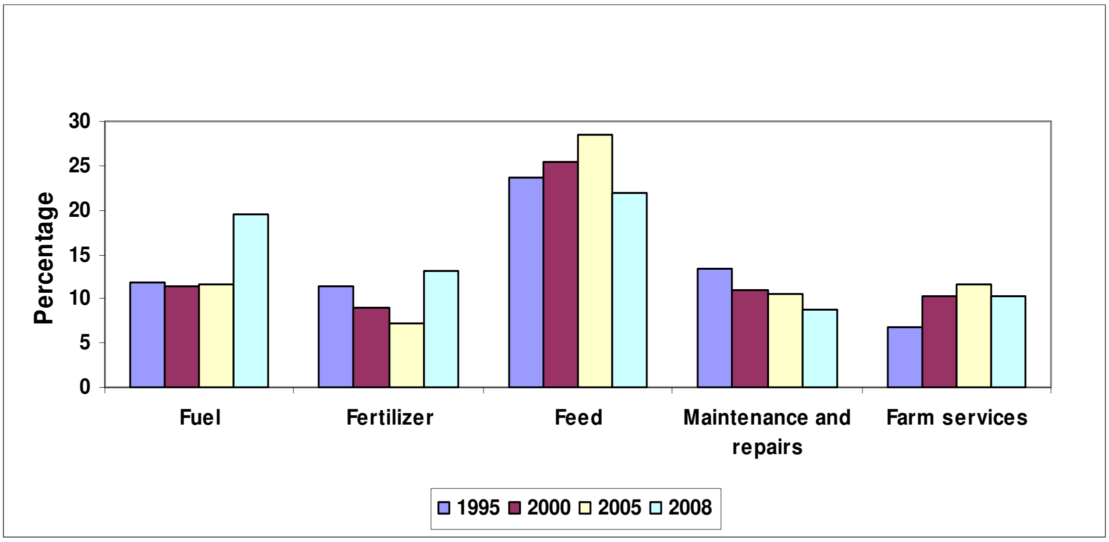

Figure 2.3: Percentage shares of selected intermediate inputs.
Source: Adapted from DAFF (2009)

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.

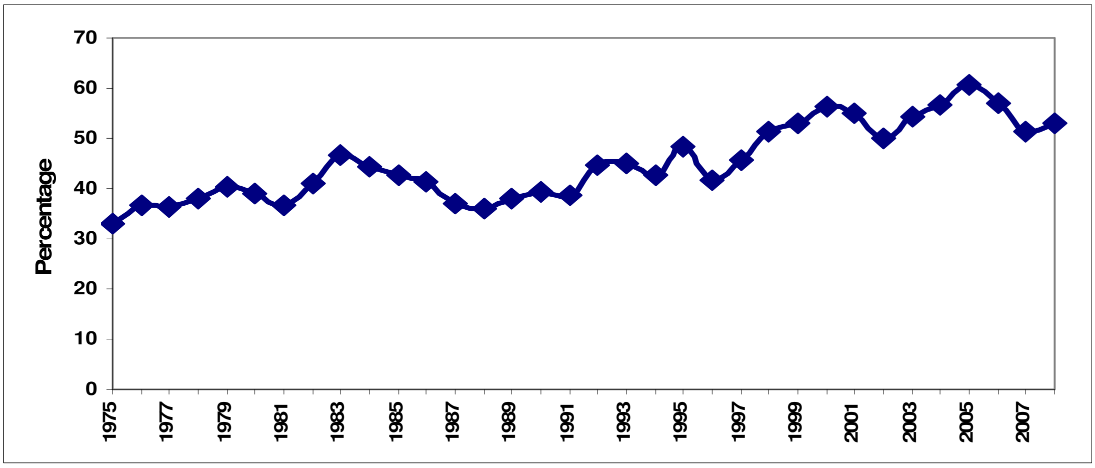

Figure 2.4: The percentage share of intermediate input expenditure in the gross value of agricultural products.

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.

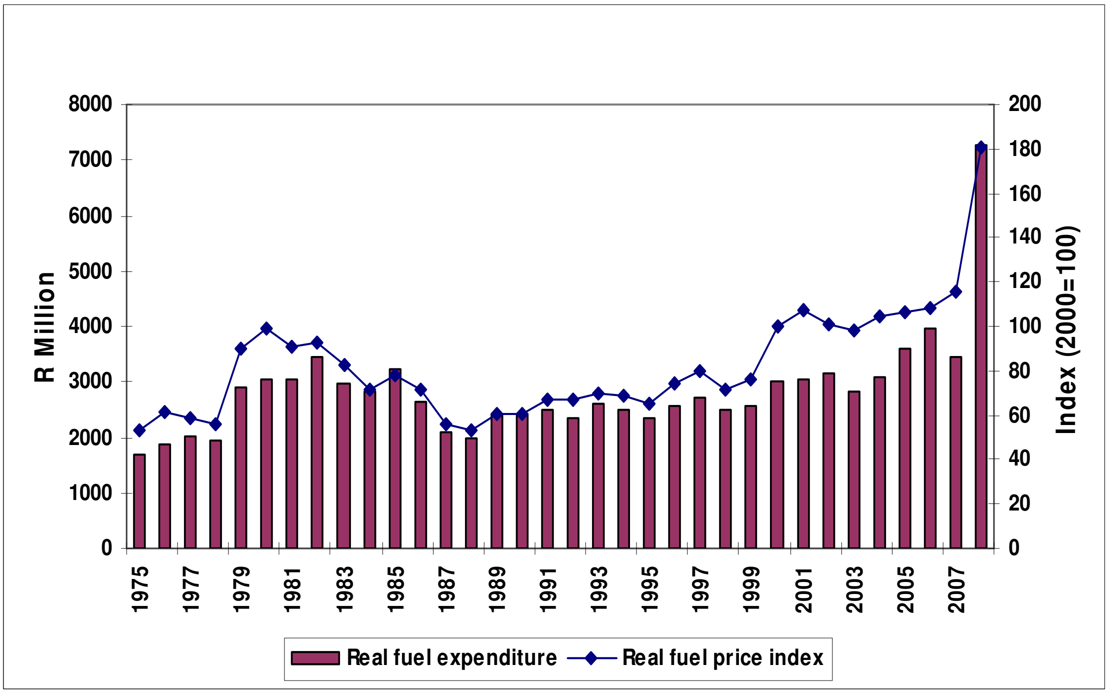

Figure 2.5: Fuel expenditure and fuel price index: deflated by PPI (2000=100)
Source: Adapted from DAFF (2009)

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.

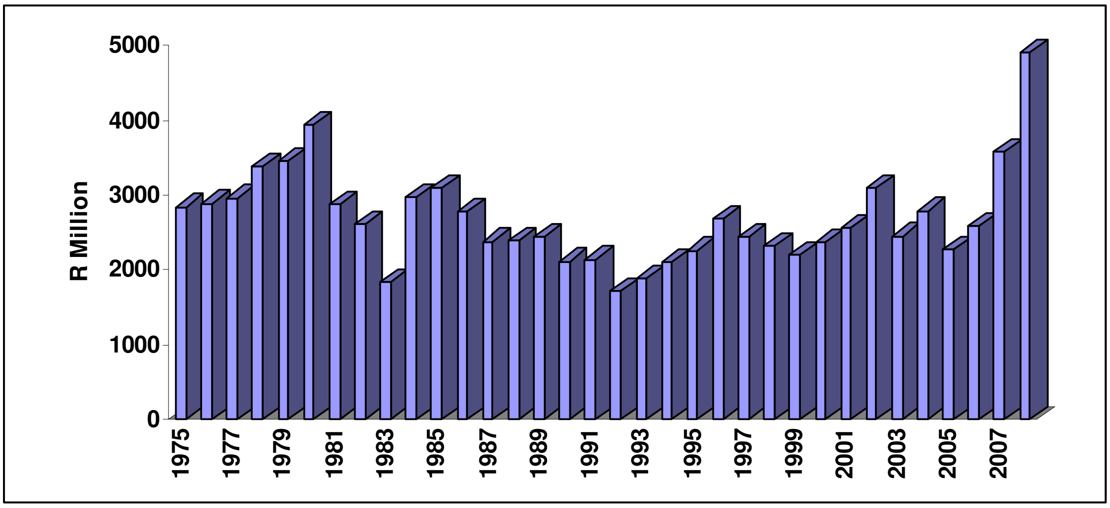

Figure 2.6: Fertiliser expenditure deflated by PPI (2000=100)
Source: Adapted from DAFF (2009)

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%).

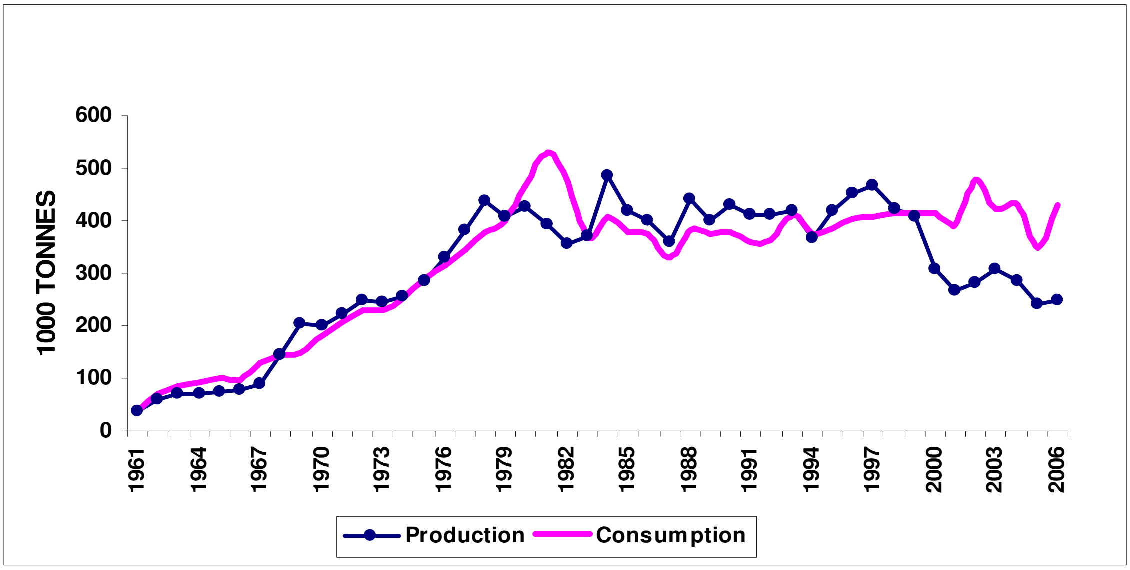

Figure 2.7: Total quantity of nitrogen production and consumption
Source: IFA (2009a)

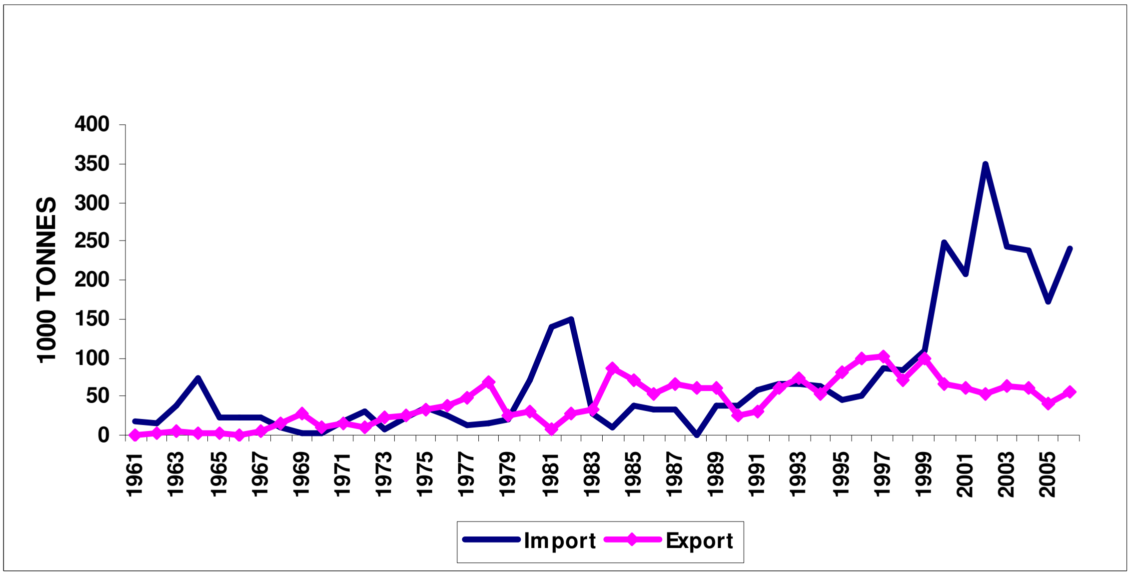

Figure 2.8: Volume of nitrogen traded in South Africa
Source: IFA (2009a)

