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DEVELOPING A SIMULATION MODEL FOR THE SOUTH AFRICAN POTATO INDUSTRY: A REGIONAL APPROACH

by

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Submitted in partial fulfilment of the requirements for the degree

MSc Agricultural Economics

Department of Agricultural Economics, Extension and Rural Development

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DEDICATION

To Naledi Nomzamo Nkosi

DECLARATION

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

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

Mhlabane Thandekile Charlotte

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Thandekile Mhlabane

University of Pretoria

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ABSTRACT

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Degree: MSc Agricultural Economics
Department: Agricultural Economics, Extension and Rural Development
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The introduction of democracy in country of post-Apartheid South Africa precipitated both economic and social changes. These changes have led to the liberalisation of the economy and the movement of the agricultural sector from being highly regulated to a market-based sector. Consequently, the country's economy has become exposed to global uncertainties. These changes brought about the need for role players to understand the dynamics of the agricultural sector in order to forecast possible future trends and assess their impact on agricultural production and consumption. Projecting economic and environmental uncertainties in agriculture is essential to make informed decisions and sustain agribusinesses.

In an attempt to combat the challenges and to understand the dynamics mentioned above, a system of equations with the ability to simulate the dynamic interaction between production and consumption at a regional level for South African potato producers, policy makers and wholesalers, is developed in this study. Existing methodology on partial equilibrium modelling is applied to develop a tool that can be used to analyse the potential impact of relative environmental shifts on the South African potato industry. Individual equations, which are

collapsed into a single system of equations, are estimated by means of Ordinary Least Square (OLS). The specific objectives of this study are as follows:

- To estimate the potato area planted, yield and consumption of various categories of potatoes, in order to determine the price elasticity of demand and elasticity of supply.

- To develop a system of equations that will be used to generate baseline projections of demand and supply in the industry.

- To undertake impact analysis of various scenarios over the period 2011 to 2015.

Although the model developed is mainly South African focusing on regional production and national consumption, the dissertation will recommend the possibility of future studies that use this study as a springboard for further research. These recommended studies include the linking of other models to improve and simulate relations between the potato sector and other sectors, thereby emulating the actual economy.

- One such requirement is to connect the vegetable and potato industries, a move which agricultural sector experts believe will benefit the outcomes of the potato industry.

Consumption is estimated at national level, and is conducted according to the use of informal fresh and formal fresh potatoes for processing and seed potatoes. It is advisable for future research and study to estimate and project production and consumption at regional level. The baseline projection will be developed, and then the study will further undertake several scenarios which will lead to various possible future outcomes, discusses and document the response. Eventually, the model shows possible relationships, uncertainties and interactions between potato productions, consumption and prices.

And that the domestic price, quantity demanded, the supply and the net exports actually determine the South African market equilibrium price and the decision to export in the South African potato industry. This is also called the near autarky situation.

The model has also successfully simulated the actual trends (real) of the potato industry (consumption, production and net export) as such it is able to assist the role players to understand how the industries function/operates. The results of the study confirm that the model can be utilised to assist in the decision making and develop precautionary measures and strategies for the possible environmental impacts.

Recommendation: For future the model to be linked with other external sector models such as vegetable and meat industries; as well as consumption at the regional level should be considered as it may have significant impact to the industry as a whole.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Potatoes are one of the five major energy crops cultivated for human consumption in the world, together with maize, wheat, barley and rice. They serve as a primary source of carbohydrate on one hand and vegetable on the other, as a result are consumed by a range of cultural and ethnic groups. Its (potatoes) versatility and popularity makes the commodity substitutes for other sources of carbohydrate such as maize, pasta and bread; and/or an alternative for or complement to vegetables such as cabbages, onions and sweet potatoes. Potatoes are cultivated across the nine regions in South Africa. The variation of climatic and environmental conditions across the regions ensures the availability of potatoes throughout the year (Potatoes South Africa, 1997); and the output harvested in one province to be distributed to other regions through the fresh produce markets and other forms of markets.

The all-season availability of potatoes is primarily because the country's large scale potato farming occurs under irrigation in almost all the regions, with an exception of the Eastern Free State region and the Mpumalanga province, where production takes place under dry-land conditions. The versatility of the commodity and its year-round marketability makes the potato industry an interesting subject to pursue. There is however a need for producers and consumers to understand possible relationships, uncertainties and interactions between potato production, consumption and price response, which arise from regional variability and economic changes.

Over the past 16 years, South Africa has experienced developmental growth, predominantly due to political and economic shift to a democratic system. Following the dismantling of the Apartheid system, the country become a member of the World Trade Organisation (WTO) and had to take part in the free market system. This resulted in South Africa to change to an open economy system. The WTO requires that all its country members should remove quantitative forms of trade control. (Schirmer, 2000). Prior to 1993, the potato industry operated a trade distortion scheme, which was referred to as the potato scheme. The functions of the potato scheme were to support and control surplus potato production in the country through intensive

government control. In 1993, the potato industry conformed to the new democratic system and the WTO's member countries' requirements by abolishing the trade distortion scheme (Van Rooyen, Kirsten & Vink, 2000).

The abolishment of the trade distortion scheme resulted in the potato industry being deregulated and no longer controlled by the government. Farmers are no longer protected as they once were in the former political regime, and are required to participate in the free market system; making the industry vulnerable and exposed to a volatile marketing environment. The instability of potato markets is extreme, in that the supply of weekly volumes can rise from 15 % in one week to approximately 177 % in the following week (Makube, 2008). The resultant volatility in supply is associated with the fluctuation in prices.

This study attempts to identify the complexities of the potato industry in South Africa, and the need to develop a comprehensive system that would incorporate all exogenous and endogenous variables simultaneously, in order to develop a simulation model within the partial equilibrium framework. The model development will be undertaken with the intention of evaluating the possible price effect from the interaction of a combination of factors that influence productivity, consumption and exports of potatoes; both nationally and within the various growing regions. The model will also evaluate the effect provinces have on each other. Such as, what happens if there is a change in one region to the Others, The model will be of considerable assistance to role players in the industry in providing estimations of possible future price changes or responses from possible external and environmental variations.

1.2 PROBLEM STATEMENT

Over the past 16 years of democracy, policies have been changed and new programmes established with the objective of improving the livelihoods of historically and politically disadvantaged citizens. This includes policies on land issues through the land reform program (Lyne & Darroch, 2003). The Broad Based Black Economic Empowerment for Agriculture (AgriBEE) programme was established with the purpose of enforcing skills transfers and ensuring equality between large commercial farmers or agricultural industries and emerging farmers/industries (Buthelezi, 2007). The achievement of these objectives is still on-going, and

associated problems are still incorporated in the potato industry. Subsequent challenges facing the potato industry are listed below, as considered by Schirmer (2000):

- The industry role players (both emerging and established) need to learn about and understand the relationships between potato prices, their environment, potato consumption, potato production (micro level), and exports with national potato prices (macro level).

- There is a need to evaluate and understand variables that influence potato production, consumption and exports over time, as a result of external changes.

- The evaluation and understanding of variables that influence potato production includes the need to review how the industry behaves and responds towards these changes.

- The industry needs to acquire more information and knowledge of the sector to enable it to make informed decisions in both the short-term and the long-term.

The main problem this study highlights is the producer and consumer's lack of knowledge regarding what effect economic and/or environmental shocks in certain regions will have on market prices. For example, how will a shock in one region affect prices in other regions?

Most studies conducted globally have concentrated on one or a combination of the following subjects: The use of cultivars to increase yield; evaluating the factors that influence or impact on potato production; consumption; and trade at international level (separately/ individually). Some of the studies also focused on necessary processes that should be implemented in response to environmental changes. Other authors analysed the effect of climate; impact of rotations; potato exports; the degree of substitutability and/or complementary effects of potatoes to other sources of carbohydrates; and domestic demand.

Focus had also been given to price estimation as a function of various variables at national level. Within the studies conducted in South Africa, attention was given to grains, white meat and red meat, and tomatoes industries. Whilst none of these studies gave specific attention to the South

African potato, this dissertation highlights the need to develop an economic instrument that will be of essential assistance to the South African potato industry. This tool will help the industry's role players to make informed decisions and to understand the impact of change on macroeconomic factors to the industry.

1.3 OBJECTIVES OF THE STUDY

The main objective of the study is to develop a system of equations (model) that has the ability to simulate the dynamic interaction between production and consumption on a regional level for potato producers, policy makers and wholesalers in South Africa. The model will be able to estimate the effect of external shocks on the potato industry, both regionally and nationally. This tool will also be utilised in analysing the possible changes in the potato industry as result of macroeconomic and other external shocks.

The specific objectives of the study are:

- To estimate area planted, yield, per capita consumption and net export at a regional level;
- To solve for equilibrium prices given a specific set of assumptions.
- To create a baseline projection of area planted, yield, net export and potato prices from 2011-2015; and
- To conduct scenario analysis.

1.4 METHODS AND PROCEDURES

Although South Africa consists of nine provinces, the potato industry has 16 main potato producing regions; namely Limpopo, Mpumalanga, Marble Hall, Western Free State, Eastern Free State, South-western Free State, Western Cape (Sandveld), Ceres, South-western Cape, South Cape; Northern Cape, Eastern Cape, North-eastern Cape, Gauteng, KwaZulu-Natal and the North West province. The purpose of the study is to model all the regions with the intention of understanding the interactions and relationships that exist among the regions in terms of demand and supply. With regards to supply, the production areas are constructed in a way that only 12 regions will be specified and the rest of the regions consolidated to form one region that will be referred to as 'Others, making them 13 regions. The model to be developed is structured in three

building blocks; namely the production, consumption (including net export) and potato price blocks. The production block first focuses on the 13 production regions which were estimated individually, and is further aggregated to national production in order to evaluate its impact on the national potato price. The consumption block was divided into four components, namely fresh formal potato consumption, informal potato consumption, seed potatoes, and processed potatoes. The consumption is modelled at national level. The potato price block addresses the national net export estimation and a final estimation on regional potato prices in relation to national level prices, in order to determine the equilibrium within the market regime.

The study makes use mostly of secondary data with a minimum inclusion of primary information sourced from industry specialist knowledge and experiences. The information used is time series data collected from different sources; including the Department of Agriculture, Forestry and Fisheries (DAFF), the Bureau for Food and Agricultural Policy (BFAP), literature and Internet reports. The rest of the information was gathered from the industry experts -Potatoes South Africa (PSA). Potato South Africa's database contains information on potato production, area planted and potato yield, prices, potato exports, sales and consumption. The data ranges from the early 1970s to the year 2010.

The time series data employed in the study starts from 1997 to 2010; the bulk of which concerned consumption, exports at national level and potato production at regional level. The variation in the national and provincial scale of information gathered was as a result of the South African demarcation system and the further sub-division of potato regions, which was initiated by the industry according to potato production seasons and climate similarities within a province. With the existing time series data, the study will project and model the baseline information of the industry. The significant medium-term forecasting data, specifically the macro-economic information in the study, was gathered from the pre-mentioned sources whereby most projections had already been conducted. The time series projections, including prices, covers the period from 2011-2015.

Forecasted data on yield (which will be produced from the rainfall estimation), area planted and production will be simulated. The projected rainfall data will be averaged and based on the planting period per region. The information collected was converted to real terms, in order to take

the impact of inflation out of price trends over the long-run. The calculation is basically the actual variable divided by the CPI multiplied by hundred to get the real variable

It is necessary for the simulation model to be constructed within a partial equilibrium framework, in order to be able to generate reliable estimates and projections of endogenous variables that can be applied practically in the simulation of real life situations. The methodology that will be followed in developing the model is as follows: The model specifications will be designed. An Ordinary Least Squares (OLS) approach will be utilised in the regression of the specified equations, using Microsoft Excel software to form individual equations that will be collapsed into a single network of equations to form a model structure. The estimated model will then have to be evaluated to determine its performance and effectiveness in the real life situation.

The model is determined for a period of 14 years, hence the 14 observations. Meyer (2002) states that 'the lack of a long-run time series data determined the extent of the methodology that will be followed in the study' and 'many statistical performance procedures are difficult to apply if equations with 2 or more exogenous variables are estimated with only 13 observations'. Noting that the estimations in this study are to occur over a data series of 14 years, statistical validation of the model will not take place but rather alternative estimation and procedures for the validation will be followed.

This includes economic validity of the model, the construction of elasticity matrices, and the graphical illustration of the estimations compared to the actual trends of the exogenous variables over time; in order to certify whether the model simulates the real world. Whenever necessary, synthetic parameters will be utilised to ensure acceptable model behaviour. Furthermore, real and possible scenarios informed by the industry specialist (Potato South Africa) and real world situations will be analysed to assess the usefulness and practicality of the model.

The results of the model performance will be presented in tables, on spread sheets and in graphical illustrations. The graphs will display visual changes or trends over time, while the Microsoft Excel format will indicate the baseline information and projections, and will also be utilised in the simulation of possible scenarios. The scenarios and projection changes will be plotted to illustrate possible future outcomes and changes during the simulation.

1.5 OUTLINE OF STUDY

Chapter 1 provided the introduction and background of the study, and discussed the problem and objectives of undertaking the study. Chapter 2 presents the literature review of the potato industry, on both a domestic and global scale. Chapter 3 will discuss the methods and procedures undertaken in the development of the model. This chapter will also focus on the estimation of consumption, production, and the determination of the market price equilibrium. Chapter 4 will present the empirical results of the model estimates, the synthetic equations, and the assessment of the functionality of the model. Chapter 5 will focus on the model projections and the simulation of scenarios as informed by the industry experts. Finally, Chapter 6 will present the summary and conclusions of the study.

CHAPTER 2

LITERATURE REVIEW OF THE POTATO INDUSTRY LOCALLY AND ABROAD

2.1 INTRODUCTION

This chapter will present a literature review of the potato industries around the world. Potato production and consumption trends, exogenous factors influencing increase and/or reduction of potato supply and potato demand globally will be discussed. Attention will also be given to the African and South African potato industries, and will focus specifically on their nature, history and geographical distribution. Information on the quantity of potato seeds, fresh potatoes production and consumption, area planted, yield, and net export will be presented. This chapter will also review issues such as the relationship between demand and supply with regards to prices, and will include factors that bring about changes in the markets.

2.2 INDUSTRY ABROAD

2.2. 1 World Supply and Export

This section highlights the main world production trends and discusses the critical drivers that influence production. World potato production has increased by 15.5% since the 1960s; and most of this production is found in developing countries. This increase has occurred mostly in Asia, China and India which is from 11% to 42% respectively. The industrialised countries have shown a decrease in potato production from 89% to 58% between the years 2004 and 2007. This decrease is offset by the increase in the developing countries. Also, the swing in the trends of larger quantity production from industrialised countries to developing countries indicates a shift of the global potato economy towards the developing countries. Wang and Zhang's (2010) study confirmed, that, China's potato production accounted for 72 million metric tons (22%) of the increased global potato production.

The production increase of potatoes in the developing countries may have resulted from the increase in area planted and/or improvements along the value chain; such as the development of

necessary storage and irrigation facilities before the sale of potatoes and/or seed crops during the summer. Moreover, production increase may also have come as a result of the development and adoption of new potato varieties, improved chemical inputs and pesticides usage (Bowen, 2003).

2.2.2 World Demand and Import

Potatoes are one of the five major energy crops for human consumption in the world, together with maize, wheat, barley and rice. Potatoes are regarded as both a vegetable and a source of carbohydrates; as such, according to industry specialist information, they compete with other carbohydrates of maize, pasta and bread, and with vegetables such as cabbage, onions and sweet potatoes. Statistics indicate that potato consumption is increasing globally as a result of consumers' eating habits that are shifting towards western potato products (Lin, Goethe & Levi, 1992). The world increase of potato consumption primarily comes from developing countries, rising from 9kg per capita per year in 1961 to 24kg per capita per year in 2000. Over the years, the Latin America's consumption has increased by 15%. Asia consumption rose from 12kg per capita in 1992 to 14kg per capita in 1996 (Cipotato, 2010).

Fuglie, Suherman and Adiyoga (2003), argue that the increase in potato consumption initiated a growth in production; and the demand for potatoes as a vegetable grew as consumers became aware of the health and dietary benefits of consuming fresh vegetables. According to Lin et al. (1992), Japan's potato demand was found to be income elastic, meaning that as long as the Japanese economy grows, so will be the potato imports demanded by Japan. Japan's own price elasticity of demand was -0.74, which implies that an increase in the quantity of potato imports by 1% will lead to a decrease in the total revenue of the Japanese market by 0.74%. Supporting this view is a study conducted by Wang et al, (2004), who confirmed that an increase in demand, of the Chinese output forecasted to increase by 2010, is mostly driven by a shift in consumption patterns. These international transformations, although opposite, are also evident in the African and South African economies and are presented below.

2.3 OVERVIEW OF AFRICAN AND SOUTH AFRICAN POTATO INDUSTRY

Potatoes were first introduced to South Africa in the 1600s by Dutch sailors journeying towards East Asia. The sailors cultivated potatoes around the ports to ensure a supply of fresh tubers during their voyage, but the operation was unsuccessful. In the 1880s, British farmers and colonial officials introduced potatoes to Kenya and other parts of East Africa. The European farmers attempted overland exports of these potatoes to South Africa in the 1900s, but their efforts failed due to constraints, such as fungal infections and other diseases. Nevertheless, a few decades later, potatoes were successfully exported to South Africa.

By the twentieth century, potatoes were formally established in Africa. Africa produces 6% of the world's potatoes (Potatoes South Africa, 2008). There are 11 major potato production countries; the largest producer being Egypt (21 %,) followed by Malawi and South Africa (18%), Algeria (14 %), Morocco (13 %), Rwanda, Nigeria, Kenya, Uganda with Angola and Ethiopia at (6%). The remainder of African countries producing potatoes contributed the aggregated 28% in 1997 (Ferris, Okoboi, Crissman, Ewell and Lemaga, 2002).

The most important producing countries in the sub-Saharan Africa have consistently been Malawi (the largest potato producer at 2.2 million tons), followed by South Africa (at 1.97 million tons). Rwanda is the third largest potato producer in sub-Saharan Africa, with its production increasing from 100 000 tons in 1990 to 1.3 million tons in 2005, although its production decreased slightly in 2007. Nigeria is the fourth largest producer at 843 000 tons, an increase of sevenfold over a decade. Potato production in Angola has tripled with an output rising from 260 000 tons in 1990 to 615 000tons in 2007. Production in Uganda has increased from 224 000 tons in 1990 to 650 000 tons in 2007. In 2007, Kenya produced an average of 800 000 tons of potatoes. The Kenyan potatoes are cultivated by mostly female small-scale farmers and a few large-scale farmers specialising in potato production for commercial purposes (FAO, 2008).

To some extent, the sub-Saharan consumption of potatoes has also increased over the past decade, and has become a staple food in some countries. Potatoes are the second main source of calories following cassava in Rwanda; potatoes' per capita consumption being at 125kg per annum. The crops have become the main source of Malawi's food security. Malawi's potato consumption has tripled over the years, resulting in most of the produce being consumed

domestically, at an average per capita annual consumption of 88kg. Although in Kenya potatoes are considered to be a high quality crop as compared to other African sources of carbohydrate, its average per capita annual consumption is just 25kg.(FAO, 2008)

South Africa is ranked number 31 globally in its production of potatoes, supplying approximately 0.5% of the world's produce. South Africa consists of nine formally established provinces (regions) while potatoes are produced in 16 potato regions. These regions were subdivided according to their planting period and volumes produced. Areas such as the Free State, which is identified as one region in the national map, is divided into three potato regions; namely the Eastern Free State, Western Free State and South- west Free State. Another factor contributing to the subdivision of the regions is that the regions consist of different climatic conditions. A map of the potato production regions in South Africa follows (Figure 2.1)

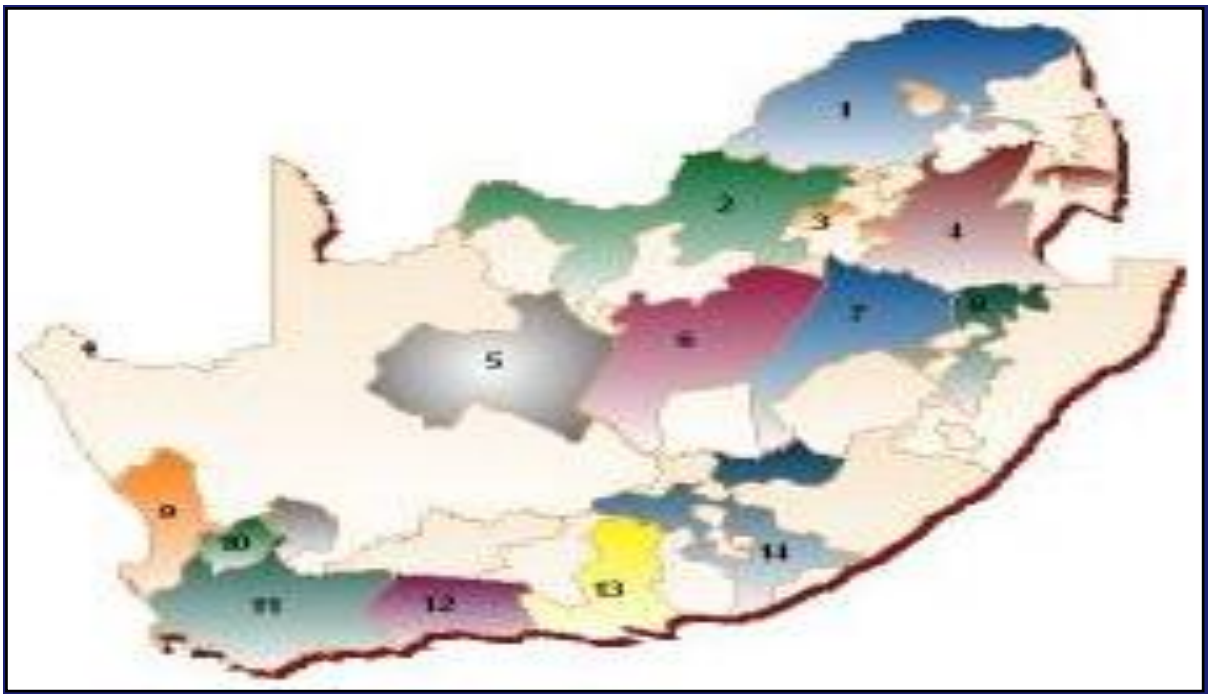

Figure 2.1: South African potato production regions
Source: aboutpotatoes, 2010

Region number 1: Northern Province; 2: North West; 3: Gauteng; 4: Mpumalanga; 5: Northern Cape; 6: Western Free State; 7: Eastern Free State; 8: KwaZulu-Natal; 9: Sandveld; 10: Ceres; 11: South Western Cape; 12: South Cape; 13 Eastern Cape; and 14: North-eastern Cape. Some of these areas were further subdivided. Mpumalanga was divided to Marble Hall and Mpumalanga

and the Western Free State being further sub-divided into South-western Free State and Western-Free State. (aboutpotatoes, 2010)

Over the years, potatoes have shown a stable production nationally. On average, about R1.6 billion worth of potatoes is harvested per year, with 2001 showing a reduction in the volume produced. Due to their availability, potatoes are consumed throughout the year in forms that include mashed potatoes, boiled and stew with starch. According to potato SA report of 2010, potatoes make up about 43% of the gross value of total vegetables in South Africa. They are grown to be sold for processing purposes, fresh and as seed potatoes. And that approximately 80% of the total production is for domestic consumption and 13% is utilised for seed potatoes.

The fresh potatoes are also sold in formal and informal markets; and are referred to in this document as fresh formal and/or fresh informal, depending on how they leave the farm gate. Potatoes are sold to processors, such as McCain, to further process them into frozen fries, frozen or canned mixed vegetables, baby food, and to restaurants, such as Spur. The percentage of potatoes sold to processors represents 19% of the total crop, and the bulk of the further processing is French fries and crisps. The South African consumer's expenditure on potatoes has been increasing over the years, with consumer spending increasing from R8.77 billion in 2007 to R10.80 billion by 2008.