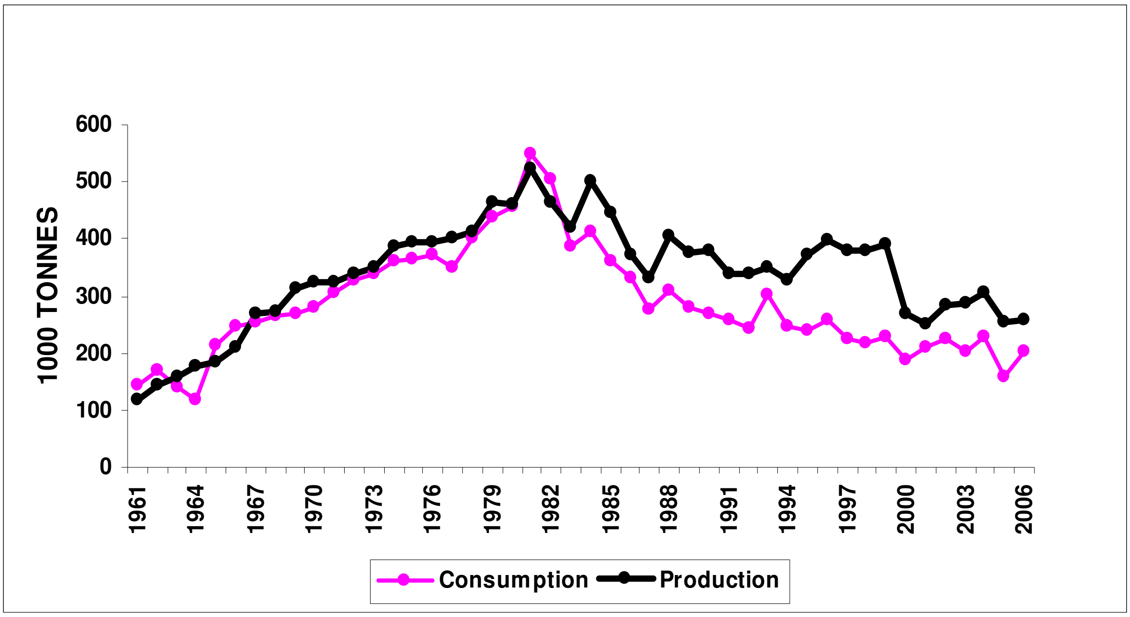

Figure 2.9: Total quantity of phosphate production and consumption
Source: IFA (2009a)

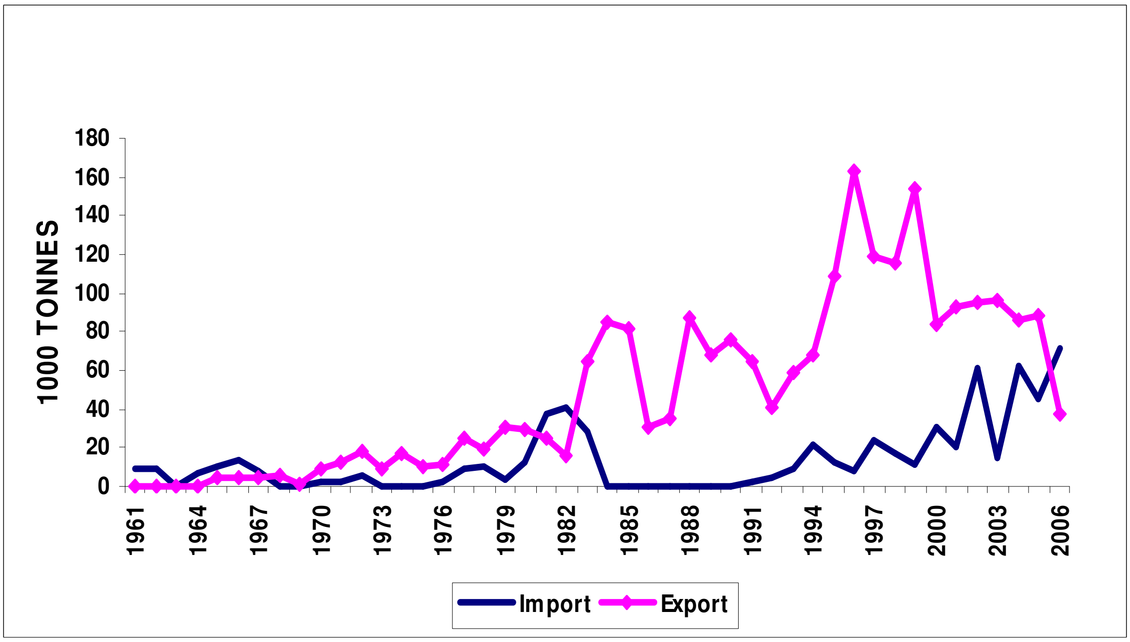

Figure 2.10: Volume of phosphate traded in South Africa
Source: IFA (2009a)

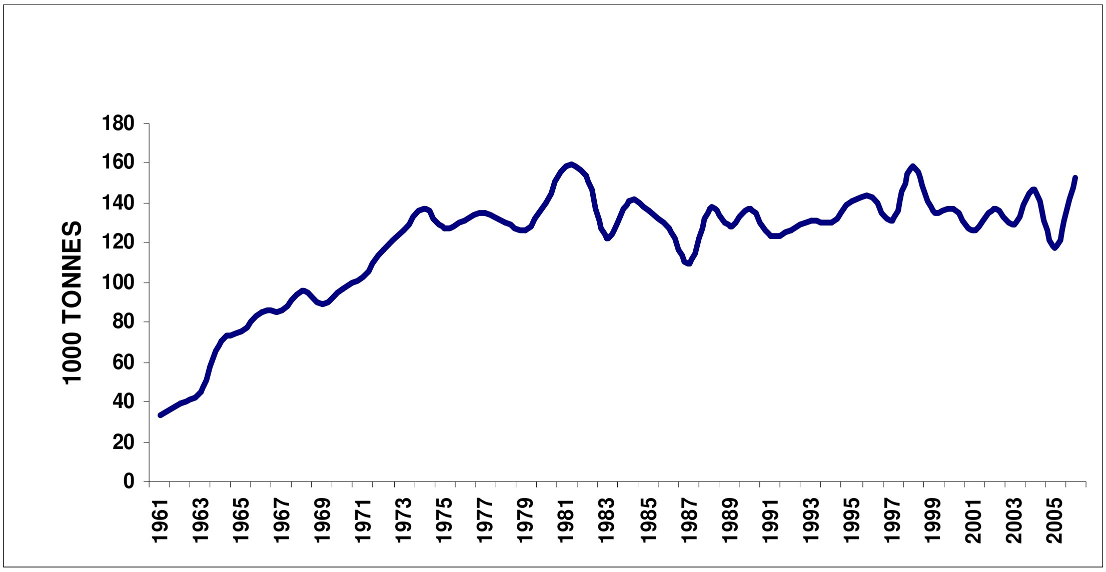

Figure 2.11: Total quantity of potash consumption
Source: IFA (2009a)

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.

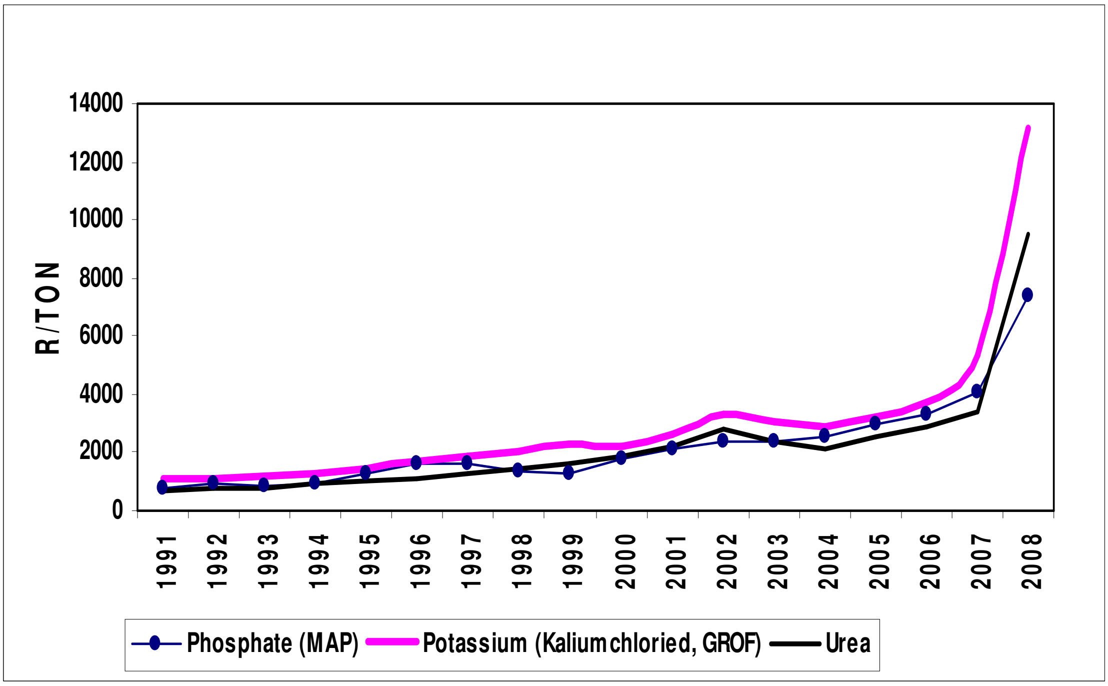

Figure 2.12: Domestic fertiliser prices of three major fertilisers
Source: GrainSA (2009)

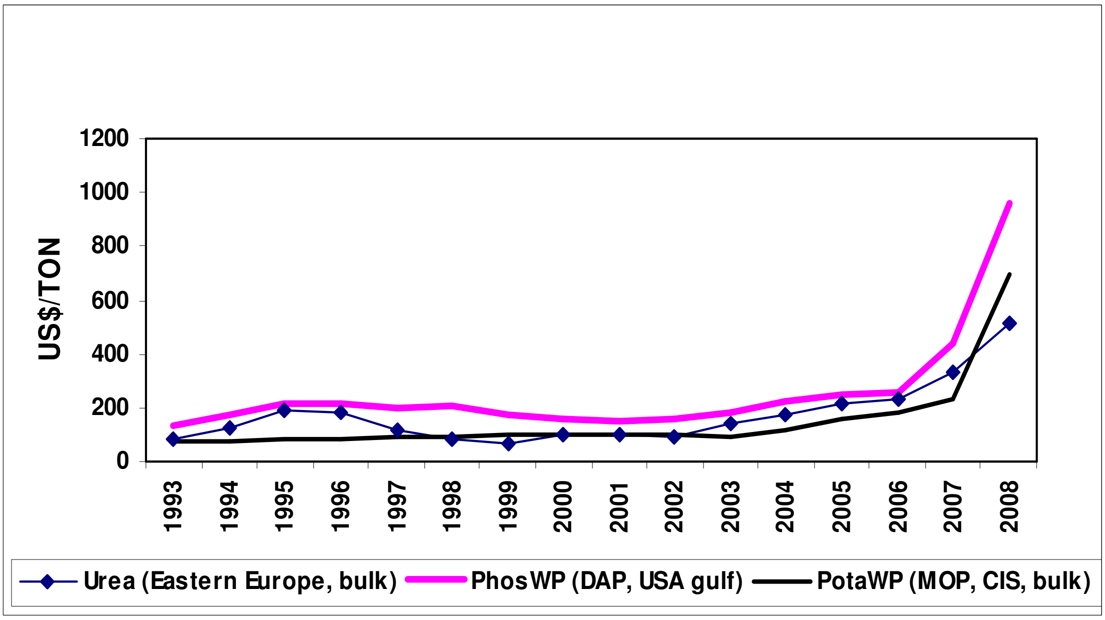

Figure 2.13: International prices of three major fertilisers
Source: GrainSA(2009)

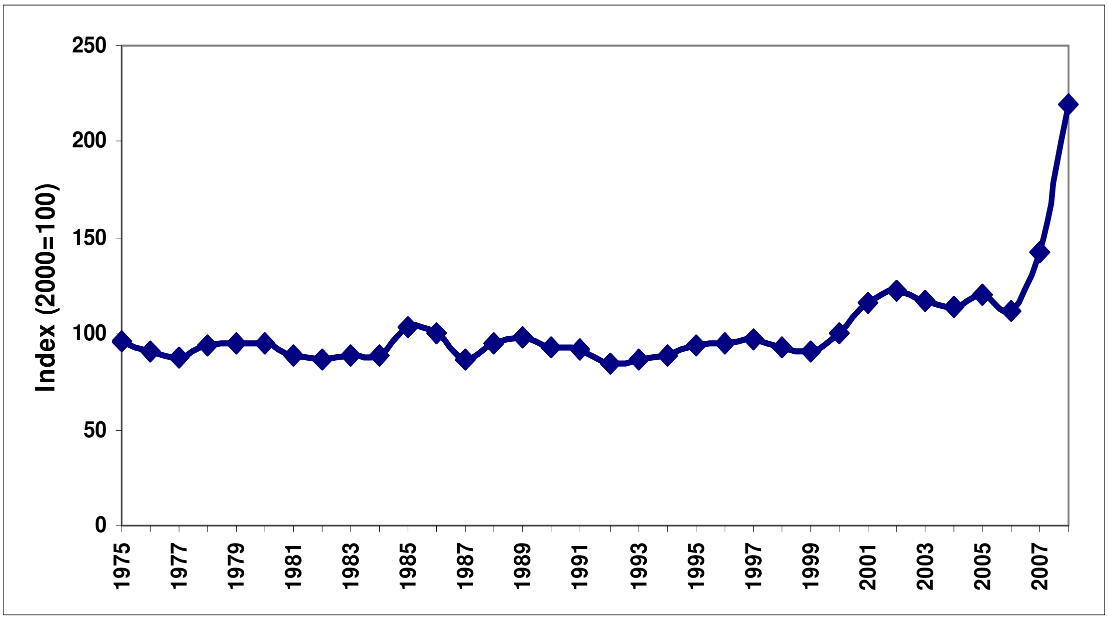

Figure 2.14: Real fertiliser price index
Source: Adapted from DAFF (2009)

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%.

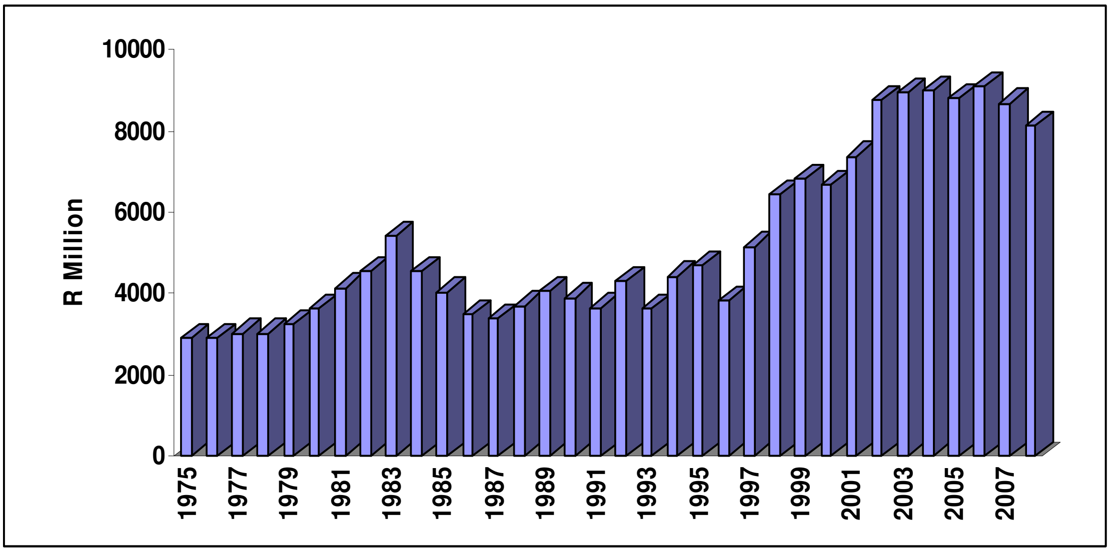

Figure 2.15: Feed expenditure: deflated by PPI (2000 =100)
Source: Adapted from DAFF (2009)

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.

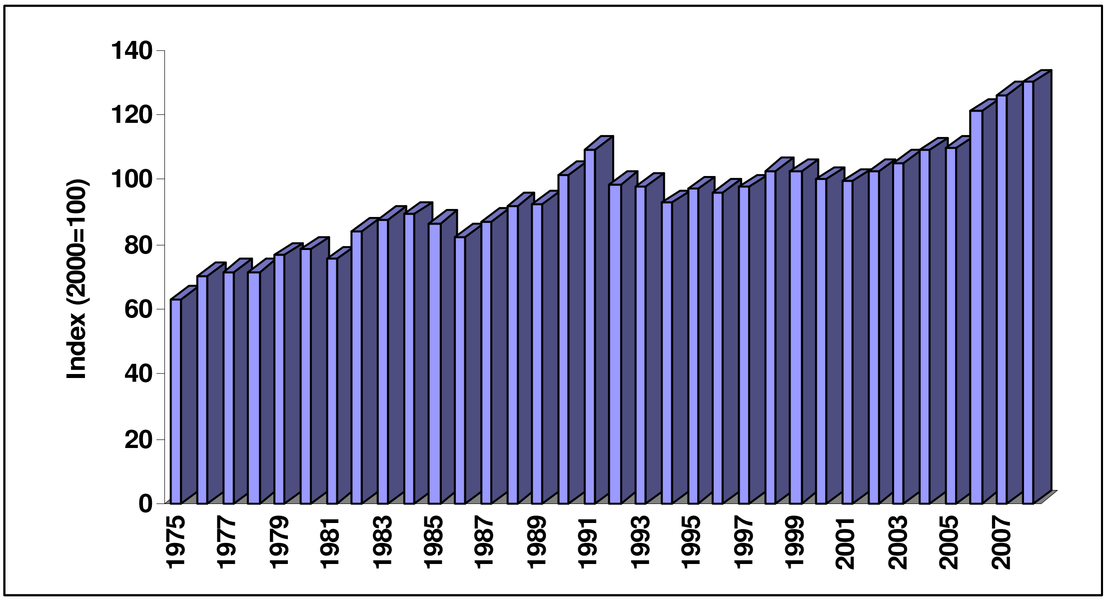

Figure 2.16: Animal products volume index
Source: DAFF (2009)

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.

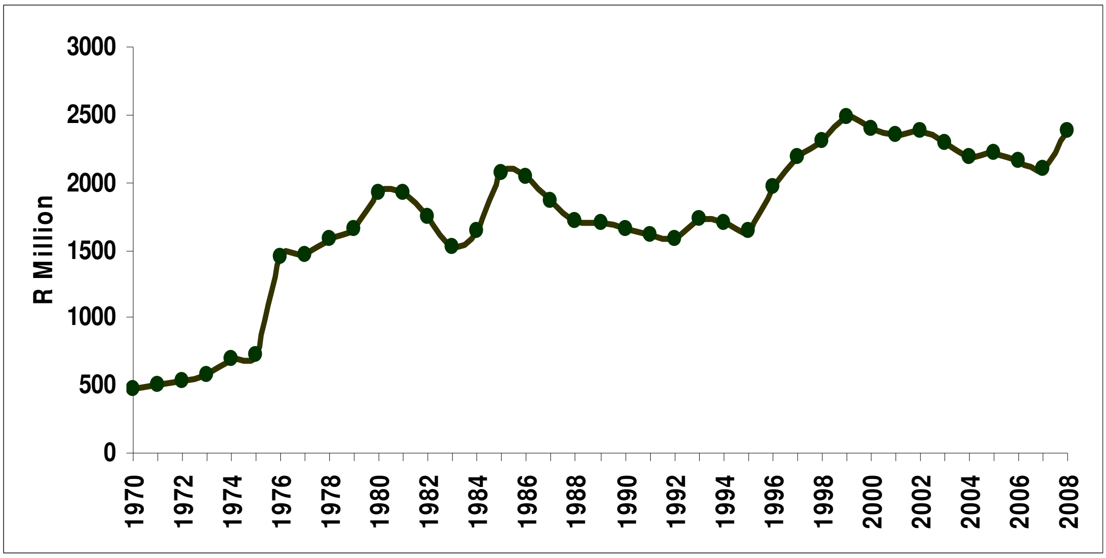

Figure 2.17: Expenditure on dips and sprays: deflated by PPI (2000 = 100)
Source: Adapted from DAFF (2009)

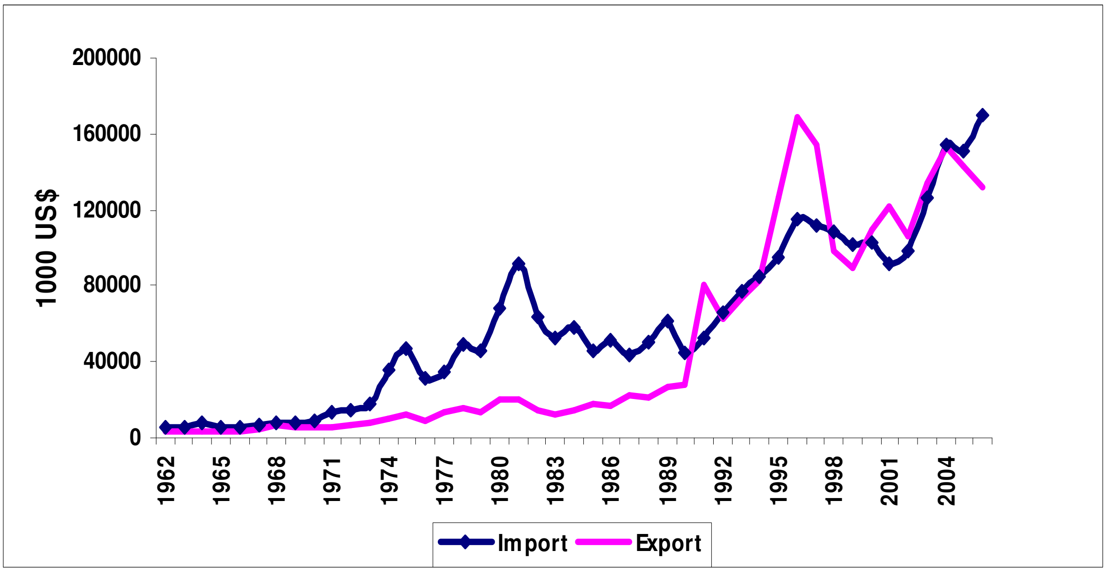

Figure 2.18: Value of South Africa's trade in pesticides
Source: FAO (2009)