The gross producer income at the farm gate increased by 35 % from 2007-2008 and 18% for the value added crops (from the farm to the consumer table). The average producer share in the consumer rand increased from 34% in 2007 to 37% by 2008 (Potatoes South Africa, 2010). Although the South African processing sector has shown a rapid increase, its growth is still insignificant when compared to developed countries. The graphical illustration of production and consumption of potatoes from 1997-2010 follows (Figure 2.2)

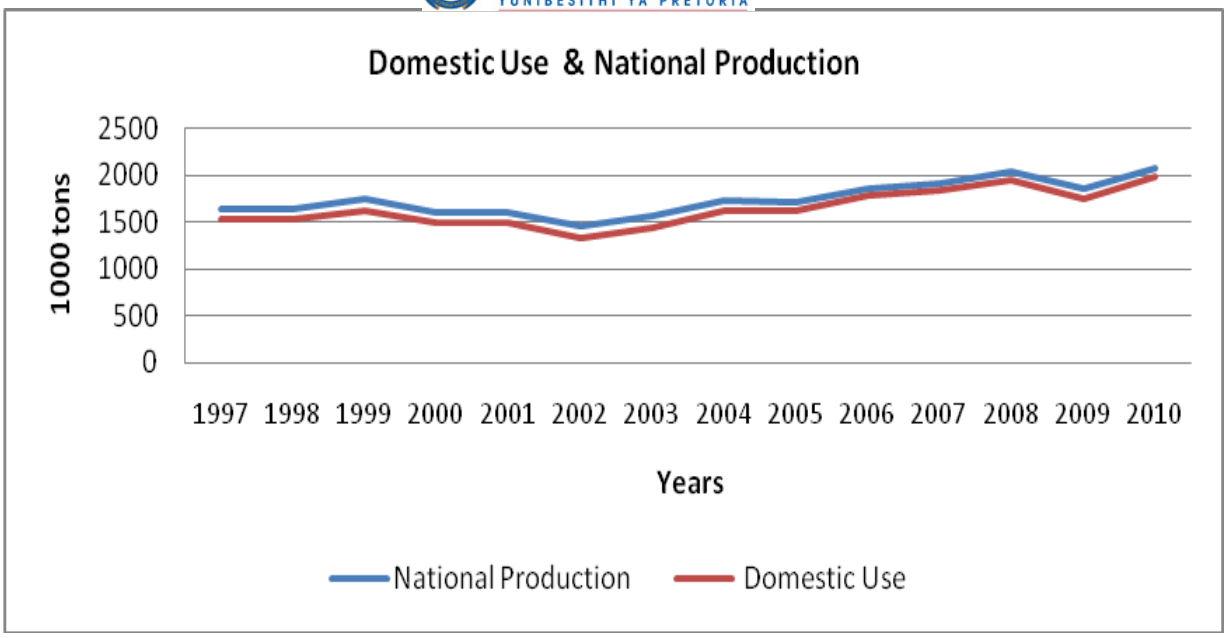

Figure 2.2: Domestic Consumption and Production of South African potatoes
Source: BFAP, 2011

Figure 2.2 shows a decrease in both consumption and production in 2002 and from 2008 to 2009 which may be a result of economic difficulties, such as exchange rates, oil price, food prices and drought (Potatoes South Africa, 2007). It also indicates that from 2009 consumption regains its momentum and rises again to 2010. The potato industry consists of approximately 1 700 farmers, which incorporate 400 seed growers and 66 600 farm labourers. Approximately 52 000 ha has been planted in South Africa, where 27% of the land is dry land and the rest is under irrigation (Potatoes South Africa, 2010).

Potatoes are mostly farmed by large-scale farmers, who produce on average a hectare yield of 37 tons. South African producers use mainly three groups of cultivars, which are divided according to the length of their growing periods and their end use. There are varieties that grow for longer periods of 120 days and more (Late Harvest, Cedara, Sackfiller and Kimberly's Choice). Potatoes that grow between 100 to 120 days form the main bulk of potatoes produced in South Africa; the most popular are BP-1 and -to-Date. The BP-1 and the Vanderplank varieties have a short growing period of about 100 days.

During the 1970s and 1980s the potato sector's vulnerability led to high government intervention, with the intention of protecting farmers through the establishment of potato schemes. The scheme was used to support and control surplus potato production. In 1993, the scheme was abolished (Van Rooyen et al. 2000). Democracy was introduced to South Africa in 1994, and accordingly, an open and free market country was established, where South Africa became a member of the World Trade Organisation (WTO).

WTO regulation requires countries to remove trade distorting domestic support, remove quantitative forms of trade control and to reduce their tariffs to ensure free market access and free trade among member countries. (Hanrahan, 2005). Although countries participate in the free trade, there are still not severe but strict measures of trade intended to ensure plants, human and animal health protection between countries.

The trade protective measures include but are not limited to sanitary and phyto-sanitary (SPS) standard- requirements that trading partners should comply with to during trade. This then may become barriers to the courtier's trade (USTR, 2010). Based on the above mentioned issues, South Africa, as a member of WTO, is now exposed to international shocks, challenges, trade dumping and competition while the higher SPS requirement hinders the opportunity to export to other member countries, especially the developing countries.

Deregulation has resulted in the creation of a dual economic system, which consists of the largely commercialised farmers, and emerging and subsistence farmers (Legum, 2003). To some extent, commercial farmers are more experienced and knowledgeable in the sector, and possess management techniques that they could employ during various conditions to reduce risk and improve production. Emerging farmers, on the other hand, lack market knowledge and experience on how the sector functions; and as such find it a great challenge to deal with external shocks.

The potato industry was formerly supported by the potato supply control scheme, which was removed as part of the political shift to a more democratic nation. Consequently, both these agricultural systems face a significant risk of being exposed to volatile economic conditions, vulnerability to an ever-changing environment, international competition, and instability; which all contribute to the highly volatile potato prices (Potatoes South Africa, 2004).

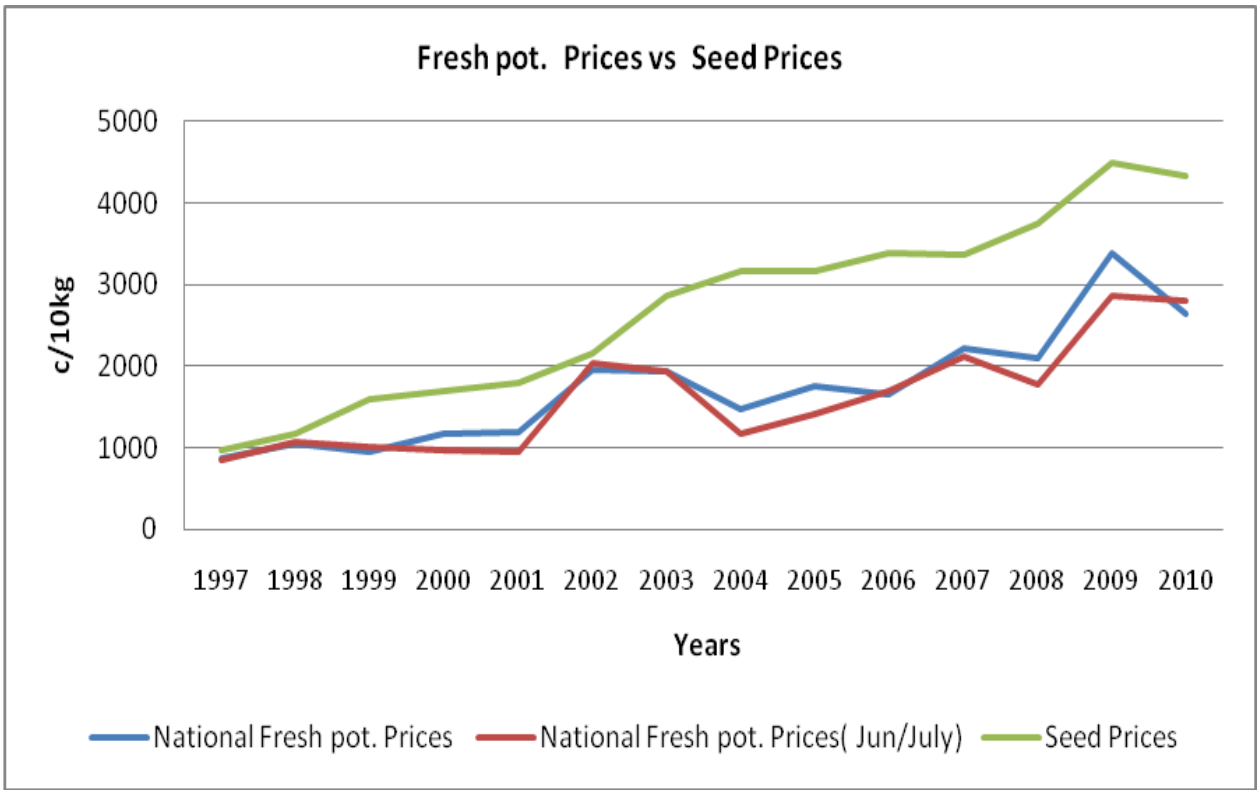

Figure 2.3: South African (nominal) potato prices, 1997-2010
Source: BFAP, 2010

Although Figure 2.3 above illustrates the annual trends in potato prices, variations occur on a weekly basis, either as frozen vegetable prices or as fresh potatoes. It is well known that exchange rates and transport cost play a role in all trade. South African imports are purchased as frozen potatoes, where exchange rates and world prices are expected to influence prices.

The fresh potato price is determined daily at fresh produce markets in the country. The market prices tend to be influenced by the quantity available and the quality, i.e. supply blended with size, quality and cultivar and from Figure2.3it is evident that seasonality is critical in potato prices. Price determination in the South African markets occurs through the process of auction or

price negotiations between fresh produce market agencies. Demand for potatoes is relatively price inelastic while supply is highly elastic, which results in price fluctuations (Potatoes South Africa, 2006).

The volatility of the potato prices is evident in their responsiveness towards inflation. The South African producer price index (PPI) increased by as much as 17.8% in 2008. Consumer prices on food products such as oil and other food increased by almost 100%, while prices for vegetables decreased by almost 11% in 2008; with fresh and frozen potatoes showing a slight increase. Potato producer price increased from R1 669/t in September 2008 to R1 879/t in October 2008 (Farmer's Weekly, September 2008:30). In addition to the above statement, potatoes react to changes in other products, such as cabbage and onion prices and/or input price changes (such as packages and fertiliser) (NAMC, 2009).

It is evident that when there is an increases in the input cost, such as fertiliser, the industry will respond by reducing the quantity of produce planted; which in turn leads to the economic increase in that commodity price (Edward, 2008). In addition to the quantity available, prices are influenced by the distance from the farm to the market. Prices fluctuate between districts/regions mainly due to supply chain activities along the value chain, the storage, and transport, as well as marketing and warehouse facilities.

2.4 SOUTH AFRICAN POTATO TRADE

The South African potato industry exports about 7% of fresh potatoes to its neighbouring countries and accounts for only 0.5% of the world production. The main markets for exports are Mozambique, Namibia, Zambia, Swaziland, Botswana, Angola and Mauritius. South Africa mainly imports frozen potatoes. The following Figure 2.4 shows potato imports over the past decade.

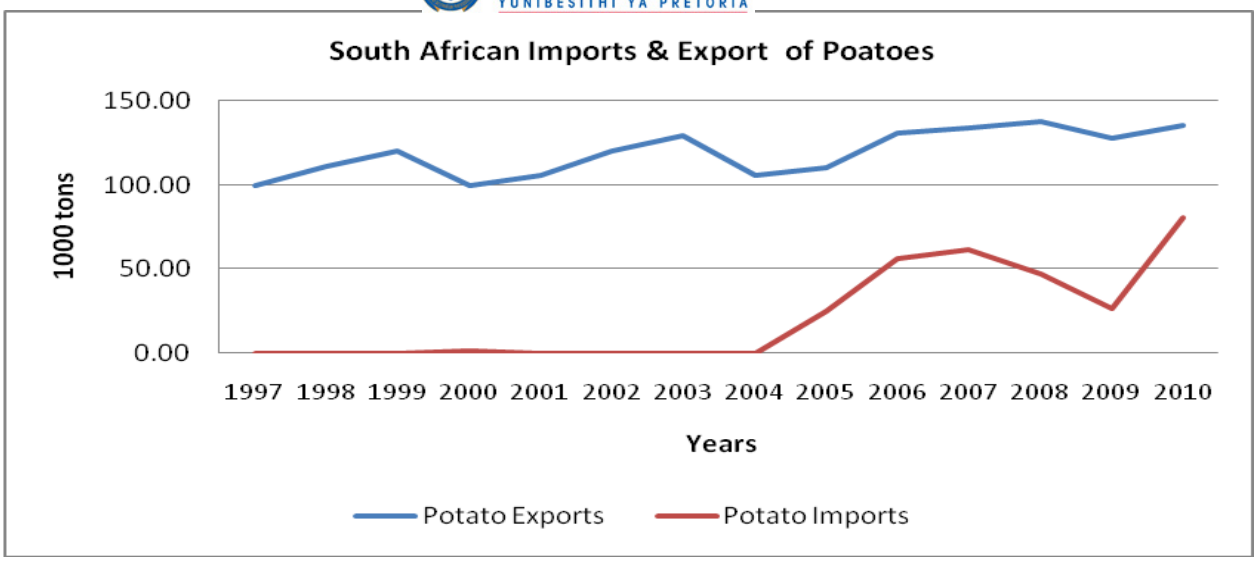

Figure 2.4: Potato imports and exports of South Africa, 1997-2010
Source: BFAP, June 2011

Table 2.1 below shows the export countries for South African potatoes. The statistical table depicts the importers of South African potatoes, its value in US$ thousands, the exported quantity per country, and export growth from 2002-2006.

The table indicates the following: Angola to have the largest exported value of US$7 347 000; which is about a 64% share in South African exports. Angola is followed by Mozambique at 21% then Zambia at 5%. Mozambique shows the highest Export growth in value between 2005-2006 % p.a although it is ranked number 78 in the world imports. The ship bunkers and The Netherlands each account for 2% shares in the South Africa‘s exports, whilst Netherlands is ranked number 3 in world potato imports. Mozambique has the second largest export value of US$2431 000, followed by Zambia with US$569 000.

Angola imported 16 839 tons in 2006, Ethiopia 5 tons, Malawi 218 tons, Mozambique 10 975 tons, Zambia 1 411 tons and Zimbabwe 216 tons. Ship stores and bunkers imported 476 tons in 2006. Mozambique’s share in South African exports is 21%, Zambia’s is 5%, and the rest of the trade partners are less than 5%; with the Congo and DRC being insignificant at less than 1%.

The export growth in value between 2005 and 2006 shows that Mozambique’s export growth showed an increase of 2 172%, followed by Congo with 133%, Malawi with 58%, and the Democratic Republic of Congo (DRC) with 28%. Exports growth value decreases were

experienced by Zimbabwe (-58%), Saint Helena (-28%) and Zambia (-13%). Further information can be found in **Appendix 1.** The potato industry is part of the Southern African Development Community (SADC) trade protocol which participates in the free-trade agreement; although it is a free-trade issue such as sanitary requirements are operational. The South African potato industry and trade partners' trade price on fresh potatoes is determined by or dependent on South African prices; and the frozen potatoes import price to South Africa is determined by several factors, which include the exchange rate. See table 2.1 below for illustration

Table 2.1: Destination of the South African potato exports

Importers	Exported value 2006 in US$ thousand	Share in South Africa's exports %	Exported quantity 2006	Quantity unit	Unit value (US$/unit)	Export trend in value 2002-2006 % p.a.	Export trend in quantity 2002-2006 % p.a.	Export growth in value between 2005-2006 % p.a.	Ranking of partner countries in world imports	Share of partner countries in world imports %	Total import growth in value of partner countries 2002-2006 % p.a.
World	11,547	100	31,280	Tons	369	12	0	28			8
Angola	7,374	64	16,839	Tons	438	15	9	7	36	0	22
Mozambique	2,431	21	10,975	Tons	222	-2	-23	2172	78	0	114
Zambia	569	5	1,411	Tons	403	63	46	-13	50	0	11
Ship stores and bunkers	260	2	476	Tons	546			17	128	0	57
Netherlands	208	2	353	Tons	589	14	-14	2	3	8	3
Ethiopia	142	1	5	Tons	28,400				146	0	
Saint Helena	91	1	181	Tons	503	22	7	-38	155	0	22
Malawi	90	1	218	Tons	413	9	-2	58	178	0	-13
Zimbabwe	74	1	216	Tons	343	62	44	-58	160	0	62
Democratic Republic of the Congo	37	0	82	Tons	451	-25	-30	28	161	0	-20
Congo	35	0	53	Tons	660	-22	-22	133	139	0	18

Source: TIPS, 2008

2.5 CONCLUSION

This chapter focused on the status of the potato industry both locally and abroad, and provided an overview of the potato industry. World potato production has shown an increase in potato production of 15.5% since the 1960s, of which most has taken place in developing countries, predominantly in Asia, China and India. In terms of potato consumption, developing countries have shown an increase from 9kg per capita per year in 1961 to 24kg per capita per year in 2000.

This chapter also looked at the industry trends abroad and examined the possible variables that affected and influenced potato growth, national and regional demand and supply, and its seasonality. Variables such as producer price, changes in area planted and potato yield, transport infrastructure improvements, political changes, slow improvement in living standards, market reform and markets system were significant in influencing the potato industry.

Furthermore, at the domestic level, the scale ranges from African countries to South Africa (regional production and national consumption). The chapter focused on areas where potatoes are grown as well as trends in production and consumption within the country over the years.

The following chapter will concentrate on a combination of techniques and procedures that will be implemented in the study, and will show how the research objectives identified in the introductory chapter will be achieved. The following chapter will also serve as a link between the problem of the study and the output (project target) thereof.

CHAPTER 3

METHODS AND TECHNIQUES

3.1 INTRODUCTION

The main purpose of the study is to develop a system of equations that has the ability to simulate the dynamic interaction between production and consumption on a regional level for potato producers, policy makers and wholesalers. The first section will discuss the study area, the data (variables) considered in the model, and the methods for collecting the data. Following this, procedures and techniques that will be applied in developing the model will be discussed. The discussion will incorporate a flow diagram of the South African potato structure. The supporting literature underpinning the techniques will also be discussed. The final section will summarise conclusions drawn from the chapter.

3.2 AREA OF STUDY AND DATA

The study seeks to understand and to simulate the dynamic interaction between demand and supply among the regions, in order to determine the market equilibrium price. The study is conducted first at provincial (regional) level and then at national level. While South Africa is formally comprised of nine provinces, the potato industry is comprised of 16 production regions. Of these 16 regions, 12 regions will be modelled individually (i.e. regions with potato production of more than 500 thousand tons per annum), and the remaining regions producing less than 500 000 tons per annum will be amalgamated and termed as 'Others'. One of the reasons the industry has so many regions is because several production areas were further sub-divided in the early 1990s. Some areas have since been changed due to demarcations occurring post-1994 elections, such as Mpumalanga, which is now sub-divided into the two regions of Marble Hall and Mpumalanga. The Free State is sub-divided into the three regions of the Eastern Free State, Western Free State and South-western Free State. Other regions are KwaZulu-Natal, the North West, Limpopo, the Northern Cape, the Eastern Cape, the Western Cape (Sandveld), Ceres, the South-western Cape, the South Cape, the North-eastern Cape and Gauteng.

The data utilised in the development of the model is mainly secondary (time series) data, with the inclusion of little primary information from the industry specialists. The source of the data (exogenous and endogenous variables) is from the BFAP (2010) database. The year 2000 is used as the base year for the study. The national potato data is available from as early as the 1970s. The model construction will focus on data from 1997, following the establishment of the 16 production regions. The 14observations justify the insufficiency of the information to simulate econometric models. The variables considered in this study are informed by research previously conducted and/or as advised by Potatoes South Africa industry specialists.

The model contains both quantitative and qualitative data. The value one is used to represent the changes or the presence of the qualitative variable, and the value zero indicates that there were no changes in the variable. The dependent variables in this study are as follows: quantity of regional area planted; potato production; potato prices; and potato yield at regional and national level. Potato consumption is the quantity consumed at national level as fresh and seed consumption (domestic use); potato net export; and per capita consumption. The variables exogenous to the model are: the requisite (which is an index of all agricultural inputs consolidated); real Gross Domestic Product (GDP); Consumer Price Index (CPI: food) at 1995 base year; total population SA; real per capita disposable income; cultivar trend; Dummy 2002,and 2006 (dummy variables which might represent an unforeseen or incident that may have occurred in the region at that particular year which resulted in the changes of some variables or can represent the qualitative variable. An example is the sharp increase of potato production in Limpopo in 2007 which came s a result of large number of farmers converting to ploughing potatoes in the same year),and fertiliser. The variables include winter and summer rainfall; which are from May to October and October to April respectively. The wheat and maize prices are also included in the model as potential carbohydrate substitutes of potatoes.

3.3 STRUCTURE AND PROCEDURE

3.3.1 The procedure of the model

As mentioned in Chapter 1, partial equilibrium models have long since been applied in agricultural commodities with the intention of assisting and/or ensuring informative decision-making by the end users. The models are used interchangeably by various institutions for

different purposes. Partial equilibrium models are standard but adopt parameters suitable for a specific situation. Models are used for policy analysis and representation. Models are essential in the model closure where non-agricultural sectors and factor markets are exogenous. Their coverage can either be regional or global, or at both levels. Econometric models model/simulate trade and/or homogeneous goods. Models should pursue consistency and alignment with economic theories.

The models used in this study are recursive and static models; they are appropriate in the field of agriculture and in the generation of econometric models due to the following reasons:

- A lagging period exists between planting and harvest time in agriculture;
- The expected producer price depends on the past price;
- The quantity produced eventually determines the price of the product.

These models are in the form of a cobweb theorem which explains the cycling effect on agricultural prices and production (Ferris, 1998).

Several partial equilibrium models have already been developed. Such models included but are not limited to the AGLINK model; a dynamic supply and demand model of agriculture which uses a partial adjustment relationship. The AGLINK model intends to forecast medium-term development in the Organisation for Economic Cooperation and Development (OECD) member countries and analyse the impact of policies relating to the principal agricultural commodities. The FAPRI model belongs to the dynamic and partial equilibrium econometric models. It is a system of structural econometric models where each component indicates specific theoretical grounds and can be solved individually. In the FAPRI model, demand is treated as endogenous, while supply can either be endogenous or exogenous. The dynamics in the model come about as a result of the inclusion of lagged variables for the demand and supply functions. Projections are done for the exogenous variables for a future period of ten years.

Meyer and Kirsten (2006) developed a partial equilibrium model for the market outlook and policy alternatives for the South African wheat industry. This recursive model was implemented in the projection of demand and supply of wheat for a future period of five years. The model

consisted of lagged variables, of which one of the characteristics was agricultural commodities. A typical combination of recursive and simulation models was followed for the thesis mode. The single equations were estimated linearly using OLS, following which the results were utilised in the formulation of a single system of equations; which were then estimated simultaneously using a model equilibrator to determine the equilibrium prices. Generally, most of the models are similar in that they consist of the standard components of the partial equilibrium model; which will also apply in the simulation model constructed in this study. Although the model development follows a similar route, there is a uniqueness which is driven by the sector and product specification, as well as the regionalism. The method that will be followed consists of the four-stage approach as presented by Koutsoyiannis (1977):

Stage 1

The model specification presented previously is based on economic theory and/or on previous research undertaken; and looks at the variables selection, the expected economic relationships, the signs and magnitude of parameters. The model will consist of three blocks; namely the supply, demand and price blocks. The supply block is made out of total potato production and imports, since potatoes have no ending stock or beginning stock because of their short shelf life. The demand block is equal to the potato consumption and exports. South Africa imports very little fresh potatoes, as mentioned in the previous chapter; the study will have one variable, namely the net export (i.e. exports minus imports). This means that imports and exports will be individually estimated by the behavioural equation, but the final results will present the net export. The model will include a price block. The block depicts the interrelationship between the regional potato price and the seed prices with the national market price.

The model will not only focus on the behavioural equation but will also include identities. Identities indicate that relationships the variables hold for all values are true. The identities in the model are total supply and total demand equations (Meyer & Kirsten, 2005). The following identities are established in the model: potato production (regional and national level), national consumption, and demand and supply of potatoes.

The supply identity consists of 14 production equations and the imports. The demand consisting of formal and informal fresh national potato consumption, seed potato consumption, processed potato at national scale, and a net export equation. The net export is then followed by the equilibration of the model.

Stage 2

This stage focuses on the estimation of the model. That is assessment of the correlation between variables, and is the phase of choosing an appropriate econometric technique to be utilised in the study. The model is made out of a system of equations which represents the exogenous and endogenous variables. The Ordinary Least Squares (OLS) method will then be used to estimate the individual linear equations, in order to assess whether the variables make economic sense and their fitness to the model. The OLS is also important in this regard in that, it will be utilised to determine the behavioural relationship between a variables and its parameters. Following this, the single equations resulted from the estimates will be linked to form a single system of equations, which will later on be used for projections.

Stage 3

Following the construction of the model, the resultant evaluations will be assessed to determine whether they are an accurate reflection of real life situations. The signs and magnitudes of all the exogenous variables will be assessed to determine their alignment to the economic theories. This study will not present the statistical significance/validity of the variables because of the insufficient data series under which they are developed. Instead, synthetic parameters will be included where necessary. The study will further present the elasticity matrices for all the variables estimated. It will further look at whether potatoes have substitutes or complementary goods in South Africa, and/or whether they are inferior (the quantity consumed decreases as real incomes rise) or normal goods (quantity demanded increases as income increases).

The Microsoft Excel program is used in this study as it provides the user the ability to actually observe how the model unfolds. It also enables the graphic presentation of the estimates against

the actual results to determine if the flow diagram of the estimates catches the turning points of the actual trends over time

Stage 4

This stage is the evaluation of the forecasting power of the model. The final stage of the model is to assess the stability of the estimates and their sensitivity towards change. This stage is divided into two phases. Phase 1 is the construction of the baseline from the system of equations from 2011-2015. The baseline covers both the endogenous and exogenous variables. The model projects the endogenous variables under the influence of the forecasted variables from the BFAP baseline. Phase 2 is the development of the model or the model closure. This is computerised through the equilibrator to establish the procedures of determining the market price equilibrium of the simulation model.