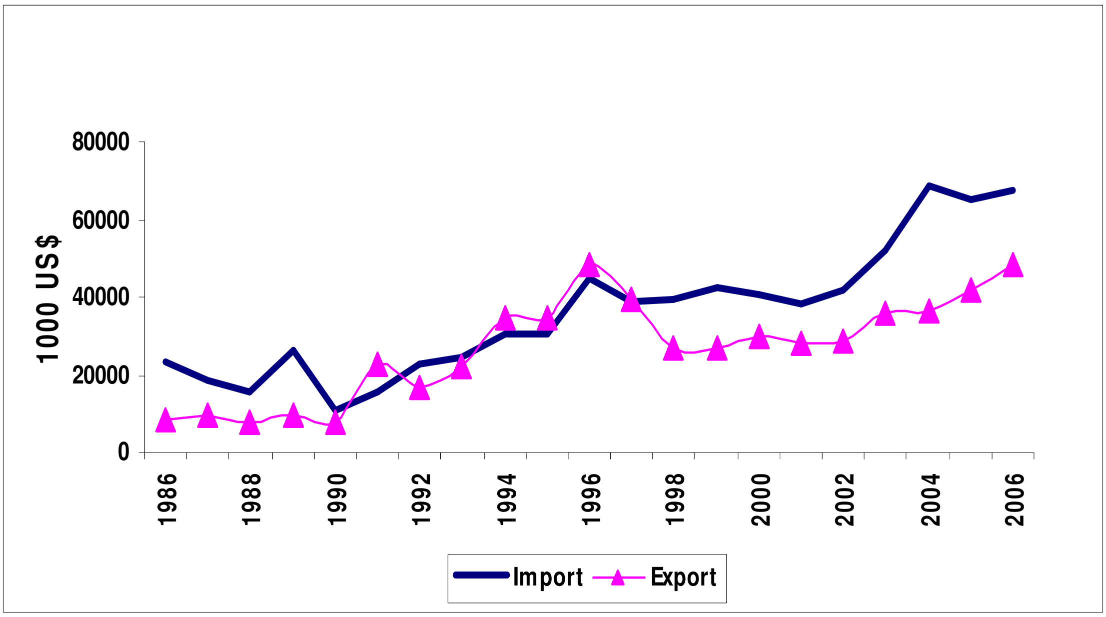

Figure 2.19: Value of South Africa's trade in insecticides
Source: FAO (2009)

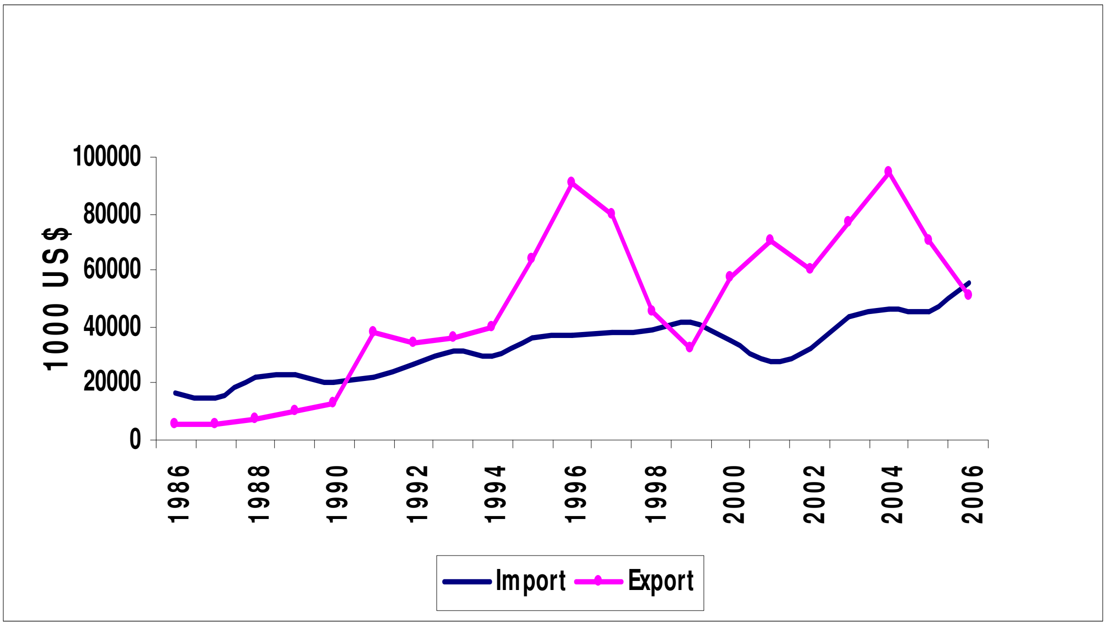

Figure 2.20: Value of South Africa's trade in herbicides
Source: FAO (2009)

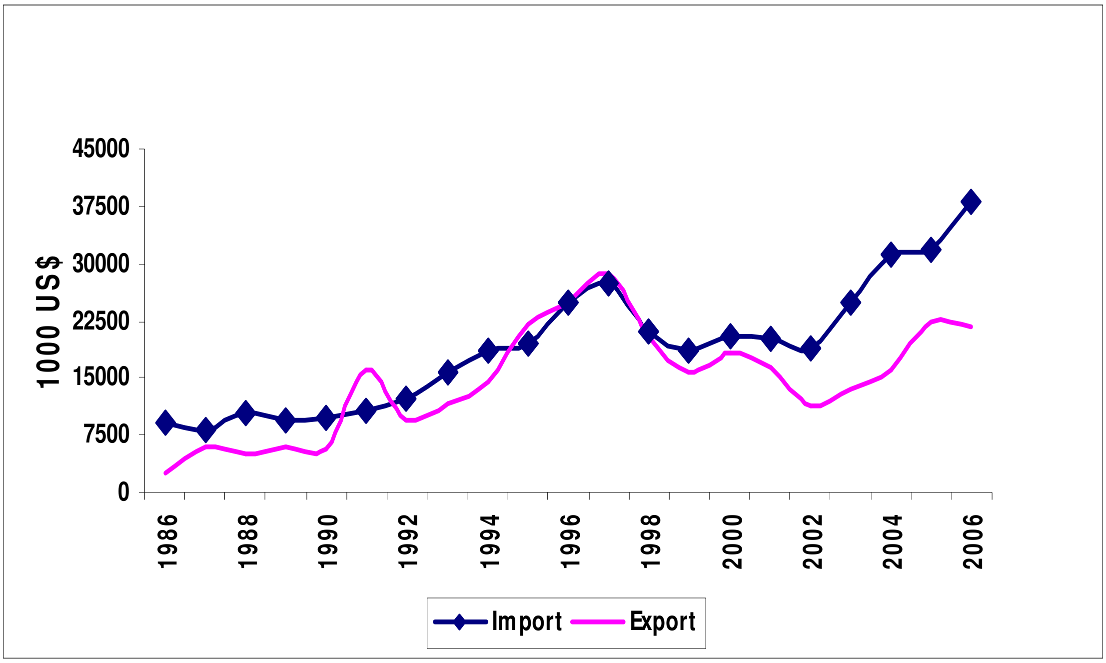

Figure 2.21: Value of South Africa's trade in fungicides
Source: FAO (2009)

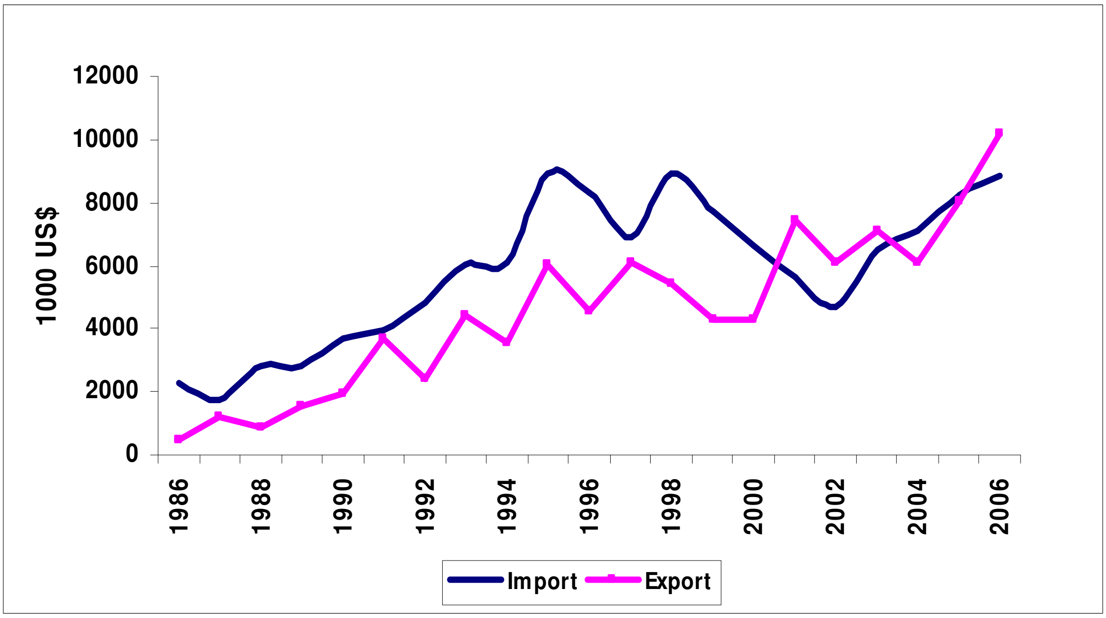

Figure 2.22: Value of South Africa's trade in disinfectant
Source: FAO (2009)

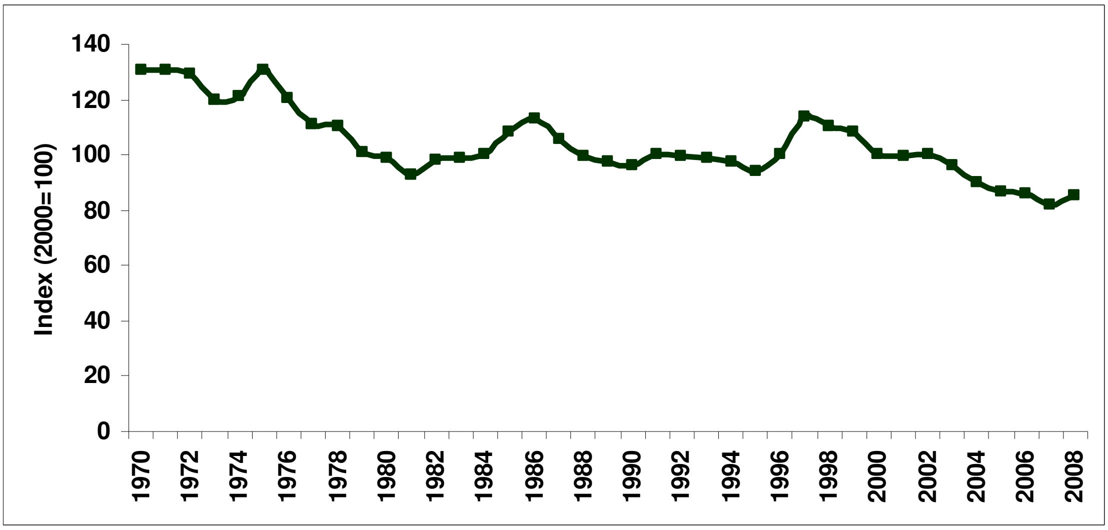

Figure 2.23: Dips and spray price: deflated by PPI (2000=100)
Source: Adapted from DAFF (2009)

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.