3.3.2 Model Structure

It is crucial to understand the structure of the potato industry and how its components are interlinked in order to ensure better simulation of the industry with its environment. A **flow diagram** that informs the structure of the model is drawn in Figure 3.1. The diagram illustrates the movements of potatoes from the farmer's gate to the market-destination. The diagram will help in outlining the interaction between potatoes and other economic and biological factors; such as the supply, demand and price interaction. The flow diagram will also serve as the director towards the empirical estimation of the model.

The potato industry is dynamic in that the national potato price influences (determines) the prices at regional level and the price levels of exported potatoes. The regional potato price is related to the area harvested. The model that is developed utilises the area planted as a proxy for the area harvested; although in some cases what is being planted is not actually what will be harvested. The area planted is the closest to the actual quantity that is harvested. The potato harvested area is influenced by the lagged area planted, potato prices, input prices, price of the substitutes and/or complements, as well as the climate. All these factors will eventually influence producers' decisions.

The graph depicts the relationship of the area planted with yield, but is not cascaded to the other variables that influence yield. Factors that influence yield in general include variables such as the type of seed (cultivar) and rainfall, which contribute to the increase in yield. However, these relationships are not displayed in the flow diagram. Yield can also be a measure of crop output per unit area of land under cultivation, because the potato area planted is positively correlated to the yield. The graph illustrates how the potato area harvested and the yield influence regional potato production. Potato production is calculated by multiplying the area harvested by the potato yield; a factor which makes the area harvested important in the model. All the regional productions consolidated sum up to the aggregated national potato production.

According to general economics, price and quantity demanded of any output are inversely related, unless it is an inferior good. The national potato production (supply) influences the national price of potatoes. The quantity produced nationally in turn influences the prices of potatoes to be consumed.

As indicated earlier, potatoes are consumed fresh directly from the farm (informally) or through the markets (formally). The national potato price also influences the price of potatoes for processing and the seed potato prices. In turn, the quantity of potatoes demanded (required) for consumption purpose is inversely related to the national potato prices. Figure 3.1 below, is the potato flow diagram. it illustrates the linkage among the total supply, demand and price of potatoes in South Africa.

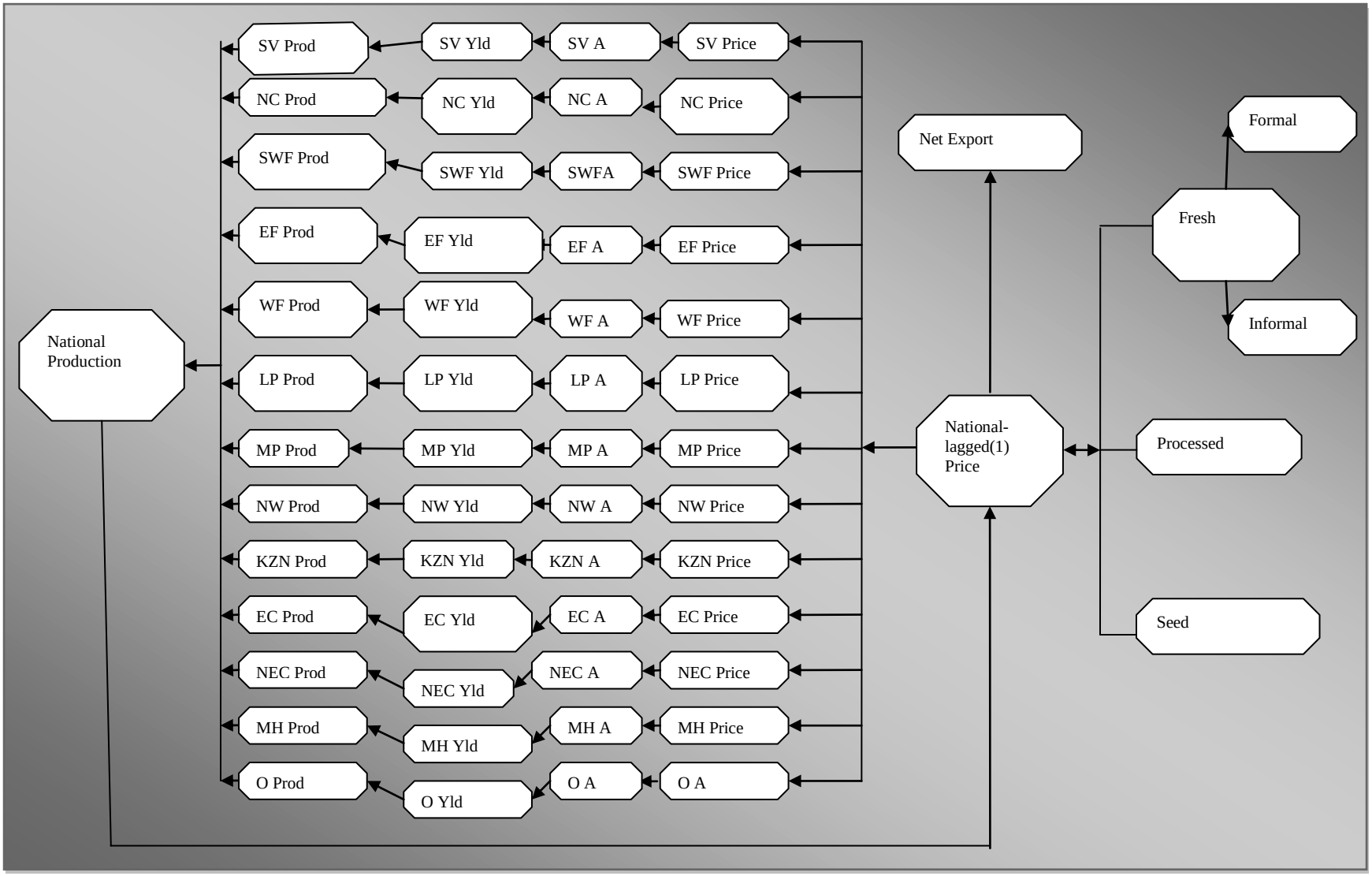

Figure 3.1: Flow diagram of the South African potato sector

3.4 MODEL SPECIFICATION

3.4.1 Supply

This section looks at the model building blocks which are the supply and demand functions. The section will address the equations that make the individual blocks. The blocks consist of production and exports. The production is determined by the area planted and the yield. The area planted will be used as a proxy for the area harvested in the model. The decision on the size of the area planted is influenced by the lagged potato area harvested; potato prices; input factors; price of substitute and/or complements; and the weather. The model factors that influence production come from the literature and from the potatoes industry specialists. This is presented in Equation 3.1:

[Equation 3.1] ***Potato area harvested***

$$PAHR = f(\ PAHR_{t-1,}\ P_{p,t} / P_{i,t}\ ,\ P_S\ ,\ Rain\ )$$

Where:

PAHR is the potato area harvested (ha) which is a proxy for the area planted;
$PAHR_{t-1}$ t is the area harvested during the previous period;
P_{pt} is the potato producer price (R/t);
P_{it} is the price of the cost of inputs (R/ha);
Ps is the price of the complements or substitutes (R/t); and
Rain is rainfall per annum (mm).

The Rainfall variable is an important factor in agricultural production, in this case potato. This is then taken from the research done by Bhattacharjee and Holland (2005) whereby the results indicated that the shortage of water for irrigation in potato has a negative impact on production and as a result potato for processing.

[Equation 3.2] ***Potato yield***

PYLDR=f (C, Rain)

Where:

PYLDR is the potato yield at the regional level (t/ha);

C is the cultivars utilised.

Also, the use of cultivars (varieties) in the model is encouraged by the study conducted by Argali and Love (2002), which resulted in the improved potato yield from investment in the Pacific Northwest Potato Variety Development Program.

The yield equations are estimated regionally and are utilised in determining production in the regions. Potato production per region is an identity and is determined by multiplying the regional potato area harvested by the regional potato yield (Equation 3.3). Total production is then calculated by summing up all regional productions to give the aggregate national production.

[Equation 3.3] ***Potato Production***

$PPRODR_t = PAHR * PYLDR$

Where:

PPRODRt is potato production.

Total potato supply per region is also an identity and is determined as follows in Equation 3.4:

[Equation 3.4] ***Total Potato Supply***

$TPS = PPRODT_t + PIMP$

Where:

TPS is the total potato supply;

PIMP reflects the potato imports.

3.4.2 Demand

The demand block is made up of the grand total of the commodity consumed, imports and the ending stock for agricultural commodities that are perennials. For potatoes, the demand block consists mainly of imports and local consumption. This is because potatoes are perishable and seasonal.

The potato consumption is guided by the theory of utility maximisation of the consumer as driven by their limited income (Equation 3.5):

[Equation 3.5] ***Potato Per Capita Consumption***

Ppcc= *f*(Ppt, Pst, INC)

Where:

Ppcc is the potato per capita consumption (kg);

Ppt is the consumer price (R/t);

Pst is the price of substitutes and/or complements (R/t);

INC is income (R per annum).

The model focuses on the four consumption methods at national scale; no focus is given to the regional level for this model. Potato domestic consumption uses the per capita consumption variable obtained by utilising the South African population and is also exogenous to the model. The consumption in this study is divided into four types; namely fresh formal

consumption; fresh informal consumption; potatoes for processing; and seed potato consumption. The demand function for fresh formal consumption is estimated as a function of potato price, price of substitutes and per capita GDP; obtained by utilising the South African population, which is exogenous to the model (Equation 3.6):

[Equation 3.6] ***Fresh formal potato consumption***

FFPOTCONS= f (RPTSA, RWMPSAt, RWPPSA, RPCGDP)

Where:

FFPOTCONS is the fresh formal potato consumption ;(1000 tons)
RPTSA is the Real South African potato prices (c/10kg)
RWMPPSA is the real white maize price of South Africa (R/ton)
RWPPSA is the real wheat price in South Africa (R/ton)
RPCGDP is the per capita Gross Domestic Product (R/Capita);

[Equation 3.7] ***Fresh informal potato consumption***

FIPOTCONS= f (RPTSA, RWMPPSA, RWPPSA, RPCGDP)

Where:

FIPOTCONS is the fresh informal potato consumption ;(1000 tons)
RPTSA is the Real South African potato prices (c/10kg)
RWMPSA is the real white maize price of South Africa (R/ton)
RWPSA is the real wheat price in South Africa (R/ton)
RPCGDP is the per capita Gross Domestic Product (R/Capita);
;

[Equation 3.8] Processing *Potato*

POTPROSCONS= ƒ (RPTPSA, RWMPPSA, RWPPSA, RPCGDP)

Where:

POTPROSCONS is potato consumption through processing ;(1000 tons)

RPTSA is the Real South African potato prices (c/10kg)

RWMPSA is the real white maize price of South Africa (R/ton)

RWPSA is the real wheat price in South Africa (R/ton)

RPCGDP is the per capita Gross Domestic Product (R/Capita);

[Equation 3.9] *Seed potato consumption*

POTSEEDCONS= ƒ (RPTASPSA, RSPSHASA)

Where:

POTSEEDCONS represent the seed potatoes ;(1000 tons)

RPTASPSA is the real South African seed potato prices (c/10kg)

RSPSHASA which is the real area planted for seed potatoes (1000 tons)

The model calculated the consumption identities by adding all the consumption types in order to obtain the aggregated consumption.

3.4.3 Trade

In this study, imports are insignificant as the focus is on net exports. Net exports are calculated by subtracting the imports from the exports. The assumption made in this regard is that the net exports are a proxy to exports and that there are no imports. The trade equation is presented in Equation 3.7.

[Equation 3.7] ***Potato net export***

PNEXT=f (MIN (0,((PTDUSA/PTPRDSA)-1));(PTMPSA/EXCH))

Where:

PNEXT is potato net export which is the difference between exports and imports;

PTDUSA is the potato consumption in South Africa;

PTPRDSA is the domestic potato production;

PTMSA is the national price of potatoes which is then divided by the exchange rate;

EXCH is the South African exchange rate in Rand per Dollar.

3.5 MODEL CLOSURE

The following equations are the potato model identities. These identities are constructed to establish market equilibrium through a price equilibrator approach. In other words, the model solves for the national price by balancing out total demand and total supply through an iterative approach with an algorithm in Excel. Hence, total demand and supply identities have to be calculated.

Total potato demand is an identity and is determined by adding the total consumption to potato exports:

Equation 3.8: Potato Identities

[Equation 3.8.1] ***Total Potato Demand*: *Identity***

TPD=PDUSA + PEXP

Where:

TPD is the total potato demand

PDUSA is the potato demand in South Africa (domestic);

PEXP is the potato net exports after subtracting the imports to South Africa.

Total potato supply is an identity and is determined by adding the total quantity produced in South Africa to the amount imported (Equation 3.8.2):

[Equation 3.8.2] ***Total Potato Supply*: *Identity***

$$TPS = TPPSA + PIMP$$

Where:

TPS represents the amount of potatoes supplied to South Africa;

TPPSA denotes the total amount of potatoes produced in the country;

PIMP denotes the quantities of potatoes imported from other countries.

As illustrated in the flow diagram, total supply is made up of domestic production and total demand is determined by the combination of total potato demand and the net exports; which in this case is the proxy for South African exports.

3.6 CONCLUSION

The use of the econometric modelling methods has already been applied in various fields of studies on agricultural products for the purposes of understanding the behavioural relationship among variables; for forecasting future changes; and for decision-making purposes**.** This chapter dealt with the procedure that will be followed in developing the structural model intending to simulate the dynamic interaction between production and consumption at a regional level for potato producers, policy makers and wholesalers.

The chapter presented the area of the study and the time series data that will be utilised. It also highlighted the independent variables considered in the study, namely the potatoes area planted in quantity; potato production; potato prices at regional and national level; potato consumption at the national level; fresh and seed consumption; wheat and maize prices at national and regional level; Requisite (which is an index of all agricultural inputs consolidated). Data also included the GDP, CPI, and the South African population.

The model contains both qualitative and quantitative data. The model is comprised of 13 regions of potato production and a single aggregated national potato production which has incorporated the South African potato imports. The model consists of four consumption equations, namely fresh national potato consumption (both in formal and informal markets), seed potato consumption and processed potato at national level. There is also a net export equation in addition to these equations.

The model uses recursive models; which are appropriate in the field of agriculture and in the generation of econometric models. The Ordinary Least Square (OLS) method will be used to estimate the linear equation. The model will present the economic validity of the estimates and incorporate synthetic parameters where necessary, but will exclude the statistical significance of the model due to the insufficient data availability. The model will further graphically illustrate the actual against the estimated flow diagram to indicate the model's goodness of fit. The single equations estimated will then be linked to form a system of equations, which will later on be estimated simultaneously to form the baseline. The baseline will then be used to project the variables' trend for the next seven years and will further be used for the evaluation of possible scenarios. This study will use a Microsoft Excel program; as it provides the user with the ability to actually observe what is happening. Graphic representation of the estimates against actual trends over time will be displayed.

The following chapter will look at the partial equilibrium model results for the South African potato industry. The South African potato balance sheet will be developed and its identities are presented. The chapter will discuss the estimated results obtained from the use of estimations produced. Attention will be given to the performance of the model; such as the statistical significance of the variables in the equation; whether the variables make economic sense; the overall model and the goodness of fit. Finally, the following chapter will discuss how the market price equilibrium is determined in the South African potato industry.

CHAPTER 4

THE RESULT OF THE EMPIRICAL ANALYSIS

4.1 INTRODUCTION

This chapter discusses the empirical results obtained from the development of the simulation model with partial equilibrium. The results are presented as the potato supply, the demand, net export blocks and the model closure. The discussions will detail the performance of the model, the parameter estimates and elasticies; which will be presented in equations, matrices and illustrated graphically**.**

4.2 EMPIRICAL RESULTS

The network of equations presented in this chapter formulates the simulation model of the South African potato industry. This component of the study will discuss the economic validity of the parameter estimates and will illustrate price elasticity matrices of the exogenous variables concerned. The study will graphically illustrate the goodness of fit of the model, whereby the estimate will be compared to the actual variables' trends over time. This will reflect how well the estimated flow diagram reflects the historical trends of the exogenous variables; and hence, how effectively it simulates real life situations. If the model mimics reality, it will then be further employed to provide accurate projections of reality. Due to the limited time series observation on the estimated equations, the study will not cover the statistical validation of the model, but rather the already mentioned procedures, in order to evaluate the model's ability to handle real-life situations. This will cover the inclusion of the synthetic parameters where necessary as the proxy.

The definitions for the variables in the equations are included to enable better understanding and ease in the interpretation of their validity. The results are organised by categories as demand, supply and model closure. Potato demand is constructed through the estimation of the area harvested and the yield to formulate 13 regional productions. The regional production is further aggregated to form a single national production; which is computed in

order to compare national supply and demand. Thereafter, the results of the demand block are presented at a national level; mainly because potatoes cultivated in one region are distributed throughout the country and beyond its borders. The consumption is presented as seed potatoes, potatoes for processing and fresh potatoes marketed at formal markets and informal markets. These four pillars of consumption will then be collapsed to form the national consumption. The national consumption, however, is incomplete without the inclusion of exports; or in this case, net exports. This is the demand block in the study. The final results present the model closure, which will determine the market price equilibrium of South African potatoes.

4.3 DOMESTIC SUPPLY

The domestic supply is comprised of production and potato imports. It is important to note that potatoes are considered perishable as there is no carry' over stock from the previous year. The area planted, regional potato yield including the identities comprises the production block. This is presented in equations 4.1 to 4.40. The results obtained from estimates will be utilised in the formation of regional production identities. The identities are then aggregated to form national potato production; hence the supply block of the simulation model.

4.3.1 Sandveld Area harvested

The Sandveld region is situated in the Western Cape Province. The region is characterised by extremely low rainfall of less than 200 mm per annum. The landscape is covered by very low nutrient sandy soil as a result farmers practice intensive agricultural production through the application of large quantities of fertiliser and irrigated 'circle' (rotations) (Yeld, 2005). Potato production is the main economic driver and the largest employer of the Sandveld region; and is also the largest user of water and the largest transformer of natural veld. In spite of potato farming using an average of 7 000 cubic meters of water per hectare per year, its water requirement still exceeds the province's supply and the source of irrigation is mainly groundwater (African Conservation, 2010)

In the Sandveld region, potato production takes place throughout the year. There are two peak seasons; from January to April for the summer crop and June to July for the winter crop. As a

result, marketing of the produce occurs all year round; with the winter sales reach the its peak from February to April and the summer sales is the highest from October to December. A total of 38% of the South African crop is also produced in this region (Potato South Africa, 2010).

These activities in the area inform the structure of the equations; namely that the area under potato production is modelled as the function of lagged area, the ratio of Sandveld potatoes, fertiliser price, and the real wheat price.

Equation 4.1: *Sandveld potato area harvested (thousand hectares)*

Explanatory variable	Parameter	Elasticity
Intercept	5.100	
LAG (PHSAND)	0.09	0.09
SANDP/FERTP	0.32	0.321
LAG (WHP)	-0.001	-0.11

Variable name	Definition	Units
PHSAND	Potato area harvested in Sandveld	Thousand 'ha
P/FERTP	Ratio of Sandveld and fertiliser price	R/ton
HP	Wheat price	R/ton

The elasticity of 0.09 implies that the increase in the previous year's area planted in Sandveld by 10% will lead to an increase in the area planted this year of 0.9% ceters porilus. The 10% increase in Sandveld and the fertiliser price ratio will increase the area planted by approximately 3.2%. The results indicate a negative relationship between the potato area planted and the wheat price in Sandveld; in that an increase in the wheat price by 10% will result in farmers reducing the quantity of potatoes planted by 1%, uteri porilus.

Equation 4.2: *Sandveld potato yield (tons/hectare)*

Explanatory variable	Parameter	Elasticity
Intercept	6.79	
LN (CULTIVAR)	0.33	0.33
LN RAINFALL	0.2	0.21

This result justifies the use of improved cultivars in the region; It implies that, if producers were to increase their use of improved cultivars by 10% potato yield will increase by 3.3%. Considering the limited supply of water in this region, a 10% increase in rainfall would improve the yield by 2.1%.

Equation 4.3: *Sandveld estimated regional production (thousand tons)*

The following equation is the estimated production identity of the Sandveld region. This is calculated by multiplying the estimated yield by the estimated area harvested, as follows:

PTPROSAND= PTAHSAN*PTYSAN

Variable name	Definition	Units
PTPROSAND	Potato production Sandveld	Thousand tons
PTAHSAN	Potato area harvested Sandveld	Thousand hectares
PTYSAN	Potato yield Sandveld	Tons/hectare

As indicated earlier, the goodness of fit is plotted below to demonstrate how the model fits the real situation. The graph below illustrates the comparison between the estimated production and the actual potato production in Sandveld region.

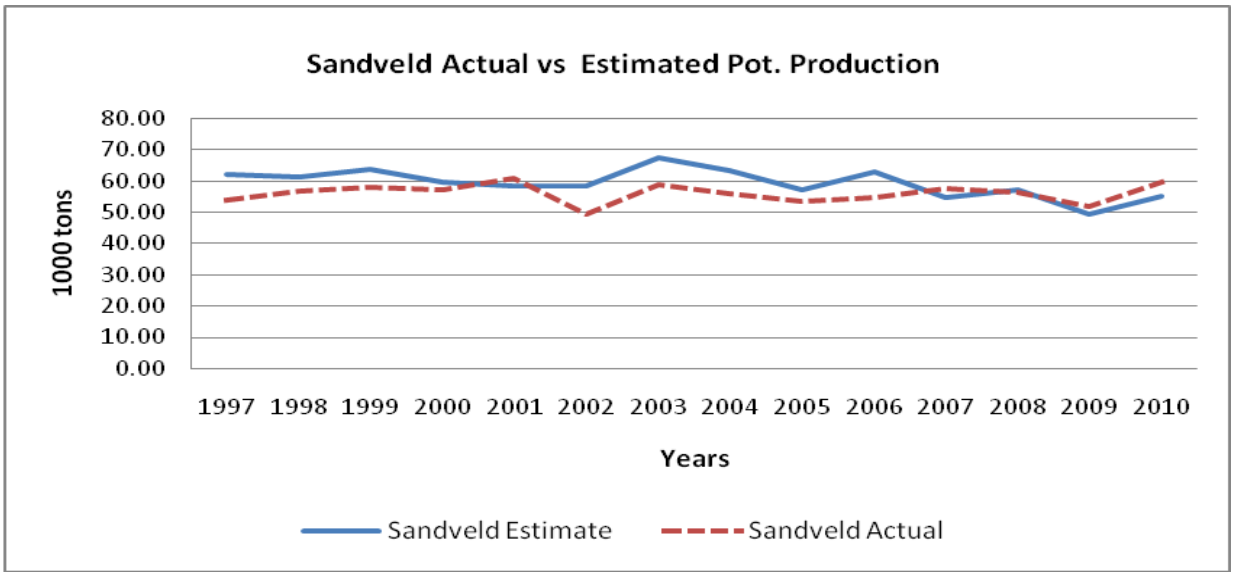

Figure 4.1: Sandveld actual and estimated potato production

4.3.2 Northern Cape

The Northern Cape is the largest South African province, with its landscape covering 30.5% of the country's land. The region is a significant exporter of table grapes and also produces white maize, cotton, wheat, ground nuts and potatoes (South African Info, 2010). About 14% of the country's wheat is derived from the Northern Cape (FAO, 2010). Potato production is achieved under irrigation. Planting occurs in areas near the Vaal River and the Orange River in Hopetown. About 68% of potatoes produced in this area is seed potatoes. The planting occurs over two periods; an early planting in August and a late crop planting from November to January.

The area under production is estimated as the function of the lagged area planted, the price of white maize, the Northern Cape potato price and the fertiliser price ratio.

Equation 4.4: *Northern Cape potato area harvested (thousand hectares)*

Explanatory variable	Parameter	Elasticity
Intercept	1.22	
LAG (PHNC)	0.25	0.25
NCP/FERTP	0.04	0.14
RLAG (MAP)	-0.001	-0.04

Variable name	Definition	Units
PHSAND	Potato Area Harvested in Northern Cape	Thousand hectors
NCP/FERTP	Ratio of potato price in the Northern Cape and fertiliser price	R/ton
MAP	Maize price	R/ton

The 0.25 price elasticity of the area planted last season implies that an increase of 10% in the last seasons' area planted for the Northern Cape will increase the current season's area by 2.5%. If the potato/fertiliser price ratio increases by 10%; the area planted will increase by approximately 1.4%. A reduction in the white maize price of 10% will lead to an increase in the potato area planted by 0.4%.

Equation 4.5: *Northern Cape potato yield (tons/hectare)*

Explanatory variable	Parameter	Elasticity
Intercept	6.5	0
LN (CULTIVAR)	0.23	0.23
LN RAINFALL	0.25	0.25

The price elasticity of 0.23 indicates that if the cultivar usage increases by 10 %, the Northern Cape yield will increase by 2.3%. A 10% increase in rainfall will increase the yield by 2.5%.