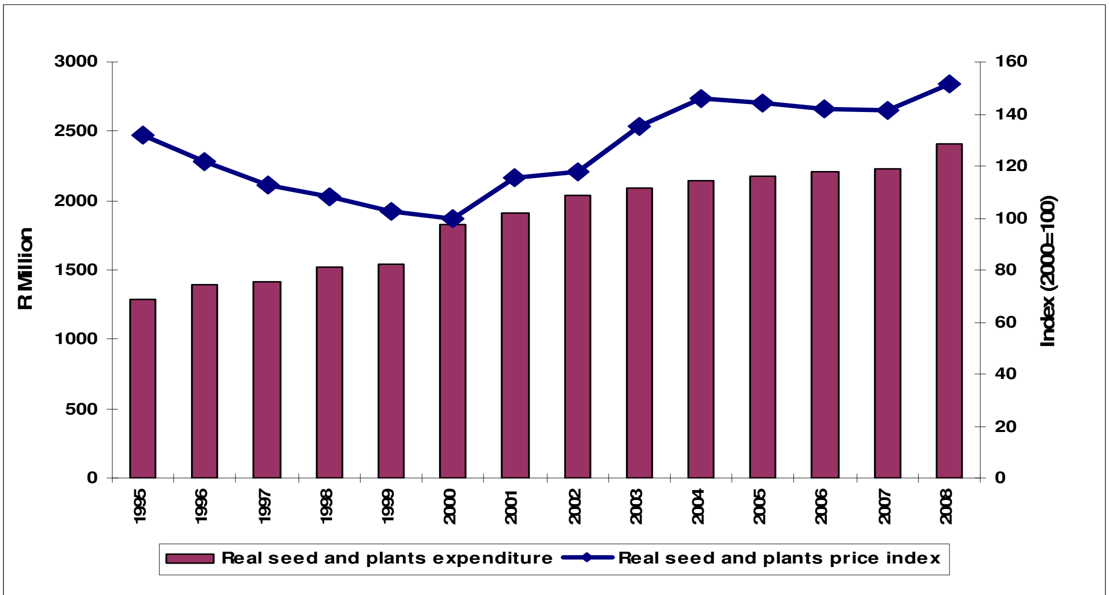

Figure 2.24: Seed and plants expenditure and seed cost: deflated by PPI (2000=100)

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.

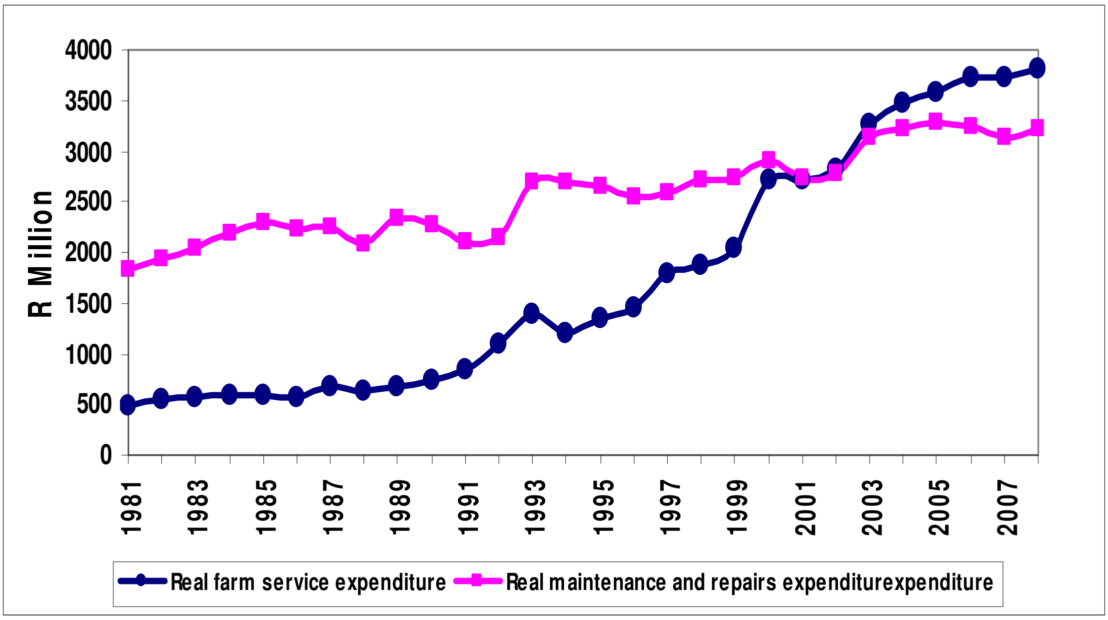

Figure 2.25: Real farm services and maintenance and repairs expenditure: deflated by PPI (2000=100)
Source: Adapted from DAFF (2009)

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).

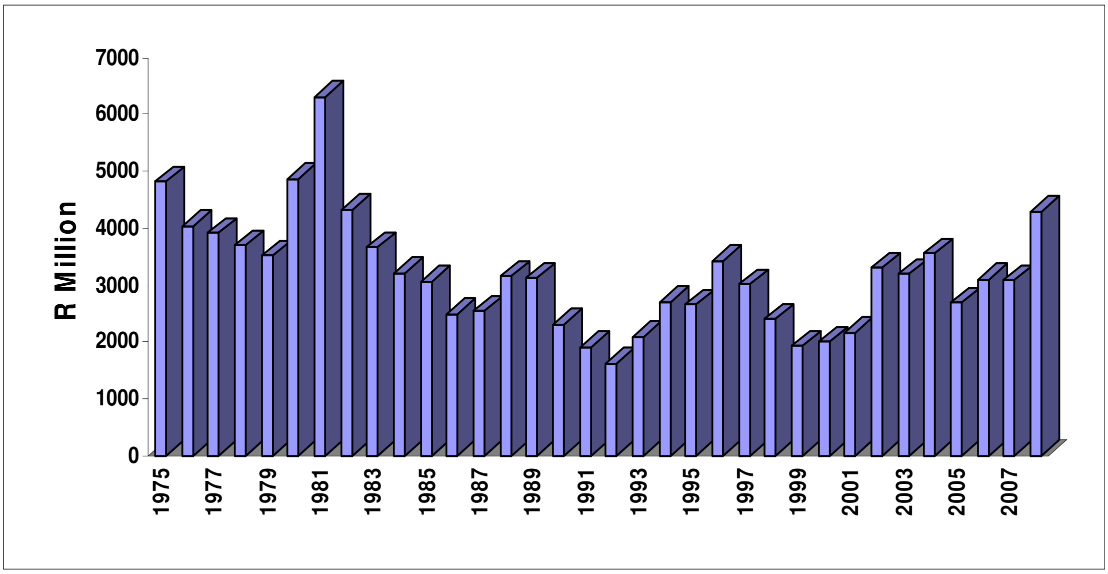

Figure 2.26: Real gross capital formation: Tractors, machineries and implements: deflated by PPI (2000=100)

Source: Adapted from DAFF (2009)

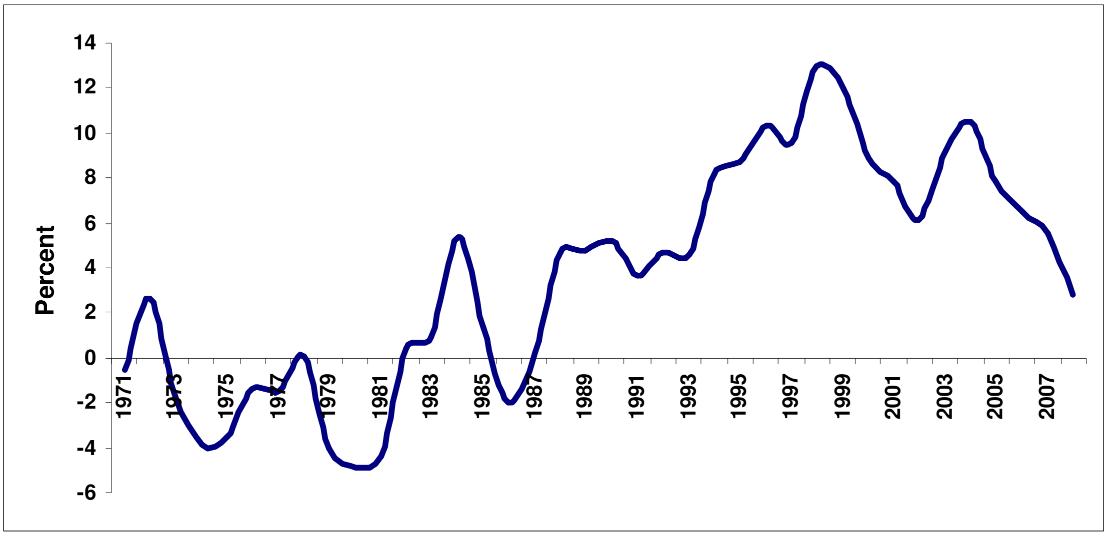

Figure 2.27: Average real interest rate: (average nominal interest rate – inflation)
Source: Adapted from Directorate: Agricultural Statistics (2009)

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.

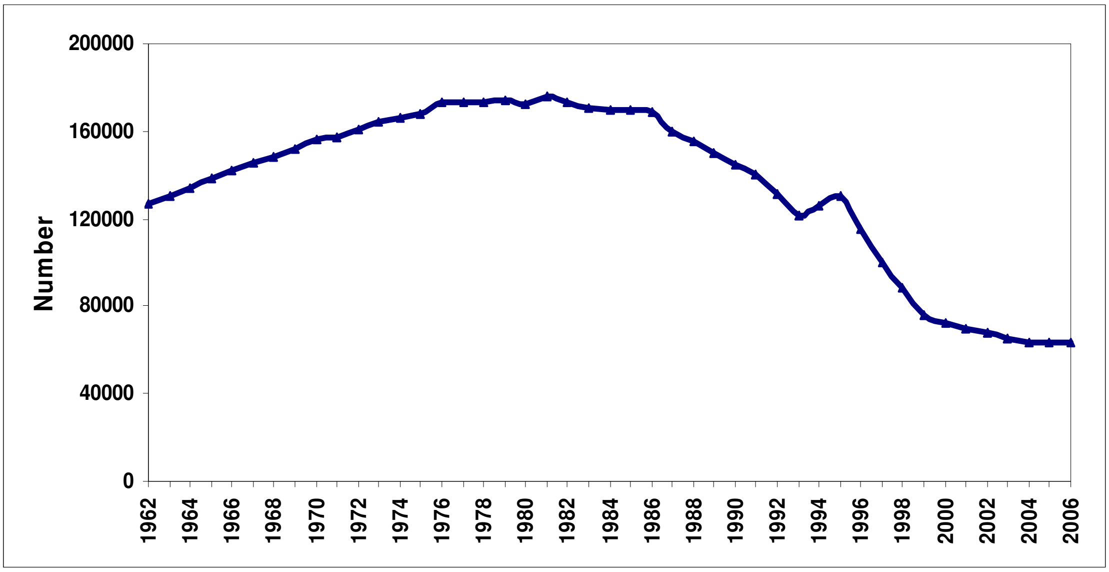

Figure 2.28: The number of agricultural tractors in use in South Africa
Source: FAO (2009)

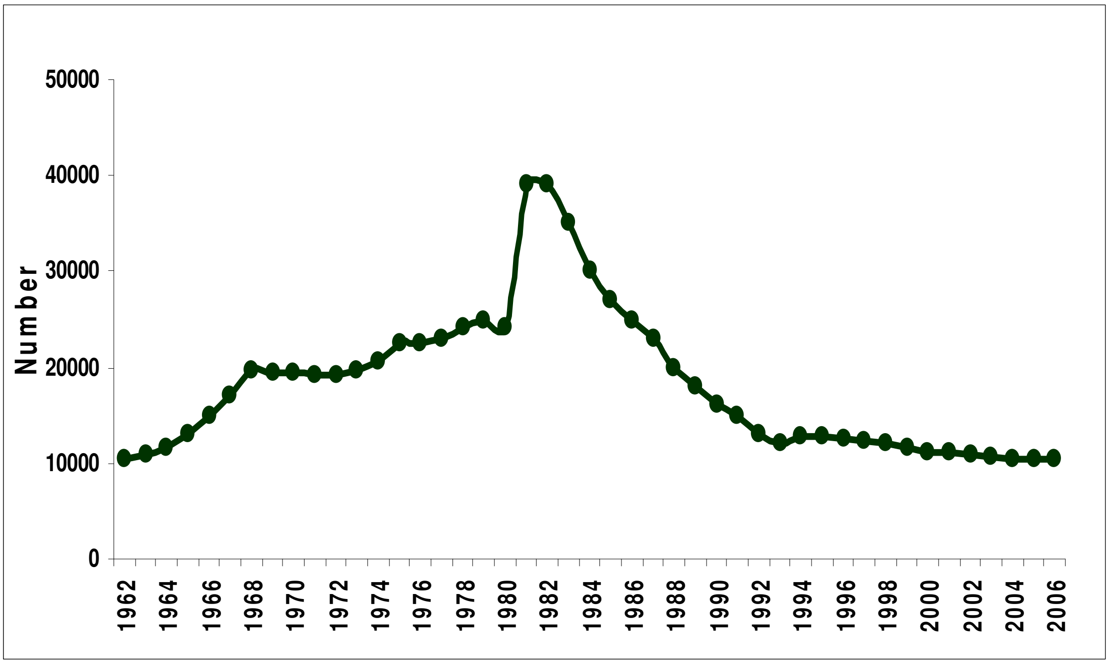

Figure 2.29: The number of combine harvesters-threshers in use in South Africa
Source: FAO (2009)

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.