Equation 4.6: *Northern Cape estimated regional production (thousand tons)*

The following equation is the estimated production identity of the Northern Cape region. This is calculated by multiplying the estimated yield by the estimated area harvested, as follows:

PTPRONC= PTAHNC*PTYNC

Variable name	Definition	Units
PTPRONC	Potato production Northern Cape	Thousand tons
PTAHNC	Potato area harvested Northern Cape	Thousand hectares
PTYNC	Potato yield Northern Cape	Tons/hectare

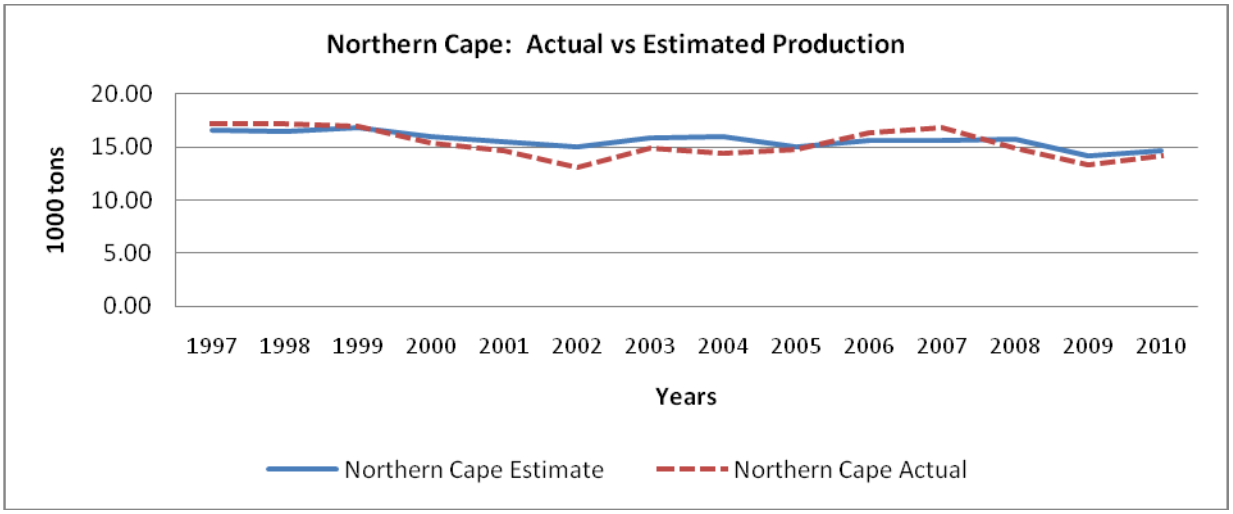

Figure 4.2: Northern Cape actual and estimated potato production

4.3.2 North- Eastern Cape

While the larger proportion of potato production has been under dry-land for years in this region, there has been a recent move towards increasing use of irrigation. This shift is primarily because of the need to reach the market at an earlier stage and because of the high input costs. About 60 % of the crop is produced under irrigation and the remaining 40 % under dry-land conditions. The planting period takes place from August to November, and the marketing season from January to December.

The area under the North-eastern Cape is modelled as the function of lagged area, the ratio of the North-eastern Cape potato price and fertiliser price, and a dummy variable in 2002.

Equation 4.4: *North-Eastern Cape potato area harvested (thousand hectares)*

Explanatory variable	Parameter	Elasticity
Intercept	0.41	
LAG (PHNEC)	0.21	0.25
NECP/FERTP	0.16	0.54
DUMMY 2002	0.91	0.05

Variable name	Definition	Units
PHSAND	Potato Area Harvested in Northern Cape	Thousand hectors
P/FERTP	Ratio of potatoes and fertiliser price	R/ton
MAP	Maize price	R/ton
DUMMY 2002	The dummy represent qualitative variable or an possible incident in 2002 at Northern Cape which could have happened only ones	

The lag area planted has an elasticity of 0.25. This reflects that, if area planted last year is increased by 10 %, the result will be an increase in this year's area by 2.5 %. Similarly, a 10 % increase in the price ratio of Northern-eastern Cape potatoes and fertiliser will lead to an increase in the area planted by approximately 5.4 %.

Equation 4.5: *North-Eastern Cape potato yield (tons/hectare)*

Explanatory variable	Parameter	Elasticity
Intercept	7.41	
LN (CULTIVAR)	0.25	0.25
LN RAINFALL	0.08	0.08

The price elasticity of 0.25 indicates that if the cultivar usage is increased by 10 %, the Northern Cape yield will increase by 2.5%. Also 0.08 price elasticity implies that a 10% increase in rainfall will increase the Northern Cape potato yield by 0.8%.

Equation 4.6: *North-Eastern Cape estimated regional production (thousand tons)*

The following equation is the estimated production identity of the North-Eastern Cape region. This is calculated by multiplying the estimated yield by the estimated area harvested, as follows:

PTPRONEC= PTAHNEC*PTYNEC

Variable name	Definition	Units
PTPRONEC	Potato production North-Eastern Cape	Thousand tons
PTAHNEC	Potato area harvested North-Eastern Cape	Thousand hectares
PTYNEC	Potato yield North-Eastern Cape	Tons/hectare

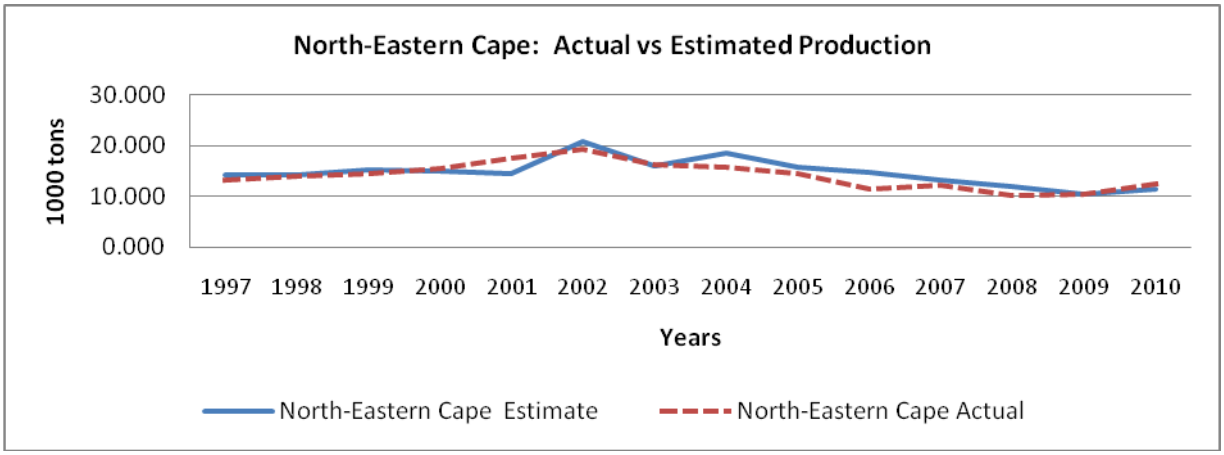

Figure 4.3: North-Eastern Cape actual and estimated potato production

4.3.4 Eastern Cape

In the Eastern Cape Province, potato production occurs under irrigation, with planting time ranging from October to March for the summer crop and from April to September for the winter crop. This region only produces table potatoes. Due to the nature of dryness, water for irrigation is supplied by main storage dams, such as the Kouga dam in the Gamtoos valley. The area harvested is estimated as the function of lagged area, the ratio of Eastern Cape potato price and fertiliser price.

Equation 4.11: *North Eastern Cape potato area harvested (thousand hectares)*

Explanatory variable	Parameter	Elasticity
Intercept	0.85	0
LAG (PHNEC)	0.24	0.20
NECP/FERTP	0.08	0.31

Variable name	Definition	Units
PHEC	Potato area harvested in Eastern Cape	Thousand hectors
P/FERTP	Ratio of potatoes and fertiliser price	R/ton

The elasticity of 0.20 means that an increase in the last season's area planted in the Eastern Cape of 10% will lead to a 2% increase for this season's area harvested. Similarly, a 10% increase in the price ratio of the Eastern Cape and fertiliser will increase the potato area harvested by approximately 3.1%.

Equation 4.12: *Eastern Cape potato yield (tons/hectare)*

Explanatory variable	Parameter	Elasticity
Intercept	7.35	0
LN (CULTIVAR)	0.45	0.45
LN RAINFALL	0.05	0.05

The elasticity of 0.45 on the use of varieties and 0.05 for the rainfall imply that if the cultivar usage increases by 10%, the yield will increase by 4.5%. If rainfall decreases by 10%, there will be a 0.5% reduction in potato yield in the Eastern Cape region.

Equation 4.13: *Eastern Cape estimated production (thousand tons)*

The following equation is the estimated production identity of the South-western Eastern Cape region. This is calculated by multiplying the estimated yield by the estimated area harvested, as follows:

PTPROEC= PTAHEC*PTYEC

Variable name	Definition	Units
PTPROEC	Potato production Eastern Cape	Thousand tons
PTAHEC	Potato area harvested Eastern Cape	Thousand hectares
PTYEC	Potato yield Eastern Cape	Tons/hectare

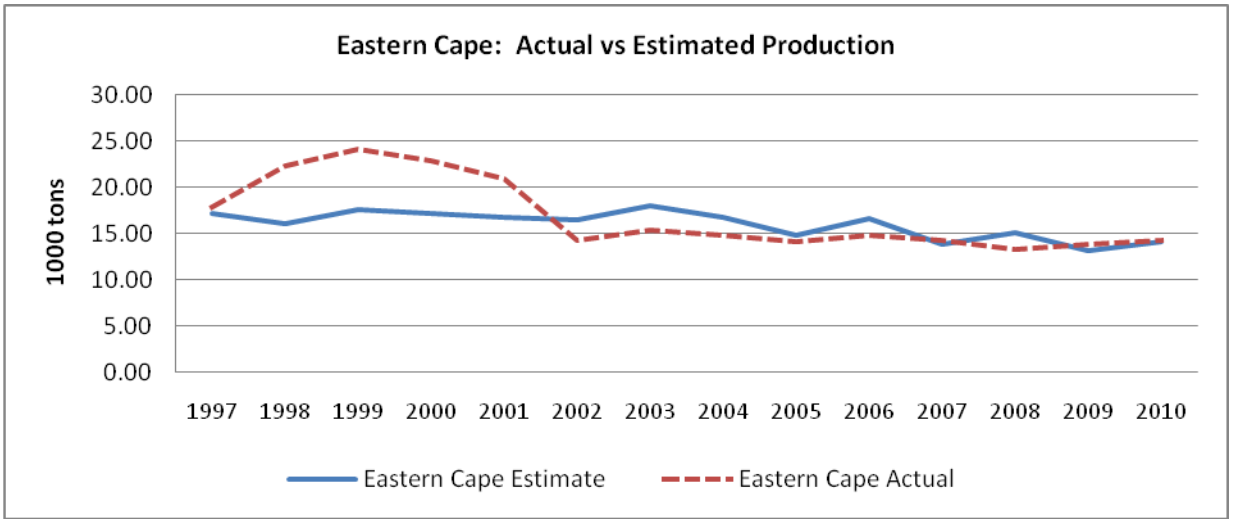

Figure 4.4: Eastern Cape actual and estimated potato production

4.3.5 Free State Province

The Free State province is situated on the flat plains in the heart of South Africa. Its landscape is characterised by rich soils and very good climatic conditions, rendering it suitable for agricultural production. The province is ranked number one in the production of biofuel in South Africa and produces 32% of South Africa's wheat. The province, as indicated in earlier chapters, has been further sub-divided into three regions; the Western Free State, the South-western Free State and the Eastern Free State. (Free State Business, 2009)

4.3.5.1 Western Free State Region

The Western Free State region is semi-arid, with summer rainfall of 559 mm per annum. The regional summer temperature ranges from a minimum of 15 degrees Celsius to 31 degrees Celsius. The Western Free State experiences very cold winters, with temperatures ranging

from -2 degrees Celsius to 17 degrees Celsius. The area lies along the Vaal River, which is a bulk water supplier for agricultural activities. Maize is the main commodity produced in the Western Free State, where Bothaville is the centre of maize production, followed by wheat, and to a lesser extent vegetables, nuts and sunflowers. Potatoes are produced along the eastern part of this area. Most of the potato farming occurs under irrigation and about 11% of the crop is produced under dry-land conditions.

The planting season for this region is from August to October for the early crop and November to February for the late crop. The marketing of the early crop occurs from December to March and the harvesting of the late crop from April to October. The Western Free State potato area harvested is modelled as the function of lagged Western Free State area, the ratio of Western Free State potato price and fertiliser price, rainfall, and the real price of white maize and the SHIFT in 2001.

Equation 4.14: *Western Free State potato area harvested (thousand hectares)*

Explanatory variable	Parameter	Elasticity
Intercept	6.46	0
LAG (PHWFS)	0.15	0.15
WFSP/FERTP	0.3	0.27
REAL MAIZE SAFEX PRICE	-0.003	-0.24
RAINFALL	0.002	0.17
SHIFT 01	-1.5	-0.22

Variable name	Definition	Units
PHWFS	Potato area harvested in Western Free State	thousand hectors
P/FERTP	Ratio of potatoes and fertiliser price	R/ton
RWMP	Real white maize price	R/ton
RAINFALL	Rainfall in the Western Free State	mm/s
SHIFT01	indicator variable SHIFT equal to 1 from 2001 onwards: and it represent the further sub-division of the Western Free state to South Western free state over the years from 2001 and “has a significant negative impact on the area planted for potato production	R/ton

The price elasticity of the Western Free State area is 0.154, indicating that, if the area planted last season increased by 10%, there will be an increase in the area planted in the current season of 1.5%. The price elasticity of the fertiliser/potato price ratio is 0.27 meaning that a 10% decrease in the price ratio will lead to a 2.7% decline in the Western Free State area planted with potatoes. A 10% reduction in the price of maize will lead to an increase in the potato area harvested by 2.4%. Rainfall increase in this area by 10% will lead to 1.7% extra hectares being planted. The SHIFT through the subdivision of the area to smaller areas has a negative impact on the area available for potato production since Western Free State is the main producer of maize and biofuel. The impact of the shift is visible from 2001.

Equation 4.15: *Western Free State potato yield (tons/hectare)*

Explanatory variable	Parameter	Elasticity
Intercept	5.8	
LN (CULTIVAR)	0.25	0.25
LN RAINFALL	0.35	0.35

The use of the varieties in improving the yield is actually a positive correlation; in that the results show that an increase in the use of cultivars by 10% will improve the potato yield by 2.5%. Rainfall in this region plays a significant role in that an increase by 10% will increase yield with 3.5%.

Equation 4.16: *Western Free State estimated regional production (thousand tons)*

The following equation is the estimated production identity of the Western Free State region. This is calculated by multiplying the estimated yield by the estimated area harvested, as follows:

PTPROWFS= PTAHWFS*PTYWFS

Variable name	Definition	Units
PTPROWFS	Potato production Western Free State	Thousand tons
PTAHWFS	Potato area harvested Western Free State	Thousand hectares
PTYWFS	Potato yield Western Free State	Tons/hectare

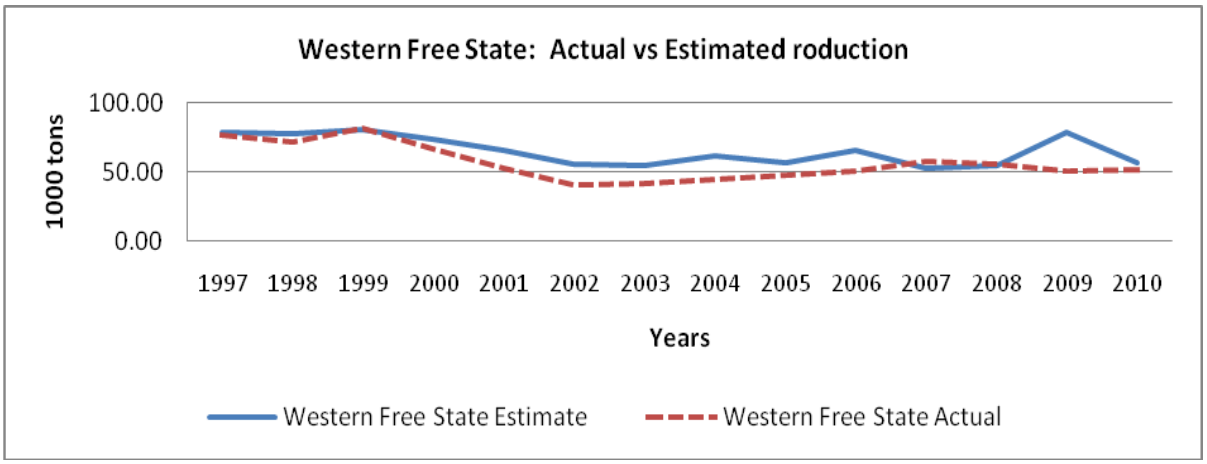

Figure 4.5: Western Free State actual and estimated potato production

4.3.5.2 South-western Free State region

The South-western Free State, called the Xhariep district, is the dry southern area of the Free State province. The area's agricultural activities include, but are not limited to, sheep production, walnuts, and grapes for wine production. In this region, potato cultivation takes place under irrigation and its water supply is derived mainly through irrigation schemes and boreholes. Only 1% of the produce is rain-fed. The larger proportion of production occurs at Petrusburg.

The larger quantity of potatoes produced in this region are table potatoes and only 2% of the crop is seed potatoes. This region consists of two harvesting periods in one year. August to November is the early harvest, and December to January is the late harvest. The early harvest is marketed from December to April and the late harvest from May to September.

The profile of the area actually informs the relationship of the estimations in this region. Hence the South-western Free State potato area under production is a function of lagged area, the South-western Free State potato and fertiliser price ratio, as well as the real price of white maize.

Equation 4.17: *South-western Free State potato area harvested (thousand hectares)*

Explanatory variable	Parameter	Elasticity
Intercept	1.23	0
LAG (PHSWFS)	0.4	0.4001
SWFSP/FERTP	0.035	0.13
REAL MAIZE SAFEX PRICE	-0.001	-0.42

Variable name	Definition	Units
PHSWFS	South Western Free State potato area harvested	Thousand hectors
P/FERTP	Ratio of potatoes and fertiliser price	R/ton
RWMP	Real white maize price	R/ton

The elasticity of the area is 0.4, indicating that an increase in the last season's area planted by 10% will result in an increase in the area planted in the current season of 4%. The results show a positive correlation between the potato/fertiliser price ratio and the potato area planted. This is evident in the price elasticity of 0.13, implying that a 10% decrease in the price ratio will lead to a reduction in the area planted by 1.3%. Maize is inversely correlated to the area planted, in that an increase in the maize price of 10% will lead to a reduction in potato area planted by 4.2%.

Equation 4.18: *South-western Free State potato yield (tons/hectare)*

Explanatory variable	Parameter	Elasticity
Intercept	4.83	
LN (CULTIVAR)	0.5	0.5
LN RAINFALL	0.45	0.45

Again, cultivars play a positive role in improving the potato yield. Cultivars have an elasticity of 0.5 in this region, meaning that an increase in the usage of varieties by 10% will result in yield growth of 5%. If rainfall increased by 10%, the potato yield would increase by 4.5%.

Equation 4.19: *South-western Free State estimated regional production (thousand tons)*

The following equation is the estimated production identity of the South-western Free State region. This is calculated by multiplying the estimated yield by the estimated area harvested, as follows:

PTPROSWFS= PTAHSWFS*PTYSWFS

Variable name	Definition	Units
PTPROSWFS	Potato production South-western Free State	Thousand tons
PTAHSWFS	Potato area harvested South-western Free State	Thousand hectares
PTYSWFS	Potato yield South-western Free State	Tons/hectare

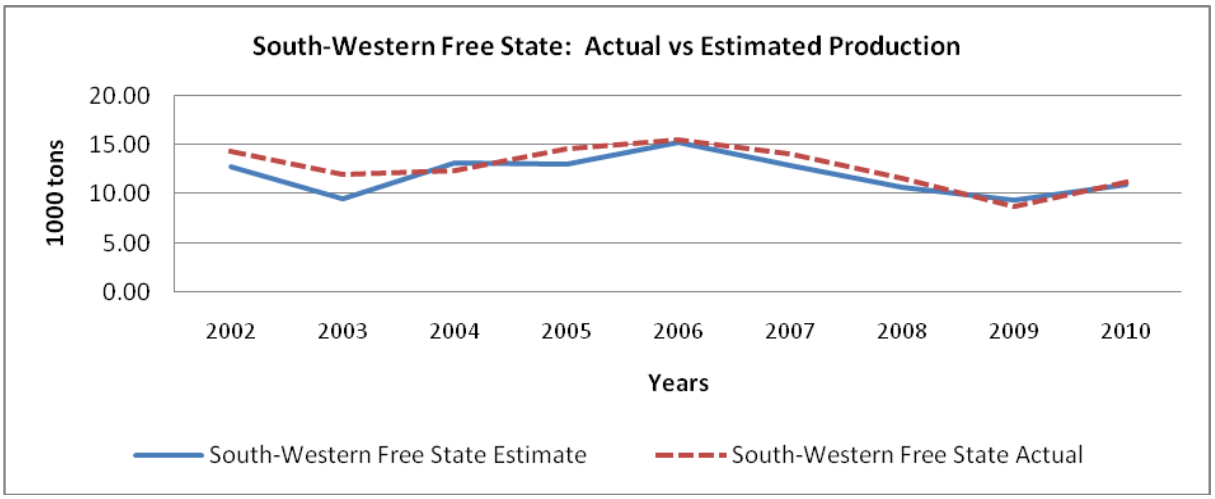

Figure 4.6: South-western Free State actual and estimated potato production

4.3.5.3 The Eastern Free State

The Eastern Free State frequently experiences snowfalls, particularly at the higher elevations. The area is characterised by an average rainfall of 680 mm per annum. Its summer temperature ranges from a minimum of 13 degrees Celsius to a maximum of 27 degrees Celsius. Winters experience temperatures that can reach a maximum of 16 degrees Celsius and a minimum of -2 degrees Celsius. The eastern area is well watered and produces 90% of

South African cherries. The farmers in this area also specialise in production of potato seed. About 40% of South African potatoes come from the high-lying areas of this province (Free State province, 2008). This region cultivates 70% of this crop under dry-land conditions and only 30% under irrigation. As such, the larger area under dry-land may lead to a large variation in the potato yield. Situated along the north east of the area lies what is known as the bread basket of South Africa, which derives the bulk of its water from the Vaal dam for extensive maize, wheat and sunflower production.

The potato planting period takes place from August to December, followed by the marketing period from January to September. Table potatoes make up 98% and seed potatoes make up 2% of the produced crop. The potato harvested area in the Eastern Free State area is estimated as a function of lagged area, the ratio of Eastern Free State potato price and fertiliser price, the real price of white maize, and the rainfall factor that influences the farmers' decision to plant.

Equation 4.20: *Eastern Free State potato area harvested (thousand hectares)*

Explanatory variable	Parameter	Elasticity
Intercept	4.2	
LAG (PHEFS)	0.26	0.26
EFSP/FERTP	0.72	0.41
REAL MAIZE SAFEX PRICE	-0.0045	-0.27
RAINFALL	0.003	0.21

Explanatory variable	Parameter	Elasticity
PHEFS	Eastern Free State potato area harvested	thousand hectors
P/FERTP	Ratio of potatoes and fertiliser price	R/ton
RWMP	Real white maize price	R/ton
RAINFALL		mm/s

From the results presented above, it is evident that the Eastern Free State potato area has an elasticity of 0.26 for the lagged area, which indicates that an increase in the last year's area planted of 10% will result in an increase in the area planted in the current year of 2.6%. The results show an elasticity of 0.41 for the Eastern Free State/fertiliser price ratio, meaning that a

10% rise in the price ratio will result in an increase of the area planted by 4.1%. The cross price elasticity of maize price is -0.27 and the elasticity for the rainfall is 0.21. This means that a 10% increase in the maize price will lead to a decrease in the area planted by approximately 2.7% and that an increase in rainfall by 10% will result in an increase of area planted by 2.1%.

Equation 4.21: *Eastern Free State potato yield (tons/hectare)*

Explanatory variable	Parameter	Elasticity
Intercept	3.36	
LN (CULTIVAR)	0.8	0.8
LN RAINFALL	0.55	0.55

The province is one of the two regions that produces potatoes under dry-land, and is characterised by summer rainfall. The elasticity of 0.8 for the use of cultivars implies that if the cultivar usage increases by 10%, the Eastern Free State yield will increase by 8%. The importance of rainfall is also evident in its elasticity, indicating that a 10% increase in rainfall will result in a 5.5% increase in the yield.

Equation 4.22: *Eastern Free State estimated regional production (thousand tons)*

The following equation is the estimated production identity of the Eastern Free State region. This is calculated by multiplying the estimated yield by the estimated area harvested, as follows:

PTPROEFS= PTAHEFS*PTYEFS

Variable name	Definition	Units
PTPROEFS	Potato production Eastern Free State	Thousand tons
PTAHEFS	Potato area harvested Eastern Free State	Thousand hectares
PTYSWEFS	Potato yield Eastern Free State	Tons/hectare

Figure 4.7 presented below shows the model estimates against the actual Eastern Free State production. According to the graph, the model has captured the movement of the actual production that is the actual production flow in most of the time is exactly the same as the estimated production. It can thus be concluded that the model is a true reflection of the actual production.