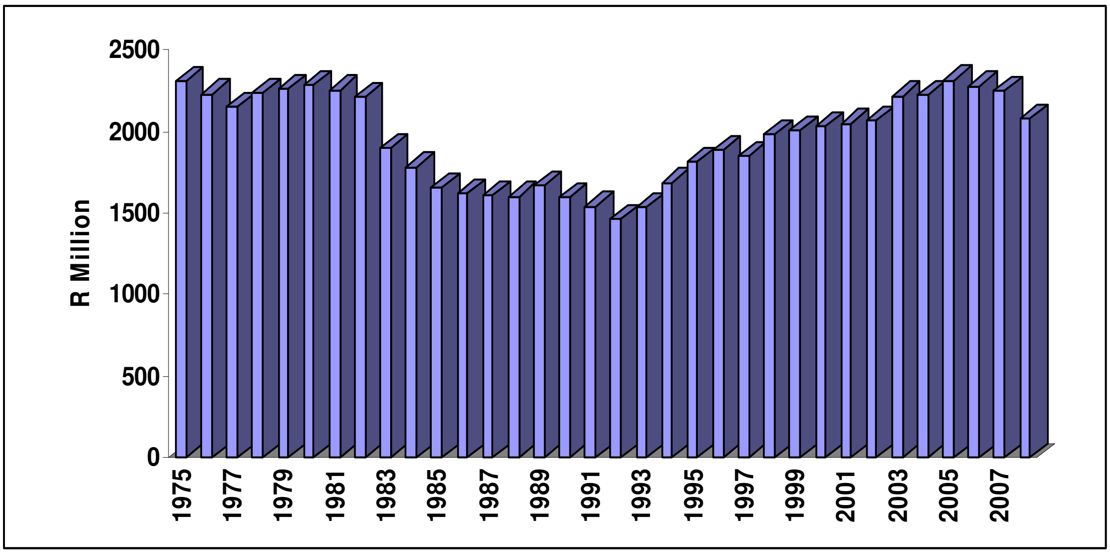

Figure 2.30: Gross capital formation: fixed improvement, deflated by PPI (2000=100)
Source: Adapted from DAFF (2009)

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.

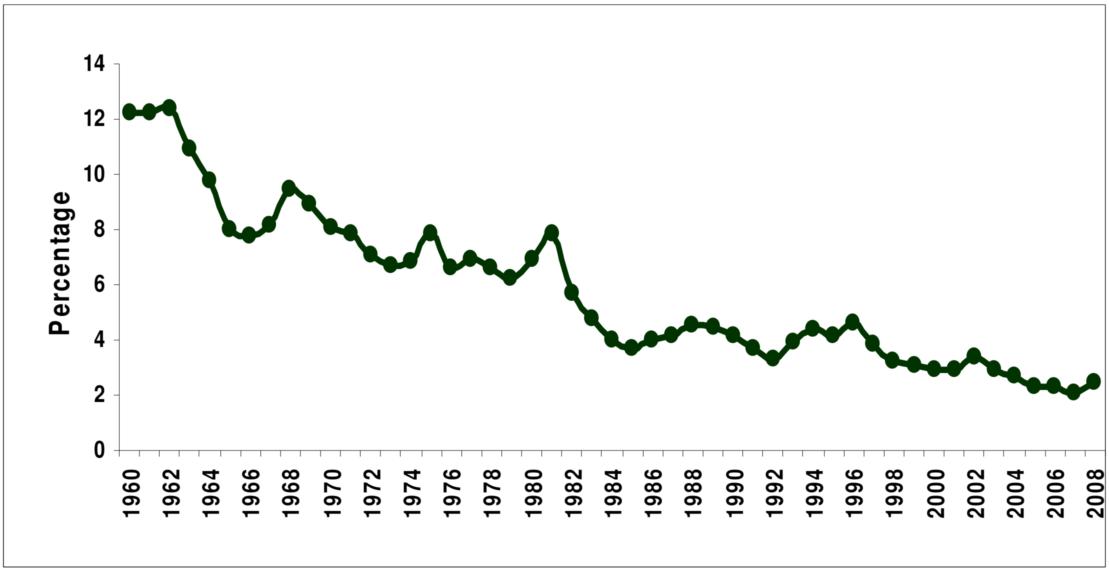

Figure 2.31: Agricultural investment as a percentage of total investment
Source: Reserve Bank (2009)

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)

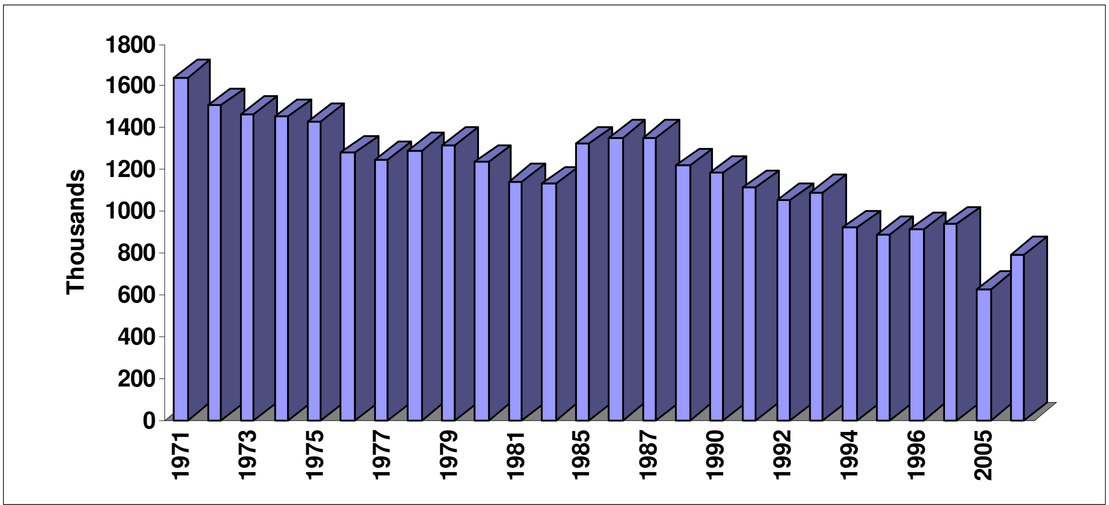

Figure 2.32: Total number of farm employees (permanent, casual and seasonal)
Source: Directorate Agricultural Statistics (2009) and StatSA (2009)

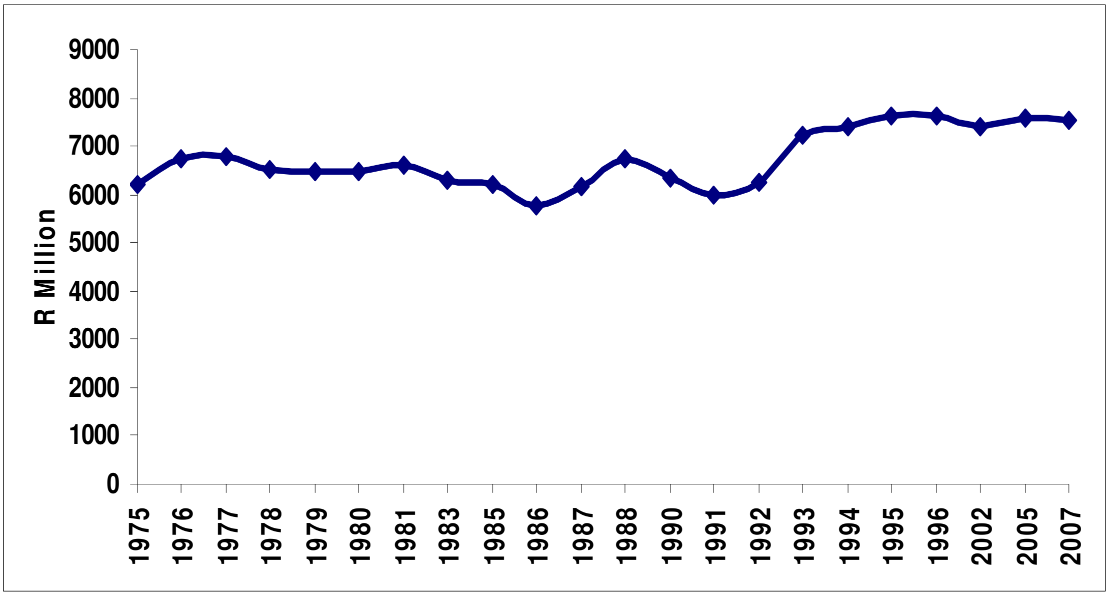

Figure 2.33: Labour remuneration: deflated by CPI (2000=100)
Source: Adapted from DAFF (2009)

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.

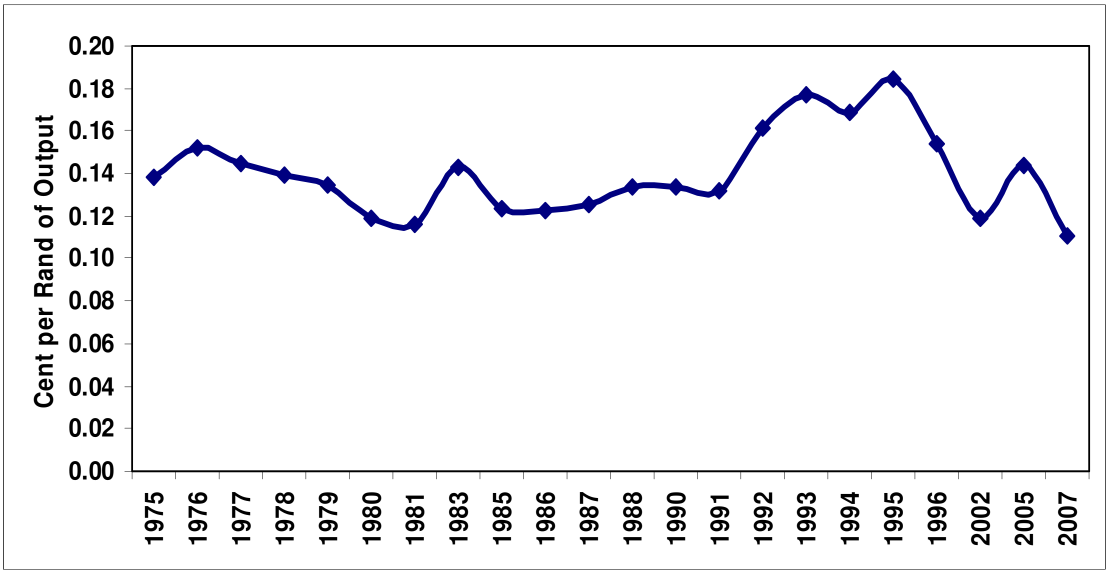

Figure 2.34: Unit cost of labour (Cent per Rand of agricultural output)
Source: Adapted from DAFF (2009)

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).

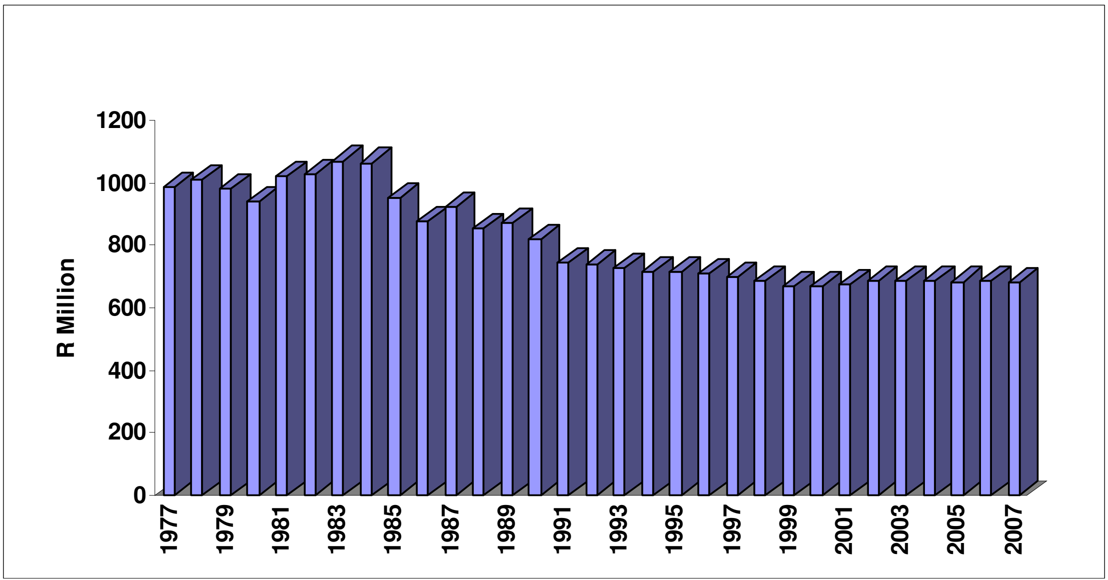

Figure 2.35: Rent paid deflated by CPI (2000=100)
Source: Adapted from DAFF (2009)

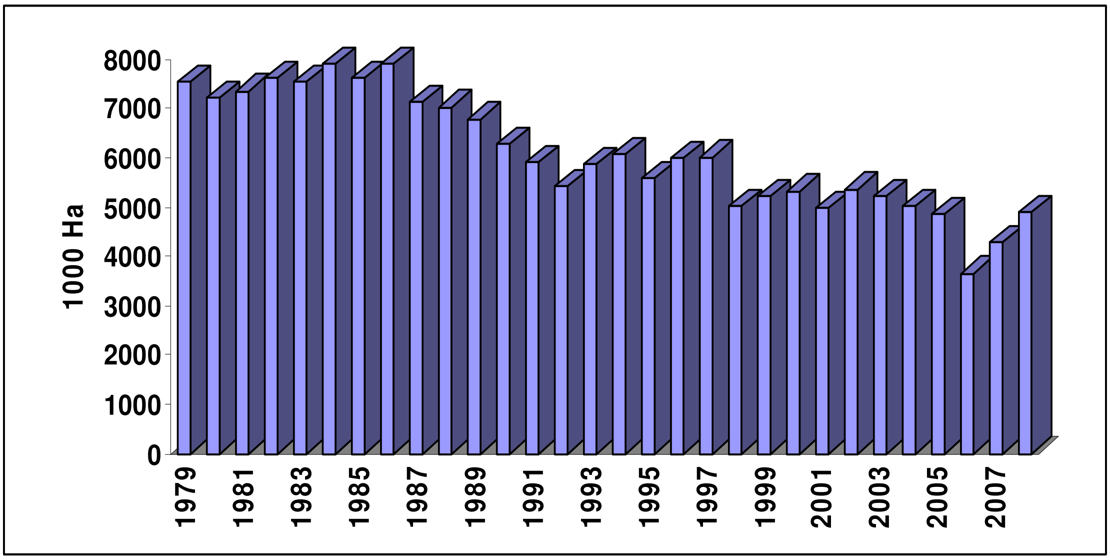

Figure 2.36: Planted area of main field crops
Source: DAFF (2009)

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.

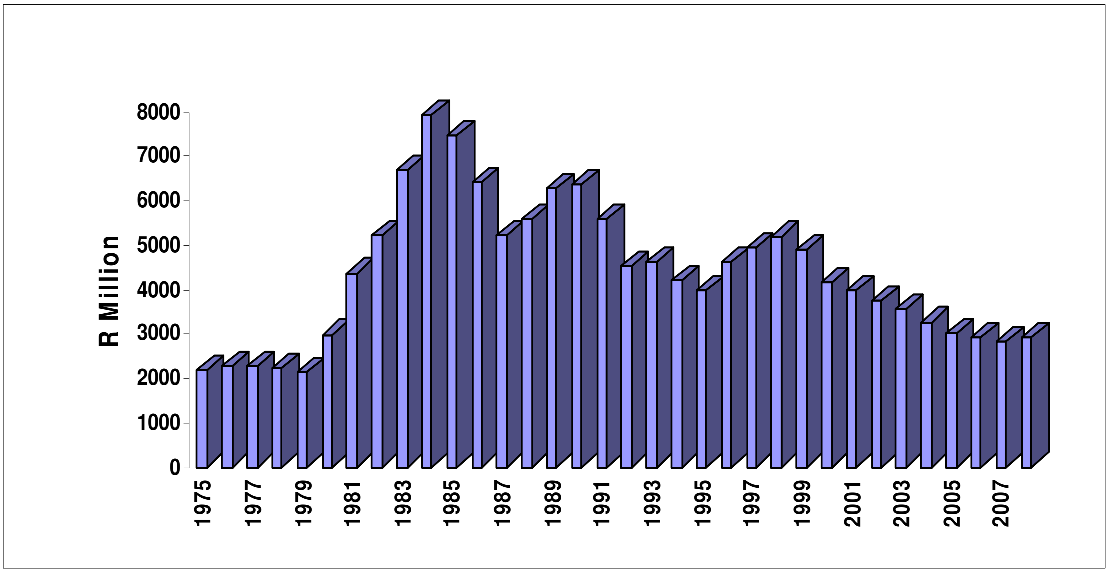

Figure 2.37: Interest paid: deflated by CPI (2000=100)
Source: Adapted from DAFF (2009)

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.

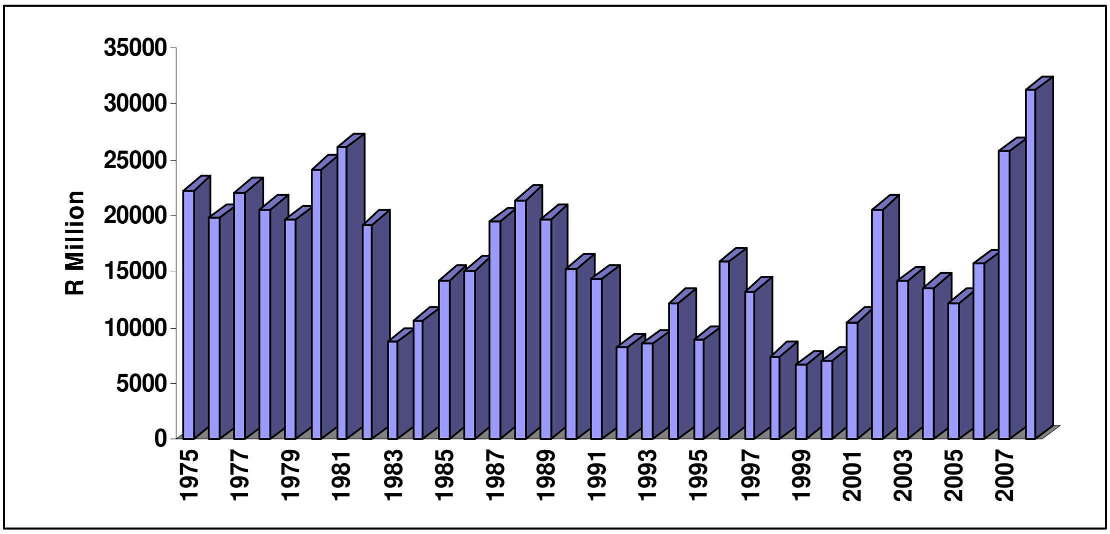

Figure 2.38: Net farm income: deflated by CPI (2000=100)
Source: Adapted from DAFF (2009)

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.

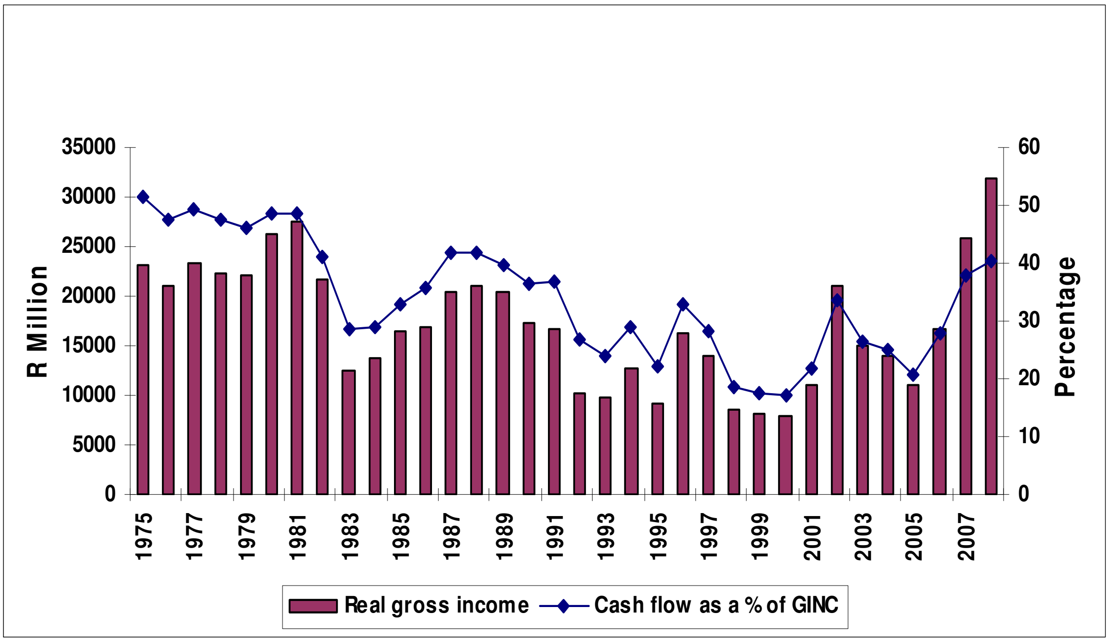

Figure 2.39: Cash flow of farmers as a percentage of gross income
Source: Adapted from DAFF (2009)

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).