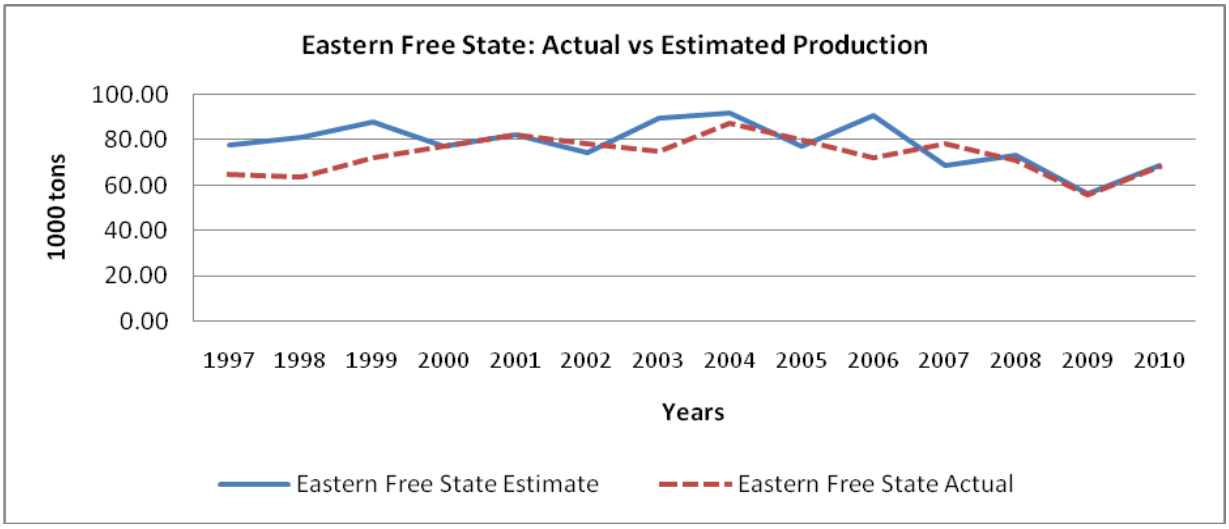

Figure 4.7: Eastern Free State actual and estimated potato production

4.3.6 KwaZulu-Natal Province

Potato production in this province occurs in the summer and winter seasons, where the summer season's crops are planted from August to January and harvested from the end of January to August. The winter crop is planted from February to July and marketed from August to February. About 78% of the summer crop is rain-fed and the rest is produced under irrigation. The summer crop is planted for the production of seed potatoes and the winter crop is mainly for the production of table potatoes. The area planted for seed potatoes covers 63 % of the area under potato farming. The province's main agricultural activities include sugar cane and maize. As a result, the KwaZulu-Natal potato area is modelled as the function of lagged area, the ratio of KwaZulu-Natal potato price and fertiliser price, and the real price of white maize.

Equation 4.23: *KwaZulu-Natal potato area harvested (thousand hectares)*

Explanatory variable	Parameter	Elasticity
Intercept	1.94	
LAG (PHKZN)	0.23	0.22
KZNP/FERTP	0.15	0.25
REAL MAIZE SAFEX PRICE	-0.0003	-0.05
SHIFT 2005	0.61	0.08

Variable name	Definition	Units
PHKZN	Potato area harvested in KwaZulu-Natal	Thousand hectors
P/FERTP	Ratio of potatoes and fertiliser price	R/ton
RWMP	Real white maize price	R/ton
SHIFT05	Indicator variable equal to 1 from 2005 onwards Although all variables that the industry expects foresee to have influence on the area planted do not satisfy the economic and econometric significant as such, it is clear that there is a qualitative variable not included from the model that contributed to changes in area planted from 2005-2010. (This might be the consumption pattern since 2005, as people need more potatoes the area planted increases)	R/ton

The results show an elasticity of 0.22, which means that an increase in last year's area planted of 10% will lead to an increase in the area planted this year of 2%. If the price ratio of KwaZulu-Natal fertiliser can increase by 10%, the area planted will increase by 2.5%. A 10% increase in maize price will lead to a decrease in the area planted by approximately 0.5%; therefore they are inversely correlated.

Equation 4.24: *KwaZulu-Natal potato yield (tons/hectare)*

Explanatory variable	Parameter	Elasticity
Intercept	4.71	
LN (CULTIVAR)	0.6	0.6
LN RAINFALL	0.4	0.4

If rainfall were to rise by 10% compared to the previous year and if producers' use of improved cultivars was to increases by 10%, the yield of potatoes would increase by 4 % with increased rainfall and 6% for improved variety.

Equation 4.25: *KwaZulu-Natal estimated regional production (thousand tons)*

The following equation is the estimated production identity of the KwaZulu-Natal region. This is calculated by multiplying the estimated yield by the estimated area harvested, as follows:

PTPROKZN= PTAHKZN*PTYKZN

Variable name	Definition	Units
PTPROKZN	Potato production KwaZulu-Natal	Thousand tons
PTAHKZN	Potato area harvested KwaZulu-Natal	Thousand hectares
PTYKZN	Potato yield KwaZulu-Natal	Tons/hectare

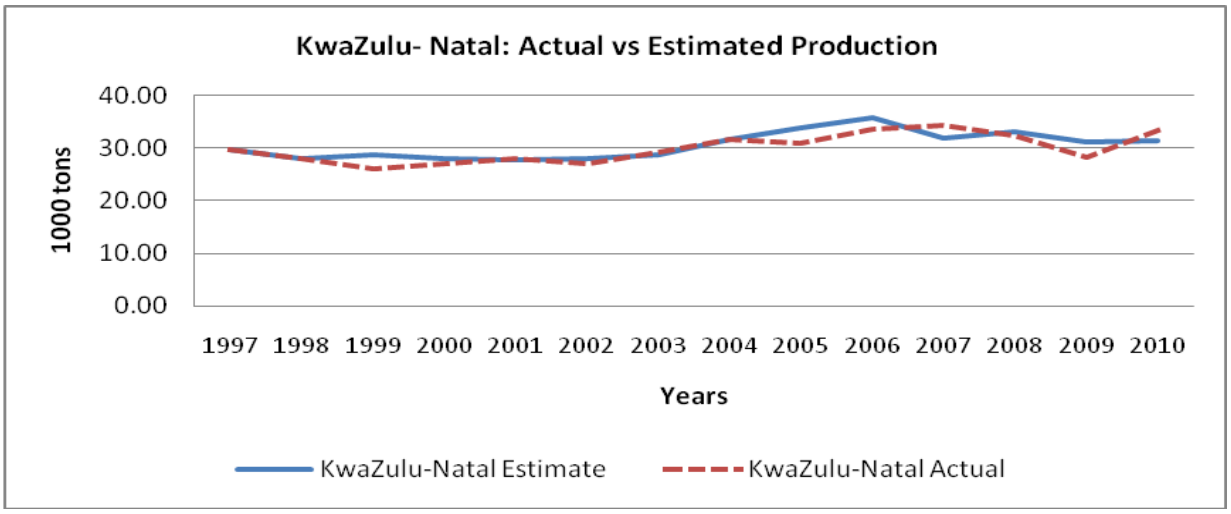

Figure 4.8: KwaZulu-Natal actual and estimated potato production

4.3.7. Mpumalanga Province

The Mpumalanga province is characterised by well-balanced agricultural activities. This is mainly due to the different and integrated climatic conditions found across the province (SESALO, 2009).The Highveld region of the province's production focuses mostly on maize as summer crops, and contributes 20% of South Africa's maize production. In addition to maize, wheat is cultivated during the winter, as well as potatoes, soybeans, barley and sunflowers to a lesser extent. The Lowveld region of the province, on the other hand, accounts for 64% of horticultural production, which includes groundnuts and sugar cane. More than 50% of the province's income is derived from the production of potatoes and other vegetables. (Opportunity Online, 2010)

Over the years, potato production has taken place under dry-land conditions, although recently this has shifted to irrigation. Table potatoes comprise 90% of the produce, with the remainder being seed potatoes. Mpumalanga's potatoes have a competitive advantage in the domestic market in that they are the first source of Gauteng's market for winter vegetables. This province's ploughing season takes place from August to December and harvesting occurs from January to June. The area harvested is estimated as the function of lagged area, the ratio of regional potato price, and fertiliser price and rainfall.

Equation 4.26: *Mpumalanga potato area harvested (thousand hectares)*

Explanatory variable	Parameter	Elasticity
Intercept	1.72	
LAG (PHMP)	0.24	0.26
MPP/FERTP	0.068	0.10
RAINFALL	0.003	0.2
SHIFT 2005	-0.44	-0.06

Variable name	Definition	Units
PHMP	Mpumalanga potato area harvested	Thousand hectors
P/FERTP	Ratio of potatoes and fertiliser price	R/ton
RWMP	Real white maize price	R/ton
RAINFALL		mm/s
SHIFT05	Indicator variable equal to 1 from 2005 onwards (The SHIFT variable indicates a further sub-division of the Mpumalanga to include Marble hall has a significant negative impact on the area planted for potato production)	R/ton

The elasticity of the lagged area is 0.26, which indicates that an increase in the last year's area planted of 10% will result in an increase in the area planted in the current year of 2.6%. There is a positive correlation between the fertiliser/potato price ratio and the area planted. In other words, an increase in the price ratio of 10% will lead to an increase in the area planted of 1%. If rainfall increases by 10%, the area planted will increase by 2%. The shift in 2005 resulted in the negative influence of the area planted; if the shift was to increase by 10% the area planted would decrease by 0.6% (i.e. they are inversely related). The more Mpumalanga is subdivided further the less will be the area available to plant potatoes. The impact of the shift is realised from 2005.

Equation 4.27: *Mpumalanga potato yield (tons/hectare)*

Explanatory variable	Parameter	Elasticity
Intercept	4.85	
LN (CULTIVAR)	0.55	0.55
LN RAINFALL	0.45	0.45

From the results above, it can be concluded that the use of cultivars and the rainfall are positively correlated to the potato yield in this region. If the variety use increases by 1%, the yield will increase by 0.55%; and a 1 % increase in rainfall will lead to an increase in yield of 0.45%.

Equation 4.28: *Mpumalanga estimated regional production (thousand tons)*

The following equation is the estimated production identity of the Mpumalanga region. This is calculated by multiplying the estimated yield by the estimated area harvested, as follows:

PTPROMP= PTAHMP*PTYMP

Variable name	Definition	Units
PTPROMP	Potato production Mpumalanga	Thousand tons
PTAHMP	Potato area harvested Mpumalanga	Thousand hectares
PTYMP	Potato yield Mpumalanga	Tons/hectare

The comparison between the estimated national production and the actual production is illustrated in Figure 4.9 below to determine the validity of the model.

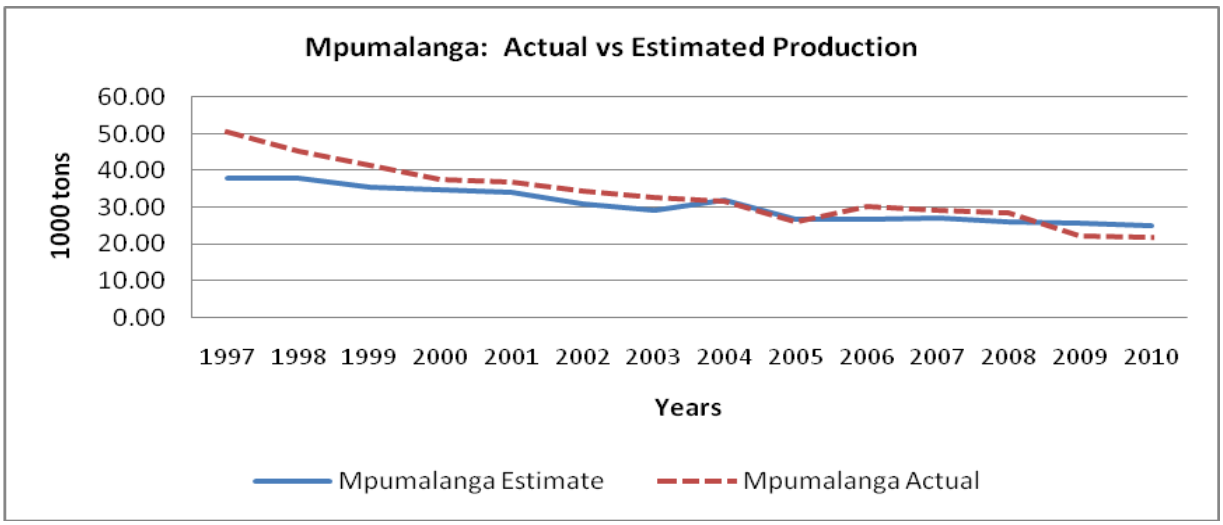

Figure 4.9: Mpumalanga actual and estimated potato production

4.3.8 Limpopo Province

The Limpopo potato production region stretches from Setlers road in the South to Pontdrift border post in the North. The region's rainfall per annum is more or less 495 mm. Temperatures range from 18 degrees Celsius to 25 degrees Celsius in the summer and 10 degrees Celsius to 15 degrees Celsius in the winter. Potato farming occurs mainly under irrigation (Limpopo Business, 2008). A large proportion of crops is table potatoes with a minimum quantity of certified seed potatoes. The province consists of 85 potato producers and 8 522 ha under irrigation. The province, like others, has two planting seasons; from January to March for the early crop and April to August for the main crop. The marketing period is from April to the end of August for the early crop and from September to February for the main crop. The area planted is modelled as the function of lagged area, the Limpopo potatoes and fertiliser price ratio, and potato consumption trend.

Equation 4.29: *Limpopo potato area harvested (thousand hectares)*

Explanatory variable	Parameter	Elasticity
Intercept	4	
LAG (PHLIM)	0.31	0.31
LIMP/FERTP	0.15	0.14
SHIFT 2005	0.95	0.06

Variable name	Definition	Units
PHLIMP	Limpopo potato area harvested	Thousand hectors
P/FERTP	Ratio of potatoes and fertiliser price	R/ton
SHIFT05	Indicator variable equal to 1 from 2005 onwards Although all variables that the industry expects foresee to have influence on the area planted do not satisfy the economic and econometric significant as such, it is clear that there is a qualitative variable not included from the model that contributed to changes in area planted from 2005-2010. (This might be the consumption pattern since 2005, as people need more potatoes the area planted increases)	R/ton

The Limpopo area planted last season is positively correlated to the current planting, with an elasticity of 0.31. This means that if the area planted last year was to increase by 10%, this year's area will increase by 3.1%. The Limpopo potato/fertiliser price ratio has an elasticity of 0.14, which implies that a 10% increase in the price ratio will lead to a 1.4% increase in the area planted in Limpopo.

Equation 4.30: *Limpopo potato yield (tons/hectare)*

Explanatory variable	Parameter	Elasticity
Intercept	4.83	
LN (CULTIVAR)	0.63	0.63
LN RAINFALL	0.45	0.45

The yield matrices show that a 1% increase in rainfall will lead to a rise in yield by 0.45%; and an increase in cultivar usage of 10% will result in an increase in yield of 6.3%. Hence, these equations reflect positive correlations.

4.31: *Limpopo estimated regional production (thousand tons)*

The following equation is the estimated production identity of the Limpopo region. This is calculated by multiplying the estimated yield by the estimated area harvested, as follows:

PTPROLIMP= PTAHLIMP*PTYLIMP

Variable name	Definition	Units
PTPROLIMP	Potato production Limpopo	Thousand tons
PTAHLIMP	Potato area harvested Limpopo	Thousand hectares
PTYLIMP	Potato yield Limpopo	Tons/hectare

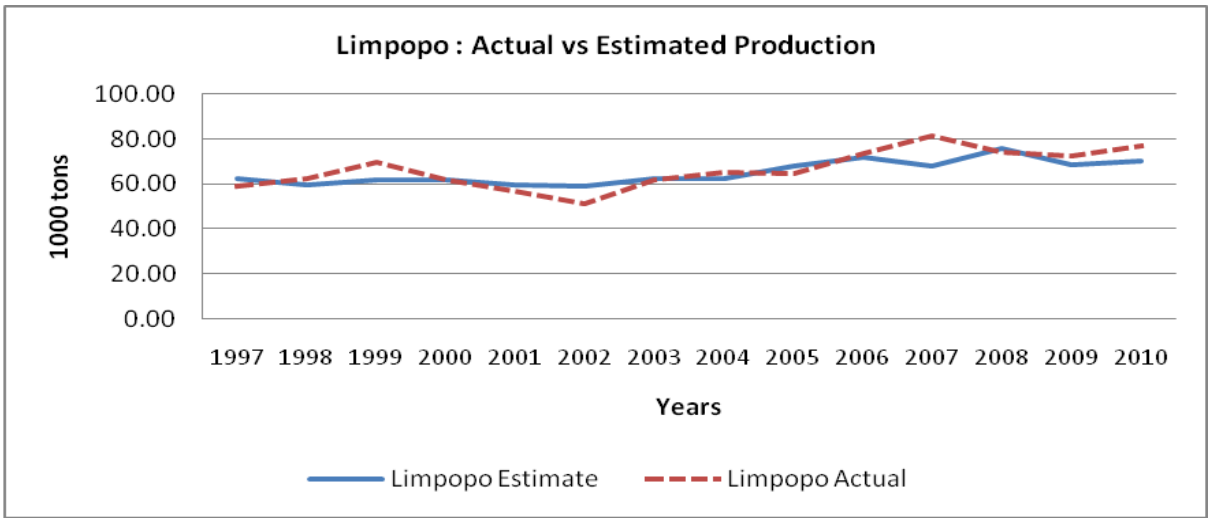

Figure 4.10: Limpopo actual and estimated potato production

4.3.9: Marble Hall Region

The Mable Hall potato production occurs under irrigation, where the water supply is derived from the Loskop dam, which is fed by the Olifants River. The planting period is from February to June and the harvest time from June to November. Production is mainly for processing (90%), with 3% of the crop going to seed and the rest marketed to the fresh produce markets. The Marble Hall area harvested is estimated as the function of lagged area, the ratio of Marble Hall potato price and fertiliser price, rainfall, the real price of white maize.

Equation 4.32*: Marble Hall potato area harvested (thousand hectares)*

Explanatory variable	Parameter	Elasticity
Intercept	0.53	
LAG (PHMBH)	0.17	0.17
MBHP/FERTP	0.164	0.67
REAL MAIZE SAFEX PRICE	-0.0009	-0.36

Variable name	Definition	Units
PHMH	Marble Hall potato area harvested	Thousand hectors
P/FERTP	Ratio of potatoes and fertiliser price	R/ton
RWMP	Real white maize price	R/ton

From the results, it can be concluded that an increase in the last year's area planted of 10% will lead to an increase in the area planted this year of 1.7%. The results further indicate that an increase of 10% in the price ratio of the Marble Hall potato price and the fertiliser price will lead to an increase in the area planted by 6.7%, reflecting a positive correlation between the variables. The maize price reflects an opposite response; a 10% increase in the price of maize will lead to a reduction in the area planted of 3.6%.

Equation 4.33: *Marble Hall potato yield (tons/hectare)*

Explanatory variable	Parameter	Elasticity
Intercept	4.89	
LN (CULTIVAR)	0.53	0.53
LN RAINFALL	0.45	0.45

In this region, if the use of variety increases by 10%, the potato yield will rise by 5.3%. A 10% decrease in rainfall will lead to a decline in the yield by 4.5%.

Equation 4.34: *Marble Hall estimated regional production (thousand tons)*

The following equation is the estimated production identity of the Marble Hall region. This is calculated by multiplying the estimated yield by the estimated area harvested, as follows:

PTPROMH= PTAHMH*PTYMH

Variable name	Definition	Units
PTPROMH	Potato production Marble Hall	Thousand tons
PTAHMH	Potato area harvested Marble Hall	Thousand hectares
PTYMH	Potato yield Marble Hall	Tons/hectares

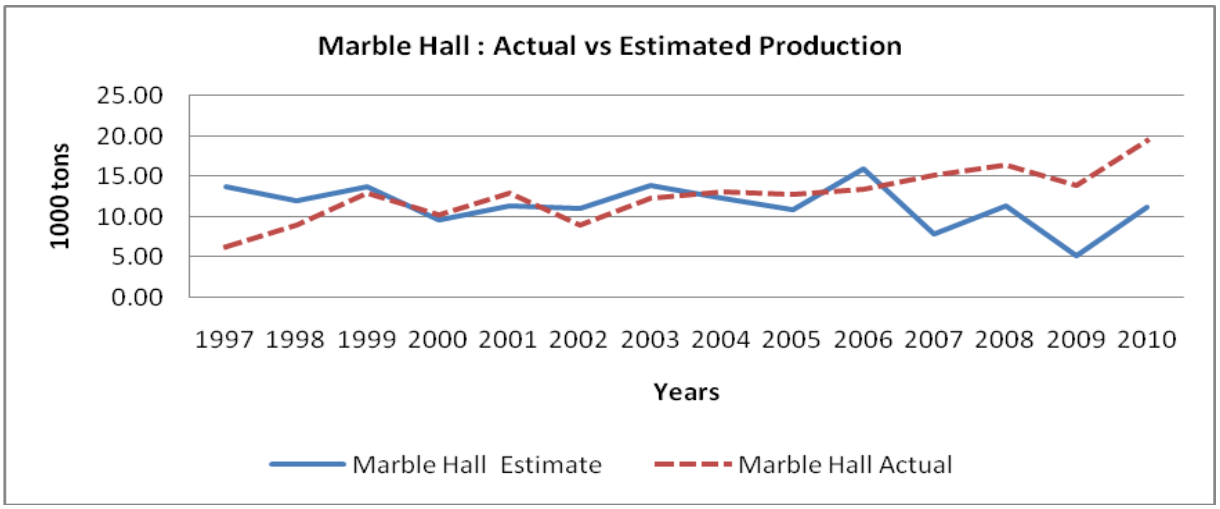

Figure 4.11: Marble Hall actual and estimated potato production

4.3.10. North-West Region

In the North West province, as with Marble Hall, production occurs under irrigation. The region consists of two planting and harvesting seasons. The early crop is planted in August and the late crop from November to January. The production of table potatoes comprises 87% of the early crop, and 72% of the late crop. The late crop is sold from April to August and the early crop from December to March. About 63% of the late crop and only 31% of the early crop is processed.

The North West potato area planted is modelled as the function of lagged area, the ratio of North West potato price and fertiliser price.

Equation 4.35: *North West potato area harvested (thousand hectares)*

Explanatory variable	Parameter	Elasticity
Intercept	0.49	
LAG (PHNW)	0.27	0.26
NWP/FERTP	0.077	0.42

Variable name	Definition	Units
PHNW	North West potato area harvested	Thousand hectors
P/FERTP	Ratio of potatoes and fertiliser price	R/ton

The lagged area planted has an elasticity of 0.26, which indicates that an increase in last year's area planted of 10% leads to an increase in the area planted this year of 2.6%. The price elasticity of the North West potato/fertiliser ratio is 0.42. This means that when the price ratio increases by 10%, the area harvested will also increase by 4.2%.

Equation 4.36: *North West potato yield (tons/hectare)*

Explanatory variable	Parameter	Elasticity
Intercept	5.42	
LN (CULTIVAR)	0.65	0.65
LN RAINFALL	0.35	0.35

If the cultivar usage increases by 1%, the yield will increase by 0.65%. A 10% increase in rainfall will lead to a 3.5% increase in the potato yield in North West.

Equation 4.37: *North West estimated regional production (thousand tons)*

The following equation is the estimated production identity of the North West region. This is calculated by multiplying the estimated yield by the estimated area harvested, as follows:

PTPRONW= PTAHNW*PTYNW

Variable name	Definition	Units
PTPRONW	Potato production North West	Thousand tons
PTAHNW	Potato area harvested North West	Thousand hectares
PTYNW	Potato yield North West	Tons/hectare

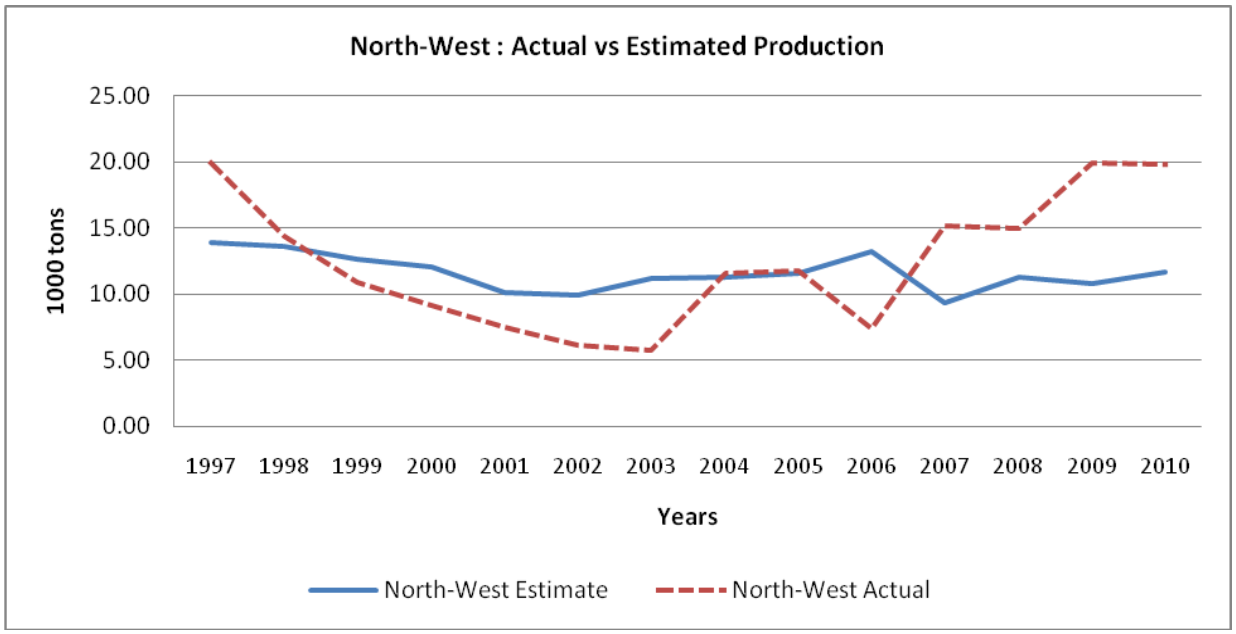

Figure 4.12: North West actual and estimated potato production

4.3.11. Other Regions

Most of the South African potato producers produce under irrigation. Accordingly, the equation of the Other regional areas harvested is estimated as the function of lagged area, the Others regions' potato price and fertiliser price ratio.

Equation 4.38: *Others potato area harvested (thousand hectares)*

Explanatory variable	Parameter	Elasticity
Intercept	1.05	
LAG (PHOT)	0.25	0.26
OTP/FERTP	0.137	0.35

A 10% increase in the one-year lagged area planted in the Other regions will lead to a 2.6% increase in those areas planted currently. The price elasticity of the rest of the potato regional prices and the fertiliser ratio is 0.35; indicating that a 10% increase in the price ratio (potato/fertiliser price ratio) will result in a 3.5% increase of area planted.

Equation 4.39: *Others potato yield (tons/hectare)*

Explanatory variable	Parameter	Elasticity
Intercept	4.37	
LN (CULTIVAR)	0.69	0.69
LN RAINFALL	0.51	0.51

The price elasticity of 0.69 implies that if the cultivar usage increases by 10%, the yield will increase by 6.9%; and a 10% increase in rainfall will lead to a 5.1% increase in yield of potatoes.

Equation 4.40: *Others estimated regional production (thousand tons)*

The following equation is the estimated production identity of the Others region. This is calculated by multiplying the estimated yield by the estimated area harvested, as follows:

PTPROOT= PTAHOT*PTYOT

Variable name	Definition	Units
PTPROOT	Potato production Others	Thousand tons
PTAHOT	Potato area harvested Others	Thousand hectares
PTYOT	Potato yield Others	Tons/hectare

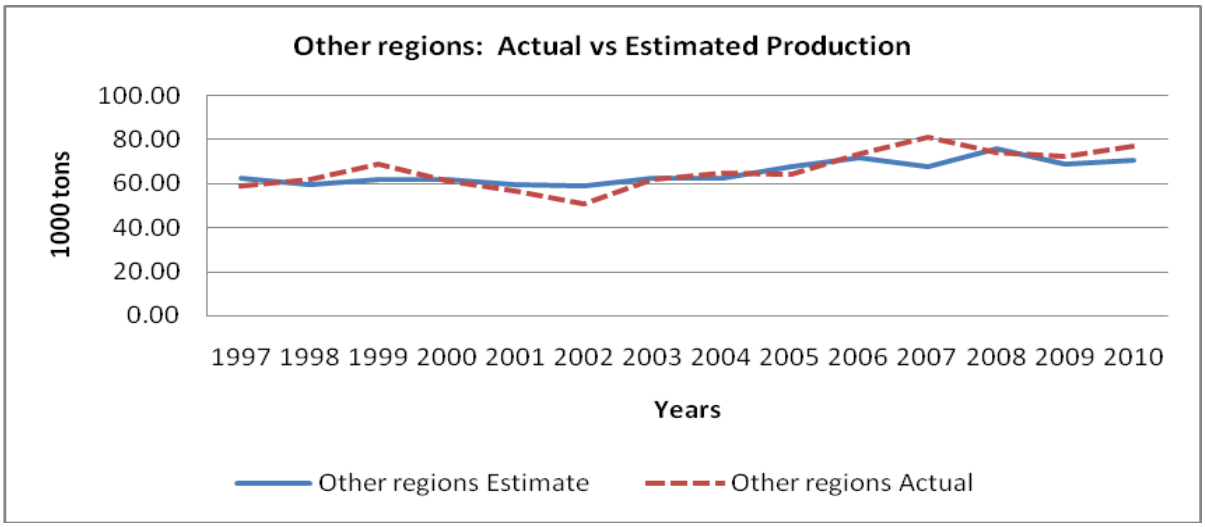

Figure 4.13: Other regions' actual and estimated potato production

4.4 Estimate and Actual aggregated production

In the results presented above, the estimated production in all the regions was mostly comparable to the actual values, in that the estimated equations determined from the area harvested and potato yield per region replicated the flow over time; thereby validating the utilisation of the model to simulate reality and its use in the projection of endogenous variables. An aggregated estimated production (sum of estimated regional potato production) is illustrated below and is compared to the actual potato production at national level. This section formulates the supply block of the potato industry.

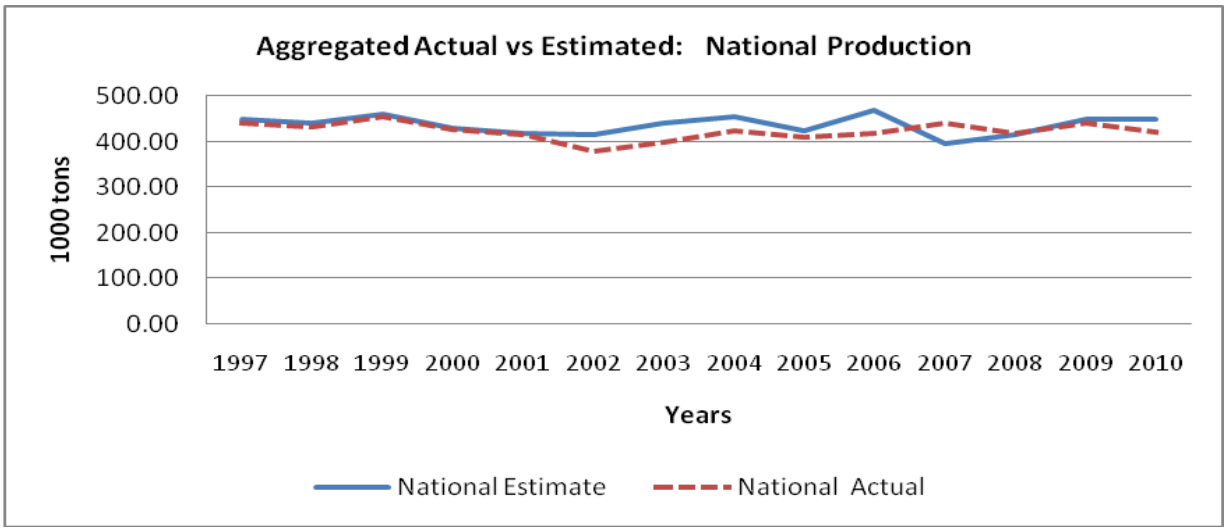

Figure 4.14: Aggregated estimates and actual potato production

As mentioned previously, the model seeks to understand the interregional relationship of the potato industry on the supply block, such as the impact of one region's production on another. When comparing the production of potatoes to their consumption, the crop is available in all the regions throughout the year for consumption while the production of potatoes does not occur simultaneously in all the regions but are planted and harvested interchangeably in different periods and seasons. This then channels the model to focus consumption from the national level and production at a regional scale. The following section of this chapter focuses on the building of one part of the demand block, which is constructed by the estimates of consumption at national level. This will later be compared to the production of potatoes at national level.

4.4 DOMESTIC DEMAND EQUATIONS

The South African consumption block consists of four equations that are presented in equations 4.5.1 to 4.5.4. The equations represent fresh formal consumption, fresh informal consumption, potatoes for processing, and potato seed consumption.

4.4.1 Potato consumption: fresh formal

Fresh formal potato consumption is estimated as a function of real potato price, real white maize SAFEX price, real wheat SAFEX price and the real per capita GDP. The actual data for the variables were sourced from the BFAP (Bureau for food and agricultural policy) 2010 database and fresh potato consumption at the formal markets was sourced from Potato SA in 2007. The variables are then converted to real terms by diving each one with the CPI multiplied by 100. This process is called "deflating" the variable. An example is the actual potato prices/CPI*100

FFPOTCONS= f (RPTPSA, RWMPPSA, RWPPSA, RPCGDP)

Equation 4.41: *Potato consumption: fresh formal (thousand tons)*

Explanatory variable	Parameter	Elasticity
Intercept	793	
RPTPSA	-0.48	-0.95
RWMPPSA	0.05	0.05
RWPPSA	0.07	0.10
RPCGDP	0.015	0.25

Variable name	Definition	Units
RPTPSA	Potato price in South Africa	c/10 kg
RWMPPSA	White maize SAFEX price	R/ton
RWPPSA	Wheat SAFEX price	R/ton
RPCGDP	Real per capita Gross Domestic Product	R/capita

An increase in the national potato price of 1% will lead to a 0.95% reduction in the quantity of fresh potatoes consumed. If the white maize and wheat SAFEX price increase by 10%, this

will result in an increase in potato consumption by between 0.5% and 1%. This means that white maize and wheat are substitutes of fresh potatoes sold at the formal markets. The results show that a positive correlation exists between potato consumption and potato consumers' income, in that a 10% increase in per capita GDP will lead to a 2.5% increase in potato consumption, which indicates that potatoes sold formally are actually normal goods.

All the parameters estimated in this section make economic sense; and this is supported by the graphical presentation that compares the estimated curve with the actual flow over years.

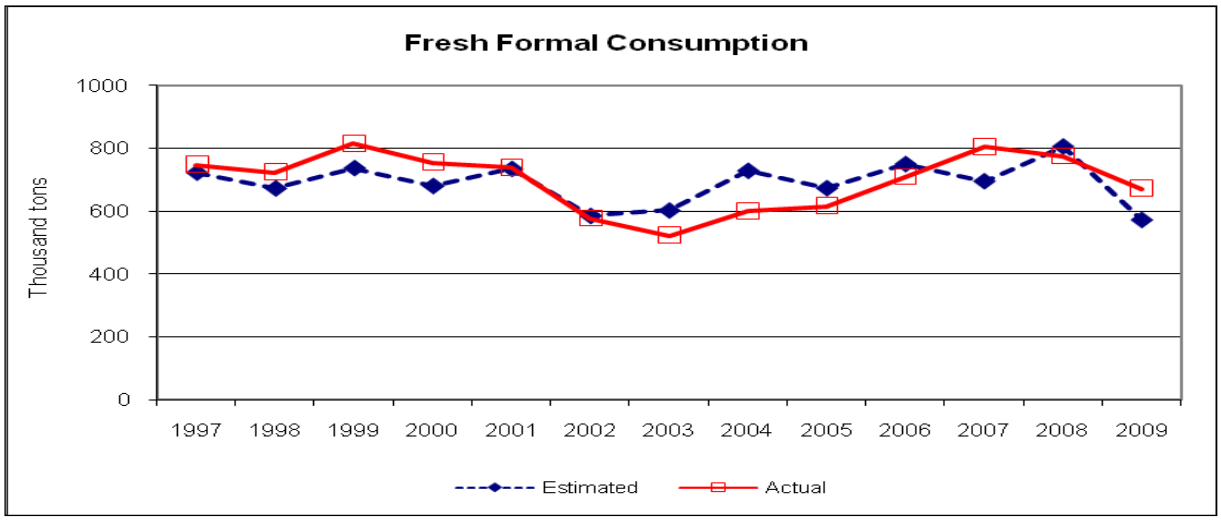

Figure 4.15: Estimated and actual potato consumption, fresh formal

4.4.2 Potato consumption: fresh informal

Fresh informal potato consumption is estimated as a function of real potato price, real white maize SAFEX price, real wheat SAFEX price, and real per capita GDP. The actual data for the variables were sourced from the BFAP (Bureau for food and agricultural policy) 2010 database and fresh potato consumption at the informal markets was sourced from Potato SA in 2007.

FIPOTCONS = f (POTRPTPSA, RWMPPSA, RWPPSA, RPCGDP)

Equation 4.42: *Potato consumption: fresh informal (thousand tons)*

Explanatory variable	Parameter	Elasticity
Intercept	92.00	
RPTPSA	-0.07	-0.15
RWMPPSA	0.07	0.10
RWPPSA	0.04	0.10
RPCGDP	0.02	0.83

Variable name	Definition	Units
RPTPSA	Potato price in SA	c/10 kg
RWMPPSA	White maize SAFEX price	R/ton
RWPPSA	Wheat SAFEX price	R/ton
RPCGDP	Real per capita gross domestic product	R/capita

A 10% increase in the national potato price will lead to 1.5% reduction in the quantity of fresh potatoes sold informally for consumption purposes. A 10% increase in the SAFEX price of white maize and wheat will lead to an increase in potato consumption of 1% for both commodities. This means that white maize and wheat are substitutes of fresh potatoes sold in the informal markets. As compared to fresh potatoes sold in the formal markets, the sensitivity towards the maize price increase is higher for consumers at the informal markets. It can thus be concluded that consumers' (at the informal markets) substitutability of potatoes with maize is higher than with consumers at the formal markets.

Moreover, low income earners spend a larger share of their income on food than high income earners. Thus a small change in prices will lead low income earners to substitute the variable with another; while high income earners will not be affected sufficiently to resort to such substitutions of the food.

A 1% increase in per capita GDP in the informal markets will lead to a 0.83% increase in the quantity of potato consumption. This may be because most consumers at informal markets are low income earners, and as mentioned previously their larger share of income mainly spent on food. Consequently, the increase in their (consumers in the informal markets) income leads to the increase in the quantity of potatoes purchased as opposed to the reaction of the consumers at the formal markets.

Below is a graphical presentation of the estimated model as compared to the actual model of fresh potato consumption in the informal markets. The curves mimic the flow of the actual situation to indicate that the model fits very well.

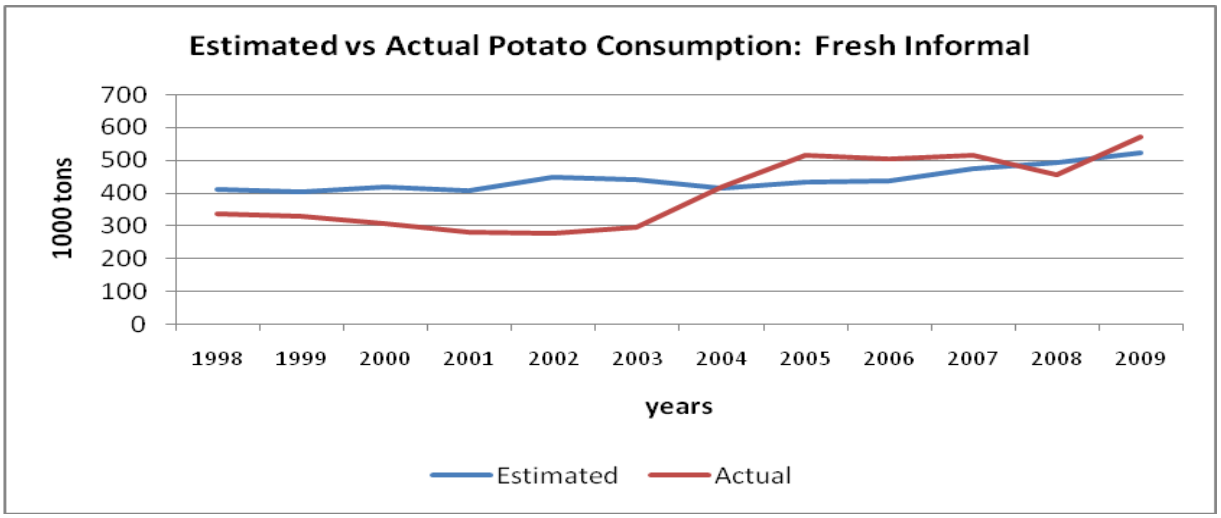

Figure 4.16: Estimated and actual potato consumption, fresh informal

4.4.3 Potatoes for processing

Potato processing forms a significant part of the South African potato industry. The country's processing production accounted for 16% in 1999, increasing to 19% of the total produce by 2009 (Potato SA, 2010). The industry has doubled over the past five years, and is still growing. The domestic processed potatoes are mainly for the purposes of the production of French fries; frozen potatoes; chips mixed vegetables; baby food; canned food; and small portion starch food. The growth in South African potato processing is geared by changing

consumer needs; enlargement of processing facilities; increasing average income of the population; nutrients as well as substitutes.

Although all 13 potato producing regions produce potatoes, their production of potatoes for processing varies from 0% to 20% of the total annual crop. Statistics indicated that 20% of the country's total annual crop for potato processing came from the Eastern Free State, followed by Limpopo and Marble Hall which account for the 19% each. These were followed by Mpumalanga (12%), Sandveld (10%), and the North West (10%). The remaining regions produced between 0% and 5% of the annual crop (Potatoes South Africa, 2010).

Potato consumption for processing is modelled as a function of real potato price, real white maize SAFEX price, real wheat SAFEX price, and real per capita GDP. The actual data for the variables were sourced from the BFAP (Bureau for food and agricultural policy) 2010 database and the data on the quantity of potatoes for processing was sourced from Potato SA in 2007.

POTPROSCONS= f (RPTPSA, RWMPPSA, RWPPSA, RPCGDP)

Equation 4.43: *Potato consumption: processing (thousand tons)*

Explanatory variable	Parameter	Elasticity
Intercept	185.00	
RPTMPSA	-0.20	-0.65
RWMPPSA	0.01	0.10
RWPPSA	0.06	0.30
RPCGDP	0.02	0.85

Variable name	Definition	Units
RPTPSA	Potato price in SA	c/10 kg
RWMPPSA	White maize SAFEX price	R/ton
RWPPSA	Wheat SAFEX price	R/ton
RPCGDP	Real per capita gross domestic product	R/capita

A 10% increase in the national potato price will lead to a decrease in the quantity of potatoes for consumed processing by 6.5%. A 1 % increase in the SAFEX price of wheat will lead to a 0.3% increase in potatoes for processing. Further, if the price of white maize increases by 1%, there will be a 0.1% increase in the quantity of potatoes for processing. A 10% increase in the per capita GDP will lead to an 8.5% increase in the quantity of potatoes utilised for processing purposes.

A graphical presentation follows that depicts how the model fits the reality (The accuracy of the model in relation to the reality).

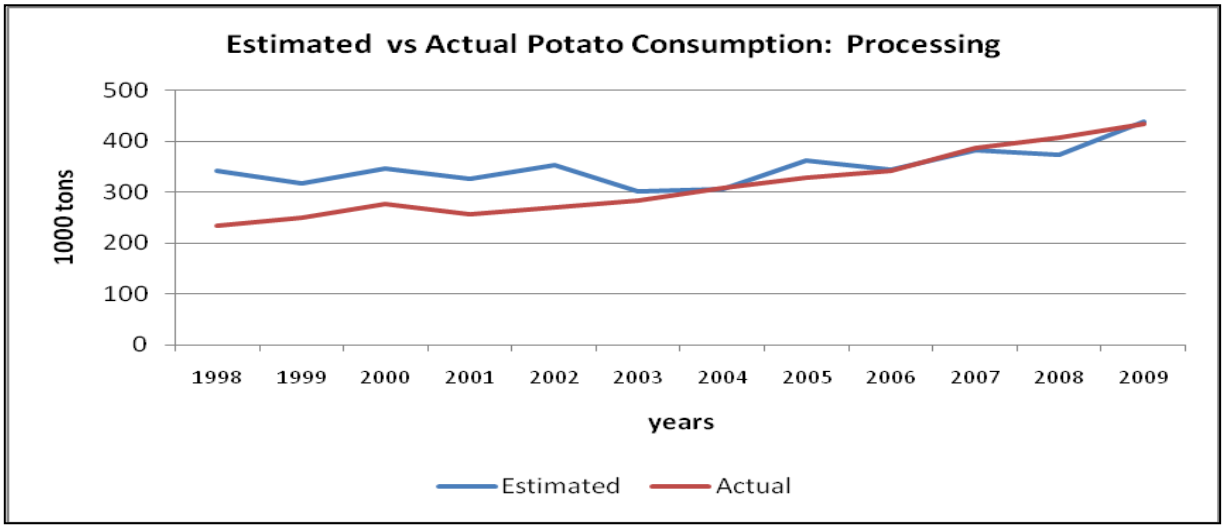

Figure 4.17: Estimated and actual potato consumption, processing

The above figure displays a validation of the estimates, in that the flow of the curves is tracked over the years to mimic the actual flow (real life situation). This then can be used as a baseline to project future scenarios.

4.4.4 Seed potato consumption

South Africa has a sophisticated seed potato industry. Seed potato production occurs all over the country, with 400 certified seed potato growers. (Potatoseed, 2005). Seed potatoes are mainly consumed by potato growers. The consumption of seed potato is modelled in this study as a function of seed potato area planted, and real price of seed potatoes. The actual data for the variables were sourced from the BFAP (Bureau for food and agricultural policy) 2010 database and seed potato database was sourced from Potato SA in 2007.

POTSEEDCONS= ƒ (PTSPSA, AHSPSA)

Equation 4.44: *Seed potatoes (thousand tons)*

Explanatory variable	Parameter	Elasticity
Intercept	-25.00	-0.14
RSPSHASA	3.92	1.12
RPTASPSA	0.02	0.17

Variable name	Definition	Units
RPTSHASA	Seed area harvested in South Africa	Thousand tons
RPTAPSA	Real potato price South Africa	c/10 kg

A 10% increase in the area harvested for seed potatoes will lead to an 11.2% increase in the quantity of seed consumption in the country. This means that seed potato production is highly sensitive towards the area planted; hence, seed potato consumption is positively related to the

actual area planted. An increase in the national seed potato price is also positively correlated to the quantity of the seed potato consumption. This is evident in the results showing that if the seed potato price increases by 10%, the quantity of seed potato consumption will increase by 1.7%. From the synthetic parameters presented above, the variables make economic sense, in that the theory of supply stipulated that an increase in the price of output will lead to an increase in the quantity of output supplied.

A graphical illustration follows of the estimated seed potato consumption Figure 4.18. When comparing the model against the actual curve, the estimates capture the flow and turning point of the real situation in the consumption of seed potatoes; with the final year (2009) being extremely close to almost a single line.

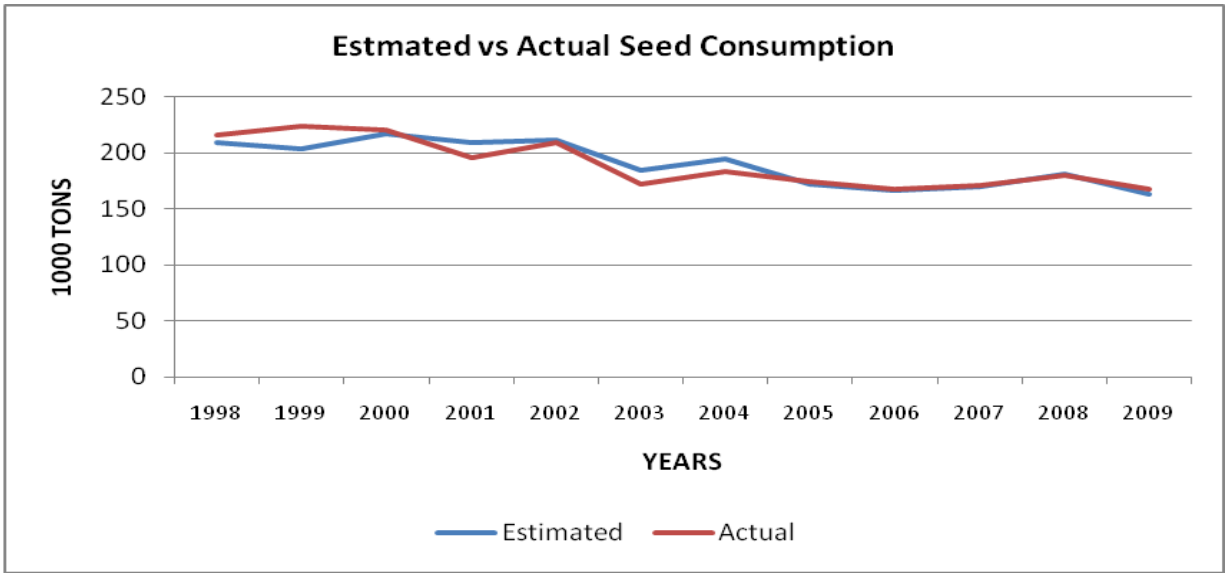

Figure 4.18: Estimated and actual potato consumption, seed potatoes

The identity of potato consumption in South Africa is the sum of fresh formal and informal, processing, seed potato consumption, and the unexplained potato consumption (which might be losses from diseases or theft)

4.5 POTATO TRADE AND MODEL CLOSURE

South Africa consumes about 98.5% of potato produced locally and the remaining 1.5% is exported. The amount imported in the country is very little and the model is estimated using the net exports, which is mainly the difference between the exports and imports. The methodology used to close the simulation model determines the approach in which the equilibrium is reached.