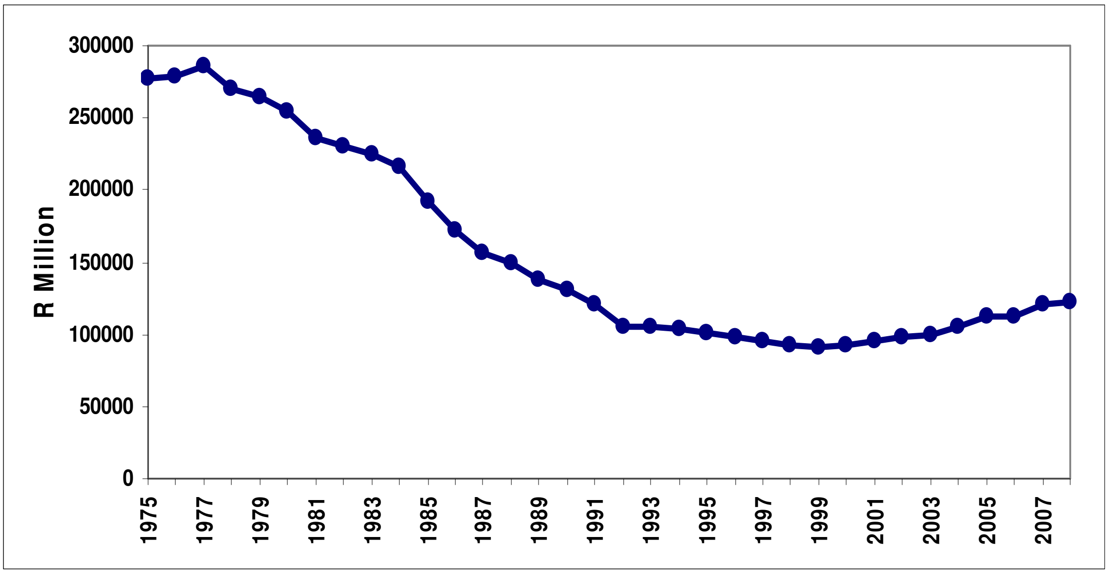

Figure 2.40: Total asset value of the agricultural sector: deflated by CPI 2000=100)
Source: Adapted from DAFF (2009)

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).

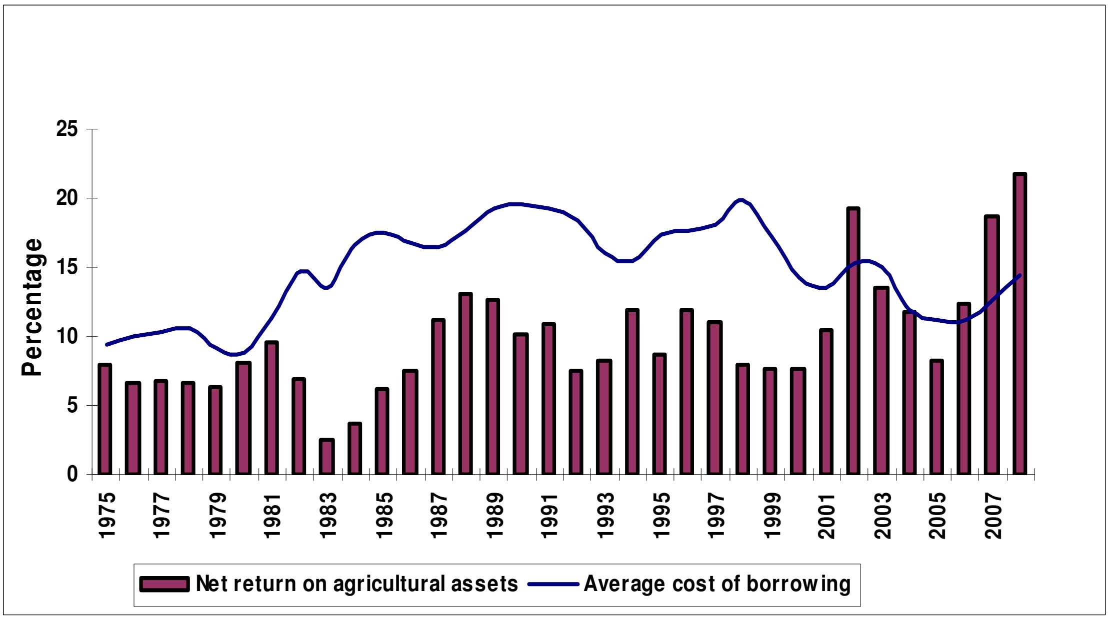

Figure 2.41: Net return on agricultural assets and average cost of borrowing
Source: Adapted from DAFF (2009) and Directorate: Agricultural Statistics (2009)

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).

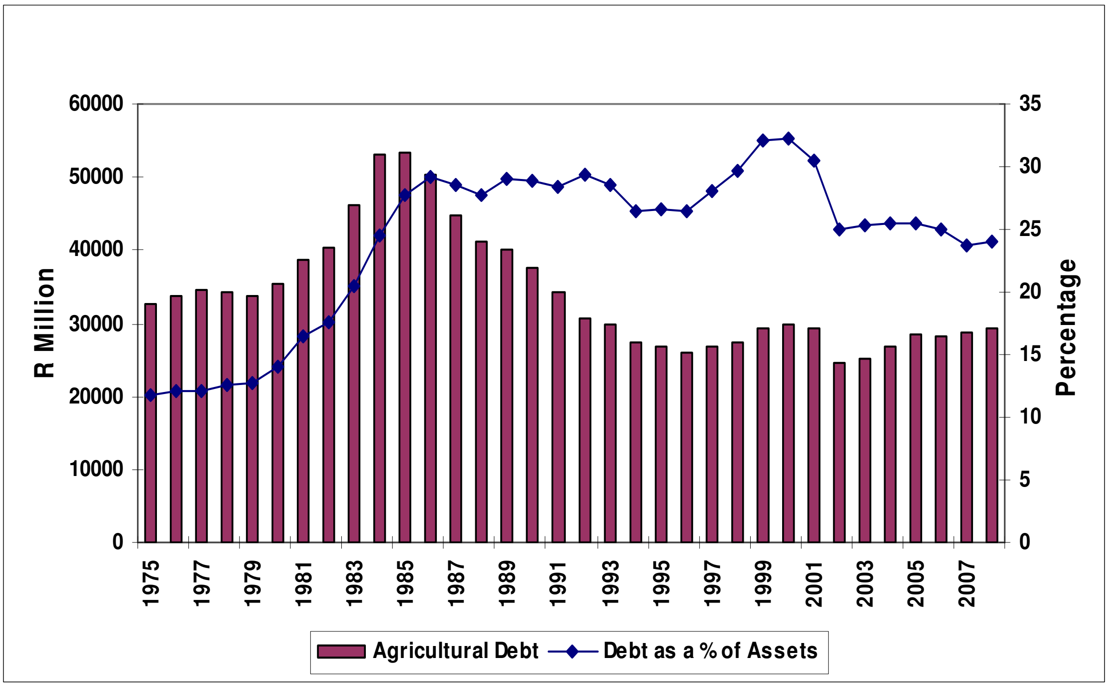

Figure 2.42: Total debt value of the agricultural sector: deflated by CPI 2000=100) and debt burden (debt as a percentage of total assets)
Source: Adapted from DAFF (2009)

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.

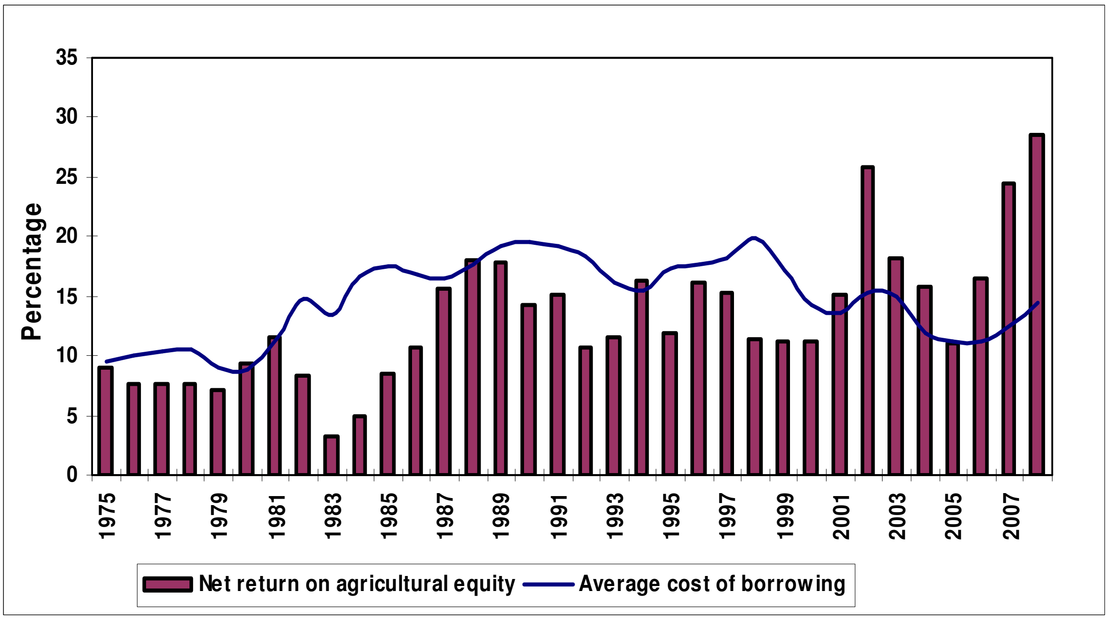

Figure 2.43: Net return on own equity of the agricultural sector and average cost of borrowing

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.

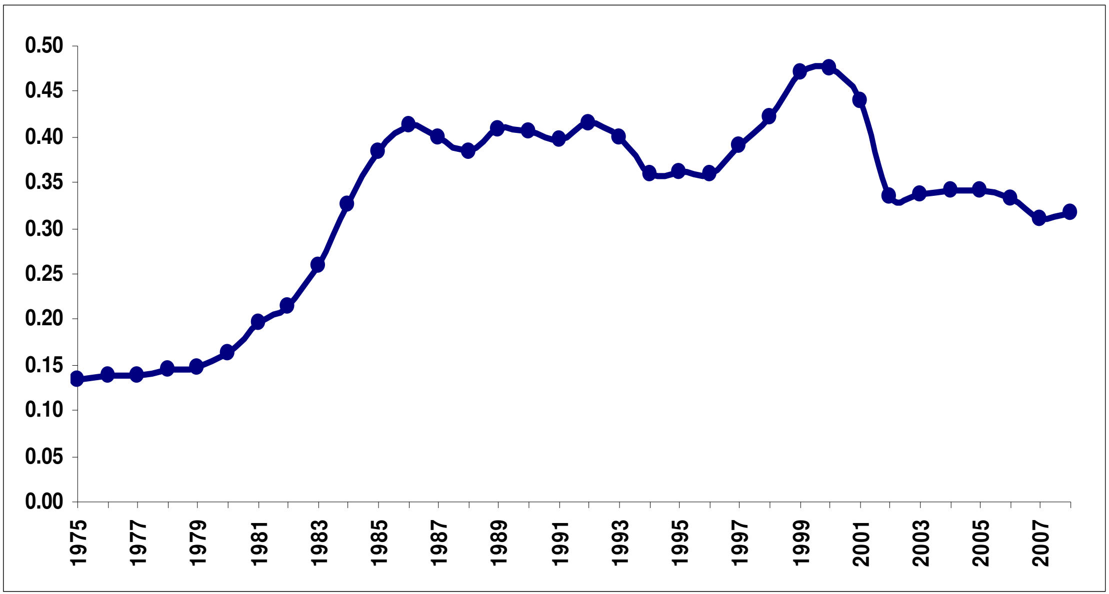

Figure 2.44: Leverage ratio of agricultural producers
Source: Adapted from DAFF (2009)

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:

$$\sigma_{ij}^{A} = S_j E_{ij} \tag{3.2}$$

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:

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

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:

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

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) ≥ 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).

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

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.