The study estimates price and trade equations separately in order to determine the market regime, and as such, the techniques to determine the equilibrium. Economically, domestic demand and supply determine the equilibrium in the market, but quantity of potato exports from the country is significant in such a way that potato trade is anticipated to contribute in influencing the domestic equilibrium price. The equilibrator is rooted on the principle that net exports demand must equal exports supply.

4.5.1 Net potato exports

The net exports demand is modelled as the function of domestic price and world price; whereby in this study its proxy is the exchange rate. Potato net exports are estimated as the function of the ratio of domestic use over domestic production, and the ratio of domestic price over the exchange rate, as follows:

$$PTNEXP = f(MIN(0,((PTDUSA/PTPRDSA)-1));(PTMPSA/EXCH))$$

Equation 4.5: Potato net exports

Explanatory variable	Parameter	Elasticity
Intercept	220	
PTDUSA/PTPRDSA	-55.1	-0.5
PTPSA/EXCH	-39.9	-0.5

The results indicate that an increase in the ratio of domestic use: national production will lead to a decrease in the quantity of potatoes exported. This implies that the rate of domestic consumption increases is more than production. Hence, the result indicates that a 10% increase in the ratio will lead to a decrease in the quantity exported by 5%.

4.6 MODEL EQUILIBRATION FOR THE NATIONAL PRICE

Production that takes place in one region is marketed to other regions at a cost. This reflects the potential of how price plays a role in impacting other regions, and as a result influences demand and supply. This study estimates regional prices as a function of the real national South African potato price, with the exception of the South-western Free State, which is estimated as a function of South-western Free State production, real national price, with the inclusion of dummy variable for 2006. The regional prices are further linked to determine the national potato prices.

Local supply and demand are not the only determinants of the market equilibrium; since the South African potato industry participates in trade, and trade is influenced by both domestic factors and factors outside the country (regional and international). Hence, there is a need to interlink the national price with the export demand and supply. The net exports and the exports supply are of vital importance in determining the market equilibrium price (Meyer & Kirsten, 2006). The level of net exports is defined as the ratio of domestic price over the average import and export price, as well as the domestic consumption and production. In establishing the price equilibrator, the difference between the potato net exports demand and the potato exports supply is calculated. The new market clearing price is simulated by linking the old market price to the difference between the potato net exports demand and the potatoes exports supply. The model is solved with the Gauss Seidel algorithm. The new market equilibrium is reached at a point when the difference between the net exports demand and the exports supply is zero, or when demand and supply are equal.

Bearing in mind that South Africa's larger proportion of potato produced is mainly consumed locally and that its exports to the nearby country are of a significant quantity. This then

justifies the finding of the model closure which indicates that the world price does not play a huge role in the South African market of fresh potato produce. Instead, domestic price and quantity demanded with the supply of net exports actually determine market equilibrium price and the decision to export. It can be concluded then that the near autarky situation is the only manner in which the South African market equilibrium conditions apply to the net export position.

4.7 CONCLUSION

This chapter concentrated on the empirical results of the simulation model within the partial equilibrium. Relationships and significance of the variables were estimated for all the supply, demand and price blocks of the model. The demand block result indicated that South African domestic production is mainly under irrigation, except in the Eastern Free State and Mpumalanga province along the Highveld area (Potatoes South Africa, 2010). It is evident from the results that the limitation of direct weather and variety impacts on the South Africa potato yield and hinders the consideration of a price as an impact on yield. Potatoes are produced throughout the country. As such, the demand block of the model was formulated through the estimation of the potato area harvested and the potato yield at the regional level, which were later on multiplied to determine the regional potato production. An assessment was undertaken to test the validity of the model to simulate the reality in the economy. This assessment included the construction of elasticity matrices, the use of synthetic parameters to ensure the model was well-behaved, and the graphical illustration of the estimations compared to the actual flow and trends of the exogenous variables over time. The regional production was then collapsed to form an estimated potato production at national level.

The demand block, which is constructed by the estimates of consumption at national level, will later be compared to the production of potatoes at the same level. Consumption is divided into four pillars; namely the seed potatoes, processing, fresh formal and fresh informal markets, which were estimated individually. Price elasticity matrices were developed and the market validity of the exogenous variable was conducted.

The following chapter discusses the development of the baseline projections and the evaluation of possible scenarios in the industry. The impact of the different policies and environmental conditions on the sector will be evaluated. Focus will be given to discussing the possible future output (structure), and the relationship among variables will be illustrated in Microsoft Excel format and graphs. This will include the evaluation of the authentic macroeconomic scenarios in order to assess the responsiveness of the variables towards shocks; and hence the confirmation of the model's ability to handle real life situations, and its practicability to be used as a decision-support tool by the producers, policy makers, processors and consumers .

CHAPTER 5

BASELINE PROJECTIONS AND SCENARIO ANALYSES

5.1 INTRODUCTION

This chapter presents the baseline and projection of the South African potato industry and the impact analysis of various potential scenarios. The initial section of the chapter will discuss assumptions that underpin the simulation of the baseline; this will be supported by a brief discussion on the baseline. The projection of dependent variables under the market equilibrating regime will follow. Thereafter, a section on industry scenario evaluation to analyse the impact of the environmental conditions, economic- and market-related shocks on the South African potato prices, supply and demand will be addressed. The scenarios to be considered in this study are yield and economic recovery after the recession, as follows:
1) The impact of the 20% decrease in Limpopo yield in 2011 on the other regions (once-off shock)2) The weak (slow rate of economic growth) against strong (higher rate) South African economic growth rate following the recession. This will be continuous shock of GDP from 2011 to 2015.

5.2 THE BASELINE

Understanding the interrelationship between biological, technical and economic factors was fundamental in the model specification, production of reliable estimates and the validation of the model's authenticity. Accordingly, the structure of a partial equilibrium model that simulates the real world was constructed. The model structure is critical in generating a baseline. Furthermore, the completion of the baseline is crucial in the projection of the endogenous variables under the market switching regime, as this will further enable the model to solve for future years (Meyer & Kirsten, 2006). The projections in this study will be referred to as commodity market outlook and not forecast, due to the fact that they are produced conditional to several assumptions. The baseline simulation is highly influenced by

the macro-economic indicators which are exogenous to the model. The presentation of the baseline and projections of economic variables will follow next see Table 5.1

Table 5.1: Baseline 1- Endogenous variable

VARIABLES	UNITS	2011	2012	2013	2014	2015
Total population of SA	Million	48.1	48.3	48.5	48.7	49.0
Exchange rate	SA cent/US	784.5	818.7	852.0	885.2	914.3
CPI: Food	Index '95	320.9	337.0	357.8	377.9	401.2
Real GDP Per Capita	R/Capita	18354.6	19179.4	20024.4	20888.4	21841.2
Real per capita disposable income	R/Capita	14003.8	14633.0	15277.7	15936.9	16663.9
Rainfall: Summer prod areas	Mm	527.8	527.8	527.8	527.8	527.8
Rainfall: Winter prod areas	Mm	264.2	264.2	264.2	264.2	264.2
Rainfall Eastern Free State Area	Mm	667.5	658.6	653.2	632.1	641.7

The macroeconomic projections presented above focus on the real GDP; Consumer Price Index (CPI); exchange rate; real per capita disposable income; rainfall; and the South African population. The rainfall incorporated into the baseline is that which is applied in the development of the model; namely the Eastern Free State, winter and summer rainfall. Although the rainfall is categorised according to seasonality, the Eastern Free State rainfall is specified because potato cultivation occurs under dry-land conditions in these regions. The baseline is developed from the BFAP database of 2011.

The baseline assumes that the South African agricultural policies remain constant and that the country was among those hard hit by the 2008-09 recession. The real GDP per capita is projected to increase continuously throughout the four years, with 2011 rising to R18354.6/capita. This increase correlates to the population increase. While the table shows an increase in the population, it also indicates that there will be an improvement on the real per capita disposable income.

Another correlation evident is the real GDP per capita and the real per capita disposable income. 2012 to 2013 show an increase in the real GDP per capita from R19179. to R20024. and the real per capita disposable income rises from R14633 to R15277.7 within the same period. Both the variables illustrate a steady but continuous increase over the projected period. The exchange rate is expected to gradually depreciate to a level of R9.14 against 1US$ by 2015. Throughout the projected years, inflation (CPI) is expected to steadily increase reflected in the rise of CPI from 320.9 in 2011 to 401.20 in 2015.

The outlook displays normal weather conditions (for summer/winter and Mpumalanga rainfall); meaning that the rainfall is held constant on average for the projected five years. The projection assumes the following rainfall: summer rainfall will remain constant at 527.78 mm and winter rainfall at 264.15 mm. The Eastern Free State rainfall, on the other hand, is expected to fluctuate over the five years. Its rainfall is projected to decrease from 667.5 in 2011 to 632.1 by the year 2014 and will begin to increase again in the year 2015.

Table 5.2 below illustrate a baseline of the endogenous variables obtained for the estimated model. The model consists of the area planted, yield, potato imports and exports. It also consists of the projected values for fresh formal and informal potato consumption, potatoes for processing and seed potatoes from 2011 to 2015. The table presents the values or trends of the total supply and domestic potato use.

Table 5.2: Baseline 2- South African potatoes

VARIABLES	UNITS	2011	2012	2013	2014	2015
Total Area	1000ha	53.98	49.14	49.09	48.58	48.33
Total Production	1000 tons	2228.01	2042.04	2067.70	2071.30	2090.47
Average Yield	t/ha	41.27	41.55	42.12	42.64	43.25
Potatoes Import (Fresh potatoes)	1000 tons	57.75	35.54	41.38	40.57	40.76
Total Supply	**1000 tons**	**2285.76**	**2077.58**	**2109.08**	**2111.87**	**2131.23**
Consump: Fresh formal	1000 tons	877.15	760.66	773.03	765.74	760.20
Consump: Fresh Informal	1000 tons	583.31	586.76	604.04	619.53	636.60
Consump: Processing	1000 tons	498.83	439.68	434.45	431.40	439.81
Consump: Seed	1000 tons	176.09	151.75	157.28	155.28	155.20
Potatoes per capita consump	kg/capita	40.71	36.99	37.34	37.28	37.49
Domestic Use	1000 tons	2135.37	1938.85	1968.81	1971.96	1991.81
Potatoes Export	1000 tons	150.39	138.73	140.27	139.91	139.43
Total Demand	**1000 tons**	**2285.76**	**2077.58**	**2109.08**	**2111.87**	**2131.23**

Table 5.2 above presents the baseline projection of the South African endogenous variables of the potato industry over the four-year period from 2011 to 2015. The area planted is projected to increase from 48.98 in 2010 to 53.98 thousand hectares in 2011. The increase in the area planted is positively correlated to the quantity produced; hence the results show an increase in the quantity produced in 2011 to be 2228.01 thousand tons. This production is a product of the increased area planted (53.98 thousand ha) multiplied by the yield of 41.27 tons per hectare. On the demand side, potato consumption at the fresh markets is projected to increase to 877.15 thousand tons in 2011. Potatoes sold in the informal markets are expected to be at 583.31 thousand tons in 2011. Consumption of seed potatoes is estimated to increase to 176.09 thousand tons and Exports to rise from 128.66 to 150.39 by 2011. This growth is accompanied by the increase in the quantity for processing at 498.83 thousand tons, and an increase of up to 40.71kg per capita GDP.

The 2011 increase in the potato hectares harvested is expected to be followed by a decline in the year 2012 of 4.84 thousand ha. From the year 2013 to 2015, the hectares harvested are projected to decrease to 49.09, 48.58 and 48.33 thousands respectively. Yield is anticipated to increase continuously over the projected period to reach of 43.25 t/ha by 2015. The production of potatoes is expected to fall by 185.97 thousand tons in 2012, and slightly starts to increase for the rest of the projected years.

The model projected a steady and continuous increase in the fresh potatoes sold in the informal market over the four years. The potatoes usage increases from 583.31 thousand tons in 2011 to 604.04 thousand tons by 2013; then a further increase by 17.07 thousand tons occurs from 2014 to 2015. Consumption at the formal fresh market fluctuates frequently over the forecasted period. Consumption decreases in 2012 to 760.66 thousand tons. This decrease is preceded by an annual increase to 773.03 thousand tons then follows by the two successive years of a decline to 765.74 thousand tons in 2014 to 760.20 thousand tons in 2015.

A similar pattern of movement is evident in the quantity of potatoes demanded for exports; whereby there is a reduction in 2012 to 138.73 thousand tons and then there is another decline in 2014 and 2015. Potato utilised in agro-processing decreases from 2012 to 2014 then

increase in 2015. The seed consumption is exceptional, in that a year of increase is followed by a reduction and vice versa. The 2011 consumption is followed by a decrease of 24.32 thousand tons, which is followed by an increase to 157.28 thousand tons by 2013. This increase is then followed by a decline of 2 thousand tons in 2014 and 2015 respectively. These swings occur as a response to potato price fluctuations.

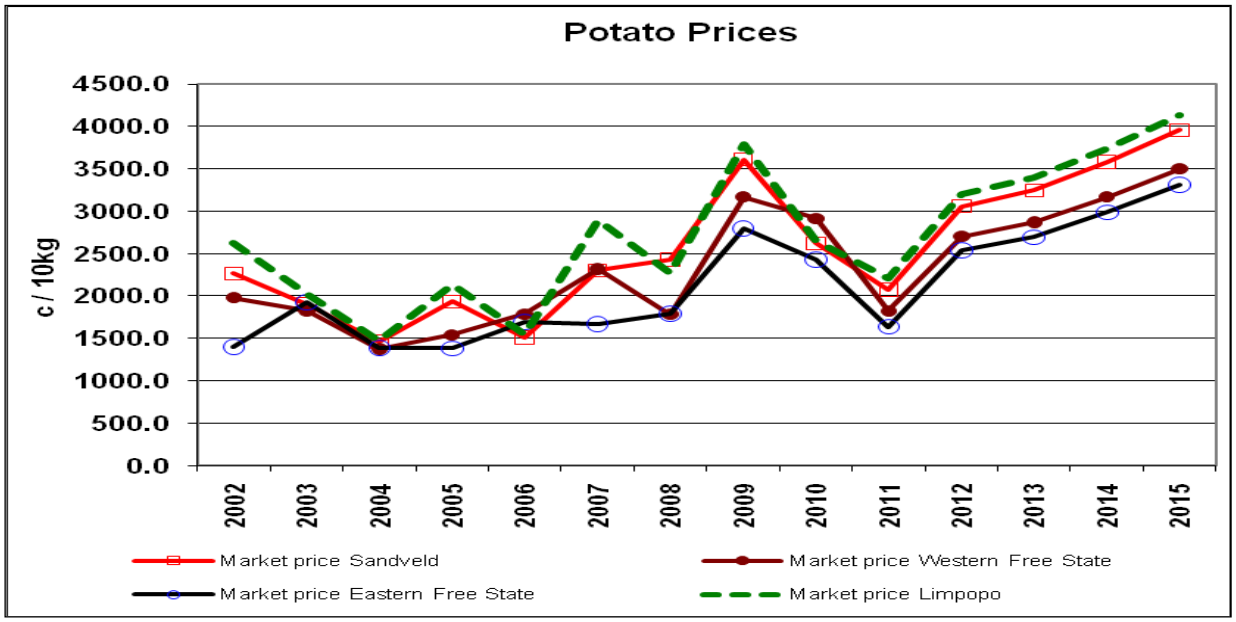

Figure 5.1: Limpopo, Western Free State, Sandveld and Eastern Free State potato market price, 2002-2015

The model indicates that potato prices declined in most of the regions from 2007 to 2008 with the exception of the Eastern Free State see Figure 5.1. The Western Free State's market price is at 1 785 c/10 kg in 2008 from 2 319.00 c/10kg in 2007. The Eastern Free State, on the other hand, showed an opposite response, whereby its market price increased from 1 666 c/10 kg in 2007 to 1 785 c/10kg by 2008. By 2009, potato prices for all regions went up. The Western Free State increased to 3 170 c/10kg; Limpopo to 3 834 c/10kg; the Eastern Free State to 2 794 c/10kg and Sandveld to 3 611 c/10kg.

The market prices for all regions are projected to increase from 2011-2015. The highest price for 2011 is projected in Limpopo at 2208.71c/10kg, followed by the North West at 2144.53c/10kg and the lowest price is from the Other regions at 1627.35c/10kg.

This pattern of price movement is evident throughout the four years, with Limpopo continuing to be the highest in the country.

The South African potato industry was among the sectors that were affected by the world recession that took place in 2008 and 2009. Although the recession started late in the year 2008, the response in the area planted was in the following year. The decline in 2009 was attributed by the lower 2008 potato prices. The response for the prices does not have to occur the following year since potatoes are cash crops and have a short season. The drop in the quantity of produce harvested in 2009 lead to the increase in potato prices in the very same year this is evident that the industry was among the hardest hit by the economical depression. see below figure 5.2

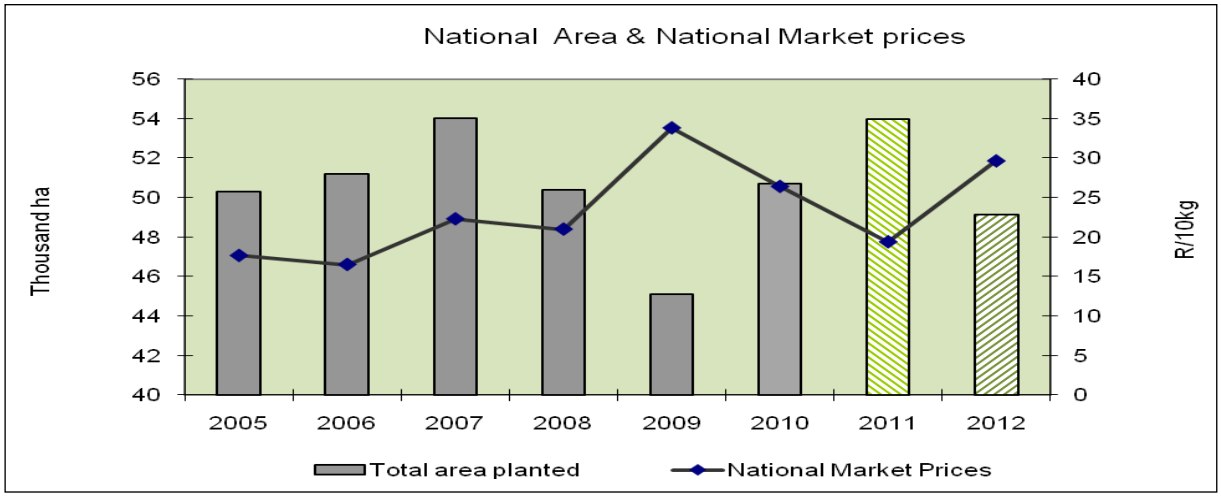

Figure 5.2: National potato area planted and prices

Agricultural input costs increased in 2008. This included but was not limited to fertiliser, packaging, fuel, repairs and maintenance. Fertiliser and fuel prices both went up by 78%, packaging increased by 33.6% and maintenance and repairs fell by 13.3%. The national potato area planted decreased from 54.03 thousand hectares in 2007 to 50.39 thousand hectares in 2008, in response to the higher input costs see Figure 5.2. The national potato price (fresh and seeds), on the other hand, shows an increase from 2011-15. The national area planted decreased further in 2009.

Seed potatoes (an input in the production of table potatoes), showed an increase from 3 361.60 c/kg in 2007 to 3 751.60 c/kg in 2008; which may also have contributed to the reduction of the area planted in 2008 and 2009. The price and fluctuations take into consideration the lagged effect that agricultural produce has. The seed potatoes price showed a decline in 2010 by 119.04 c/kg from 2009. Although prices fluctuated a lot in the past years, the year 2011 increase to 1937c/10kg and the growth continues to reach 3859 c/10kg in 2015.

The performance of the Limpopo regional area (second largest potato producer in the country) showed a decrease from 9.78 thousand tons in 2007 to 8.81 thousand tons in 2008 and a further 8.59 thousand tons in 2009. The 2010 decline in the volumes of seed potatoes could have been induced by an increase in the Limpopo area planted in 2009 from 8.59 thousand ha to 9.20 thousand ha in 2010. This increase followed by the decrease in 2011. This reduction continues until the year 2015 when it becomes 8.94 thousand tons. The Sandveld regional area planted with the potato sector as its main source of employment and characterised by high level stresses in water supply and heavy requirements of fertiliser due to the lack of nutrients of the sandy soil responded by a slight decrease from 6.89 thousand ha to 6.72 thousand ha for the year 2008. The 2008 is then followed by an increase to 7.10 thousand ha in the year 2010. This growth is followed by fluctuation over the years, to reach an amount of 6.51 and 6.44 thousand ha by 2013 and 2015 respectively.

The Mpumalanga province is the source of the winter produce and the first supplier to the fresh produce markets. From 2007 Mpumalanga shows a drastic fall from 3.38 thousand ha to 2.63 thousand ha in 2008. This reduction was followed by a further decrease of 0.12 thousand ha in 2009. The area harvested is projected to decrease in 2010 to 2.60 thousand ha, and then increase by 2011 to 2.83 thousand ha then decline until the year 2015.

According to Potatoes South Africa, the processing section of potatoes forms a significant user of the potato crop produced in the country. The processing section utilises a significant average of 250 000 tons per annum; and this is still increasing. The impact of the processing section's increasing utilisation of potatoes produced comes mainly as a result of the country's rapid rate of urbanisation, the changing lifestyle, consumer preferences and potatoes' ability to

efficiently use water (less water consumption for optimal output) compared to rice and wheat. During the recession, the per capita GDP grew at a lower rate than expected; potatoes rose from 17330.00 thousand tons to 17660.25thousand tons by 2008.

The country's consumption response on the potatoes for processing and those sold in the informal markets grew. The increase in the processing potatoes accounted for 406 thousand tons and 433.96 thousand tons for the year 2007 and 2008 respectively. By the year 2007, fresh potatoes in the informal markets was 457.01 thousand tons and it went up to 572 .06 thousand tons in 2008. Below is a graphical presentation of the aggregate South African consumption Figure 5.3. The bar charts depict the trends and shifts in the quantity of potatoes consumed per type before and after recession.

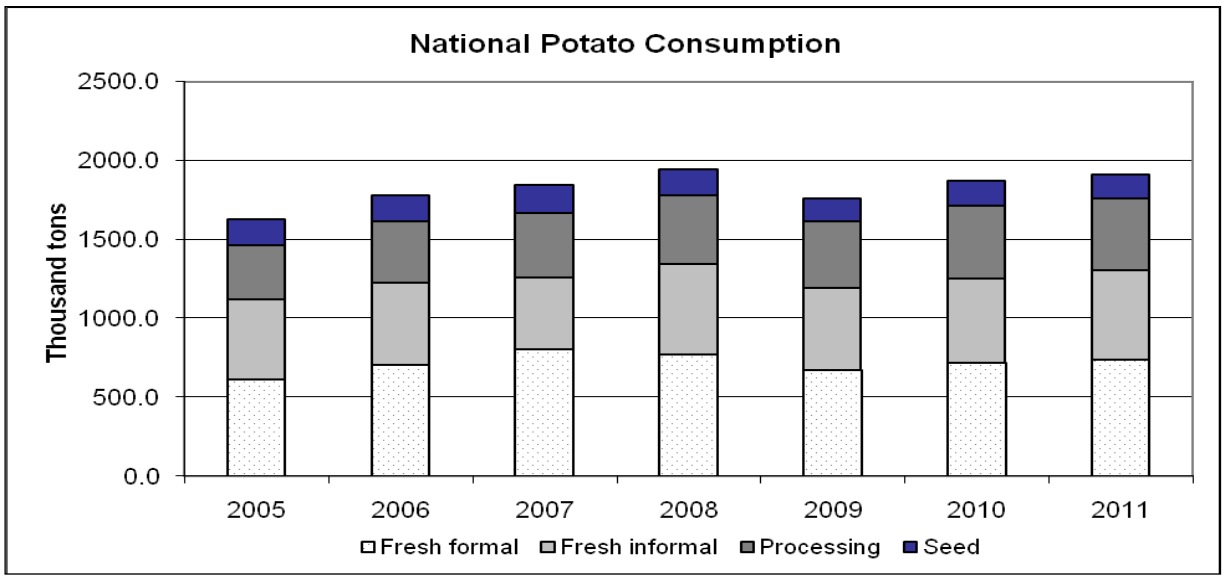

Figure 5.3: National potato consumption by type, 2005-2011

Consumption of seed potatoes and potatoes sold at the formal markets before and after the recession is displayed above. The quantity of potatoes sold at formal markets decreased between 2007 and 2008 by 29.4 thousand tons, while the seed consumption decreased from 179.97 in 2007 to 167.83 thousand tons by 2008. National potato consumption is projected to decrease in 2010, but to later gain momentum slightly up to the year 2012. According the figure 5.3, the South African potato consumption shows steady and continuous upward movement, especially in potatoes sold in the informal markets from the year 2010 upwards.

The potatoes sold at the informal markets are projected to increase to 718.37 thousand tons in 2010. The increase is then followed by the decrease to 730.73 thousand tons in 2013; which is later on followed by a further decline to 729.13 thousand tons in 2015. Consumption of potatoes in the informal markets shows an opposite projection of continued upward movement to 2015. The value of consumption rises to 538.22 thousand tons by the year 2010, further increasing to 591.10 and 623.78 in the years 2013 and 2015 respectively. The consumption of seed potatoes shows a decline in 2013 and 2015 to an average of 143.59 thousand tons. Potatoes marketed for processing indicated a decrease to 430.62 in 2013 and 445 for 2015. Consumption of seed potatoes is projected to decline slightly from 2011 to 2015 see Figure 5.4.

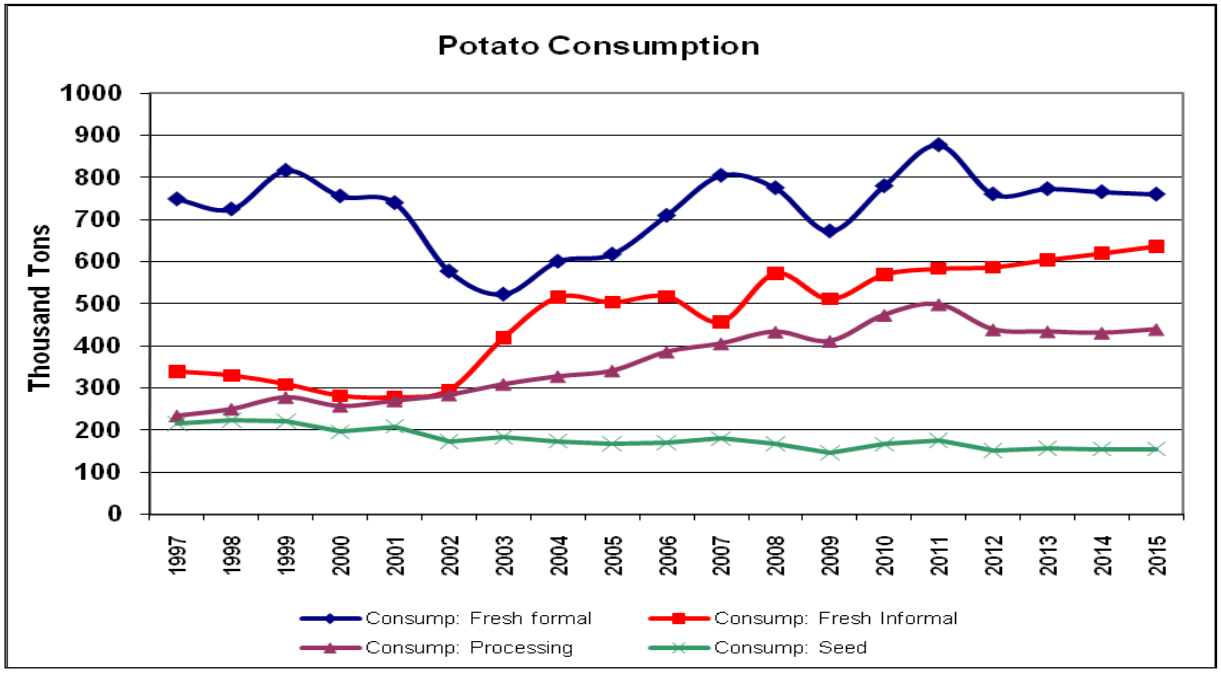

Figure 5.4: Estimated national potato consumption by type, 1997-2015

5.3 POTATO SECTOR OUTLOOK FOR SCENARIO

As discussed earlier, the performance of the model was validated to confirm the model's applicability to the real world. The following section discusses the procedure to measure the usefulness of the model through the case studies or possible scenarios in the industry. Scenario evaluation in the study implies that the farming decisions and/or activities can now be analysed using a range of '*what if?'* questions. The scenarios that will be incorporated in

this study are market-related; and take into consideration current policies and environmental changes, including economic instabilities. In every scenario applied, the model is solved and the results are compared to the initial baseline produced prior to environmental shocks in the economy, in order to measure the impact.

From the model developed and the literature in the industry, it is clear that South African potatoes are mostly produced under irrigation; with the exception of the Eastern Free State and Mpumalanga regions, where spring and summer seasons are mainly dry-land plantings. Noteworthy!, the objective of the study aims to develop the simulation model within the partial equilibrium with the intention of evaluating what happens in one region when the other regions are affected. Similarly, there is a need to understand the relationship among the potato production regions and the consumption of these potatoes by the other regions in the country. This scenario evaluates the impact of the Limpopo region, because it is the second largest producer of potatoes in the country. The province invested 91000 ha for production in 2010 which was the highest in the country.

The regional potato cultivation occurs mainly under irrigation involving about 8 555 ha. The average rainfall per annum is more or less 350 mm with a temperature range of 10 to 15 degrees Celsius in winter and from 18 to 25 degrees Celsius in summer. The province, like others, has two planting seasons; January to March (an early crop) and April to August (main crop). The Limpopo marketing period is from April to the end of August for the early crop and from September to February for the main crop. Table 5.3 contains results of the first scenario:

Table 5.3: Impact of a 20 percent reduction in Limpopo yield, 2010

VARIABLES	UNITS	2011	2012	2013	2014	2015
Total Area	1000ha	0.00%	1.77%	-0.22%	0.04%	0.00%
Total Production	1000 tons	-3.75%	1.65%	-0.21%	0.03%	0.00%
Average Yield	t/ha	-3.75%	-0.12%	0.01%	0.00%	0.00%
Potatoes Import (Fresh potatoes)	1000 tons	0.00%	7.16%	-2.17%	0.29%	-0.04%
Total Supply	**1000 tons**	-3.65%	1.74%	-0.25%	0.04%	0.00%
Consump: Fresh formal	1000 tons	-5.71%	2.43%	-0.32%	0.05%	0.00%
Consump: Fresh Informal	1000 tons	-1.27%	0.47%	-0.06%	0.01%	0.00%
Consump: Processing	1000 tons	-4.13%	1.73%	-0.24%	0.04%	0.00%
Consump: Seed	1000 tons	0.00%	3.67%	-0.78%	0.11%	-0.01%
Potatoes per capita consump	kg/capita	-3.99%	1.61%	-0.21%	0.03%	0.00%
Domestic Use	1000 tons	-3.66%	1.77%	-0.26%	0.04%	0.00%
Potatoes Export	1000 tons	-3.55%	1.30%	-0.16%	0.02%	0.00%
Total Demand	**1000 tons**	-3.65%	1.74%	-0.25%	0.04%	0.00%

The scenario conducted with an intention to evaluate the impact of reducing the Limpopo yield by 20% which may come as a result of a once-off frost just before harvest. If the frost can strike in 2011 at Limpopo and leads to the yield of potatoes being reduced by 20%, the above table shows the possible impacts this would have on the potato industry in different regions and as a result the country. After the shock, the initial impact is felt within Limpopo, whereby production decreases by 20.55% (8345.63 thousand 10kg bags) for fresh potatoes. In responding to the decline in production the Limpopo market price of potatoes increases by 14.36% in 2011.

This impact trickles dawn and is evident in the other provinces. The total production in all the regions remains unchanged in 2011 this maybe because planting has already occurred or is in process. Although production remains the same to the sister regions, prices tends to increase in the same year with the Other regions showing the highest price increase at 18.46%. This may be due to the fact that these are the regions that produce a significantly lower quantity of potatoes and/or that they depend highly on supply from Limpopo to complement its shortage.

The Eastern Free State and Mpumalanga regions are the only areas producing under dry-land conditions. Firstly, according to the baseline projections, in 2011 only Limpopo and Eastern Free State were to cultivate 9 thousand ha and were the highest. Secondly, the marketing

period for Limpopo is in August to December which coincides with the planting period for the Eastern Free State, indicating a shortage of supply in this region. Both these conditions result in the Eastern Free State being highly affected by the reduction of yield in the Limpopo region. From the scenario results Eastern Free State shows the second highest price increase followed by Mpumalanga at 17.93% and 17.08% respectively. Although cultivation occurs throughout the year in Sandveld, its market prices increase is at 15.32% which is average to the sister regions.

The Limpopo marketing period is from April to August and September to February, while its planting period is from June to July and January to April. The South-western Free State, on the other hand, experiences the least price increase at 11.83% when compared to the other regions, and its planting period is from August to November (early crop) similar to that of Limpopo. The Limpopo yield and price impacts spread further to the national market price-fresh and the price of seed potatoes. The seed prices increase by 9.02% and the national prices of potatoes increase by 17.24% in the same year. See Figure 5.5

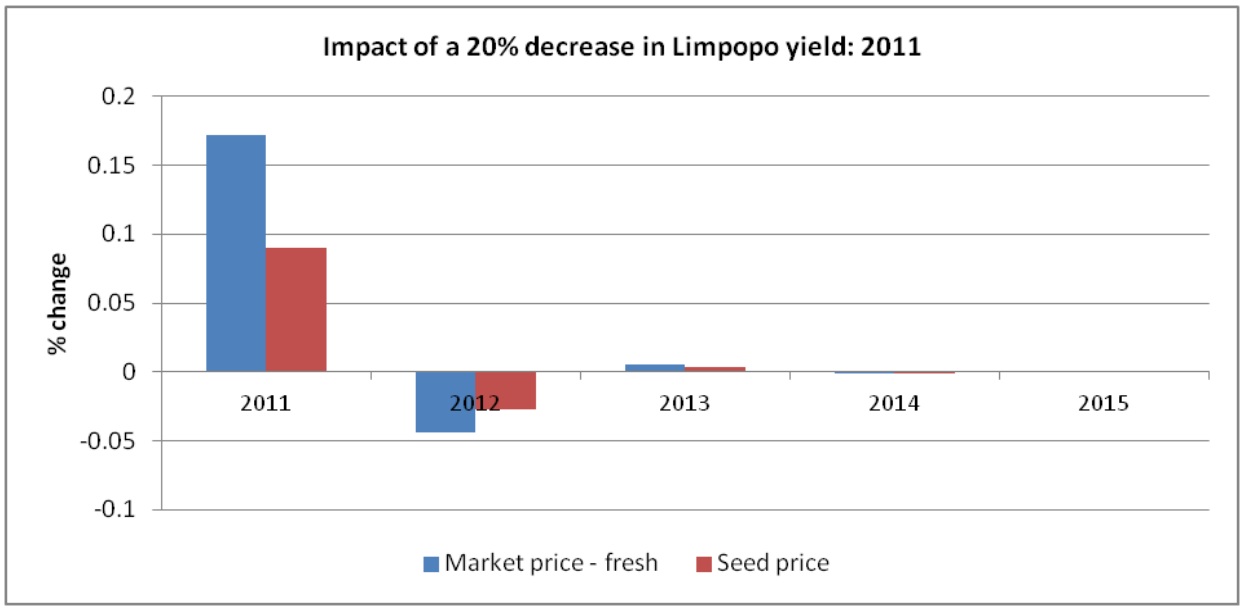

Figure 5.5: Impact of a 20% reduction in Limpopo yield, 2011-2015

The price reaction in these regions reveals the low of demand and supply in relation to price determination of goods, whereby the higher the supply of produce will lower the price of the

goods or service in question and/or vice versa. It is also evident that potatoes produced in one region in South Africa are distributed to other regions, hence ensuring year-round potato availability throughout the country and that a change in one region will affect the others.

From the model estimates it is clear that the area planted this year is lagging from the previous year and that is confirmed by the regional responses from the decreased yield. Following the year of frost (2011), the Limpopo area planted will increase by 0.62%. The North-Eastern Cape area planted for 2012 increases the most by 4.52%. This is followed closely by the Eastern Free State with 3.18%. The Sandveld, Marble Hall and Eastern Cape areas planted increase by 1.88%, 2.71% and 2.36% respectively. The aggregated increase in the regional area planted leads to an overall rise in the country's total area planted by 1.77% (0.87 thousand ha) and the total potato production by 1.65% (33.64 thousand tons). The 2012 production increase in all the regions leads to the regional and national price of potatoes-fresh and seed potato prices to decline. The highest market price reduction is in Eastern Cape at 129.27 c/10kg, followed by Sandveld, Limpopo and North West at 122.81c/10kg each. The region with the lowest price decrease is the South-western Free State at 87.64 c/10kg. The National potato-fresh and seed potato prices decrease both by 129.27c/10kg see Figure 5.5

As the years go by, the 2011 once off (20% Limpopo yield) decline effects gradually loses its powers. In responding to the 2012 lower prices, not all the farmers reduce the areas under cultivation in 2013. Only five regions reduce their area planted. The Sandveld area declines by 0.03 thousand ha, followed by Western Free State and Eastern Free State at 0.02 thousand ha each and Marble Hall and North West at 0.01 thousand ha in the same year. The reduction in the area planted leads to the decreasing production in almost all the regions, excluding the South-western Free State which experiences a production increase of 0.57 thousand tons. Although the area planted reduction seems to be little, its impact is huge in that the Sandveld production falls by 129.7 thousand tons. The National potato-fresh and seed potatoes prices increase both by 18.49c/10kg each. This pattern of interaction among regional areas planted, regional and national potato production, regional prices and seed process is projected to continue to the year 2015.

The projection shows that the consumption of fresh potatoes sold in the informal market increases at a rate constant to the consumption of fresh potatoes in the formal market. Over the past three years, the domestic and international economies experienced frequent macro-economic and environmental fluctuations. The South African population is projected to continue growing till it reaches a level of 48.7 million by 2014. This implies that the country´s available food should also increase to support this growth. The higher the population, the higher will be the food demand; this increase should taking into cognisance the per capita GDP. This then implies that the per capita GDP is the major driving force in the food supply and/or expenditure on food. Over the years, South Africa's economy has been growing positively up until the year 2008 when it was affected by the world recession. The statistics projected the South African per capita GDP to grow by 0.5% in 2009, and the growth to continue at a rate of 1.9% per year.

The increase in potato price in the year 2011 by 18.49c/10kg is accompanied by the reduction in the aggregate potato demand of about 3.65% in the same year. The decrease includes the reduction in consumption of fresh potatoes in the formal markets by 5.71% and the consumption of fresh potatoes in the informal markets by 1.27 % The difference in these consumptions is because of the fact that over the past four years, potato demanded by consumers in the fresh formal markets has declined steadily, whilst the opposite applied for the consumers in the informal markets. The export of potatoes decreases by 3.55% when the prices were high. This reaction supports the near autarky market price determination in South Africa; indicating that exports are highly influenced domestically. The quantity of potatoes consumed for processing purposes declines as a result of the decrease in production. This reduction triggered the increase in the potato market price and this led to the reduction in the consumption of potatoes for processing purposes. The price increase then triggered the reduction in the per capita consumption of potatoes by 3.99%.

The results indicate that the area planted increases in 2012 to address the limited production of the previous year and increased 2011 potato prices which resulted from the reduced 2011 Limpopo yield, leads to the decrease in the price of potatoes in the same year. This reaction results in the consumers buying more potatoes than anticipated. The consumption of fresh

potatoes in the informal markets increases by 0.47% and the consumption of fresh potatoes in the formal markets increases by 2.43% for 2012. Responding to the price reduction, the quantity of potato demanded for processing increases by 1.73% while that of seed potatoes increases by 3.67%. The increase in seed consumption as an input is felt in the following year (2013) whereby the quantity of area planted decreases by 0.22%; meaning that farmers purchase more seeds to increase their planted hectares when the seeds are cheaper and/or the demand for potatoes (output) for consumption and processing purposes is high. Since the seed prices increase as a result of the decrease in the Limpopo yield in the previous period, it can be concluded that the change in one region's yield affects the supply in the other regions and the consumption at the national level.

The following section discusses the second scenario of the study which is mainly the impact of possible economic growth rate after the Recession. This scenario is subdivided into the evaluation of a 0.5% increase and that of a 4% increase. This scenario is evaluated to determine the impact on the regional demand, supply and prices if the GDP per capita can increase by an annual average of 4% and/ or by 0.5% from 2011 to 2015.

The South African economy experienced the world economic crisis following national economic growth shrinkage (decline by most of the economic indicators) in the last quarter of 2008. This shrinkage continued for several months to the year 2009 whereby the economy fell by 6.4%. Consumer consumption contracted by 5% and was the largest contraction to be experienced by the country in 13 years. On average, household debts grew to about 80% of disposable income. The country experienced a 47% increase in company failure that led to labour retrenchments; which further contributed to the increase in the unemployment rate. Measures were introduced by the government in an effort to shield the country as far as possible from the negative repercussions of the global crisis; such as controlling the exchange rate, 'However, these measures proved largely ineffective'. (Hein, 2009)

Agriculture as a sector was among the hardest hit by the economic crisis. Given the recession's impact on the economy, this section of the study seeks to undertake scenario analysis that will be used to evaluate the impact of strong compared to weak economic growth

following the recession. Ultimately, the model should be able to illustrate the impact of this shock (economic recovery) on demand, supply and prices among regions and at national level after the recession. The results will illustrate how the industry responds after recession, the impact the recovery will have on the various producers and consumers of potatoes and the expected responsiveness towards the changes.

The results of the model estimates indicated that the per capita GDP has an elasticity of 0.05 for the consumption of fresh potatoes at formal markets, and 0.08 for those at informal markets. The baseline on the other hand showed that the quantity consumed at the informal markets is expected to increase while at the formal markets fluctuates over the four years. The model is intended to determine whether the different consumers will respond differently towards the increase of real per capita GDP annually from 2011. The scenario is as follows: What if the South African GDP was to increase at the constant rate of 4% or alternatively to grow at 0.5% from the year 2011 to 2015? The results are displayed in Table 5.4

Table 5.4: Impact of a 4 percent increase in the South African GDP, 2011- 2015

VARIABLES	UNITS	2011	2012	2013	2014	2015
Total Area	1000ha	0.00%	0.85%	0.72%	0.74%	0.74%
Total Production	1000 tons	0.00%	0.79%	0.66%	0.69%	0.68%
Average Yield	t/ha	0.00%	-0.06%	-0.05%	-0.06%	-0.05%
Potatoes Import (Fresh potatoes)	1000 tons	0.00%	3.52%	1.98%	2.24%	2.25%
Total Supply	**1000 tons**	0.00%	0.84%	0.69%	0.72%	0.71%
Consump: Fresh formal	1000 tons	-1.46%	-0.60%	-0.85%	-0.91%	-1.01%
Consump: Fresh Informal	1000 tons	2.08%	2.38%	2.37%	2.41%	2.45%
Consump: Processing	1000 tons	0.66%	1.61%	1.53%	1.59%	1.60%
Consump: Seed	1000 tons	0.00%	1.77%	1.33%	1.44%	1.45%
Potatoes per capita consump	kg/capita	0.13%	0.92%	0.79%	0.82%	0.81%
Domestic Use	1000 tons	0.12%	0.99%	0.84%	0.87%	0.86%
Potatoes Export	1000 tons	-1.73%	-1.27%	-1.37%	-1.39%	-1.44%
Total Demand	**1000 tons**	0.00%	0.84%	0.69%	0.72%	0.71%

The table above shows the impact of a 4% annual increase In response to the 4% constant economic growth from 2011 to 2015, the consumption of fresh potatoes in the formal markets decreases by 1.46% and in the informal markets consumption increases by 2.08% for the year 2011. The initial consumption response is higher in both markets but eventually its rate

declines from 2012 to 2015 for the formal markets. The informal markets show a continuous increase on its consumption with the increase in GDP. The consumption of potatoes for processing tends to increase by 0.66%, while exports of potatoes decrease by 1.73% in 2011.

The consumption of seed potatoes does not respond to the shock in 2011 because the planting has either already occurred or is in process. It then starts to increase in 2012, which may be due to the high consumption that resulted from both the increasing usage of processing potatoes and consumption of fresh potatoes from the informal markets the previous year. The per capita consumption on the other hand increases by 0.13%, while domestic consumption increases by 0.12% in 2011.

The market price shows an increase of 8.30% at national level and 4.34% for seed potato consumption in 2011. The rise in potato consumption leads to the price increase, whereby all the South African regional prices tend to increase by an average of 7.5% in 2011. The lowest price increase is in the South-western Free State region with 5.69% and Limpopo at 6.91% in the same period. This response is justifiable, since the above regions are characterised by their lower price elasticity of 0.13% and 0.14% respectively.

From 2012, the area planted, yield and production increases. This is positively related to the lagged increase in consumption of potatoes (processing and informal market) as well as the increase on the prices of potatoes in the country. The total supply in the country increases by 0.84%; this is mainly from the area harvested that increases by 0.85% and the total production in the country by 0.79%. Interestingly though, the yield of potatoes drops while production shows an increase by 0.06% in the year 2012. The North-Eastern Cape area planted shows the highest increase at 2.17% followed by the Eastern Free State area planted at 1.53%. The consumption of potatoes in the fresh informal market continues to increase throughout 2012 to 2015, while the consumption of fresh potatoes from the formal markets and exports continue to decline. The regional prices continue to increase but at a lower rate. The highest price was in the Other region at 8.88% followed by the Eastern Free State and Mpumalanga at 8.63% and 8.22% respectively. In 2012 these prices increase by 4.05% in Other regions, 3.97% in Eastern Free State and 3.84% in Mpumalanga.

The total supply of potatoes remains stable in the year 2012 and 2015 at 0.71%. The per capita GDP of potatoes per annum shows a hike in the year 2012 from 0.13% to 0.92% and continues at an average of 0.8% to 2015. The above pattern is also evident in the domestic use of potatoes whereby the domestic use increases from 0.12% in 2011 and abruptly reaches a peak of 0.99% in 2012 then stabilises at an average of 0.85% from 2012 until the year 2015.Potato prices on the other hand shows a slight increase from 2012 to 2015. Exports are projected to decline as long as GDP increases, hence the increase in potato prices and production at the regional level. The scenario on the weaker economic recovery (0.5 % economic growth) and its comparison is presented in Table 5.6 below:

Table 5.6: Impact of a 0.5 percent increases in the South African GDP, 2011- 2015

VARIABLES	UNITS	2011	2012	2013	2014	2015
Total Area	1000ha	0.00%	0.11%	0.09%	0.09%	0.09%
Total Production	1000 tons	0.00%	0.10%	0.08%	0.09%	0.09%
Average Yield	t/ha	0.00%	-0.01%	-0.01%	-0.01%	-0.01%
Potatoes Import (Fresh potatoes)	1000 tons	0.00%	0.44%	0.25%	0.28%	0.28%
Total Supply	**1000 tons**	0.00%	0.10%	0.09%	0.09%	0.09%
Consump: Fresh formal	1000 tons	-0.18%	-0.07%	-0.11%	-0.11%	-0.13%
Consump: Fresh Informal	1000 tons	0.26%	0.30%	0.30%	0.30%	0.31%
Consump: Processing	1000 tons	0.08%	0.20%	0.19%	0.20%	0.20%
Consump: Seed	1000 tons	0.00%	0.22%	0.17%	0.18%	0.18%
Potatoes per capita consump	kg/capita	0.02%	0.12%	0.10%	0.10%	0.10%
Domestic Use	1000 tons	0.02%	0.12%	0.10%	0.11%	0.11%
Potatoes Export	1000 tons	-0.22%	-0.16%	-0.17%	-0.17%	-0.18%
Total Demand	**1000 tons**	0.00%	0.10%	0.09%	0.09%	0.09%

This scenario evaluate the impact that the slow economic recovery (0.5% GDP increase) will have on the regional and national demand, supply and prices of the potato industry. When GDP increases by 0.5%, the results show a similar response but at a percentage lower than for the 4% GDP increase. At 4% GDP consumption from the informal market grows by 2.08% while under 0.5% GDP it increases by 0.26% in 2011. The result also shows that the consumption at the informal markets increases when the economy grows as opposed to that of the formal markets. This positive response at both levels is linked to the baseline, which indicates that over the past three years and the projected years, consumption of potatoes at the informal markets is increasing whilst the opposite can be said of the formal markets.

Furthermore, the results justify the assumption that many consumers in the informal markets are low income earners; hence a larger proportion of their income goes to food. The same applies on the formal markets which show a decrease by 1.4% GDP) and fall by 0.18 % GDP).

Although the increase in the rate of consumption in the informal market starts to be lower in the 4% scenario, for the 0.5% it in fact increases at an increasing rate but average rate of 3%. Consumption at formal markets and exports decreases throughout the years for both GDP growth scenarios.

The study result shows an interesting response on the consumption of potatoes and on the prices as income increases. Consumption at the informal market has a positive response while at the formal market decreases regardless of the magnitude of the GDP growth. The variation on these markets is mainly attributed from the relative sizes of its own price elasticity and its income elasticity for both markets. On the informal market the income elasticity (0.83%) outweigh the own price elasticity (-0.15%) in absolute value, as such the increase on income tends to have more effect on the movement of consumption .That is the overall impact of the rise in the GDP increases potato consumption in the informal market.

The formal market consumptions' reaction is totally the opposite. In that the effect of increasing income on the formal market is overpowered by its own price elasticity. That is, its income elasticity is 0.25 against the own price elasticity of -0.95 (absolute values). The size of the own price elasticity influences the movement in the formal market as GDP increases, such that the increase in income in this market leads to the drop in the volumes of potatoes consumed over time. See figure 2.1 below the consumption response at the different GDP growth:

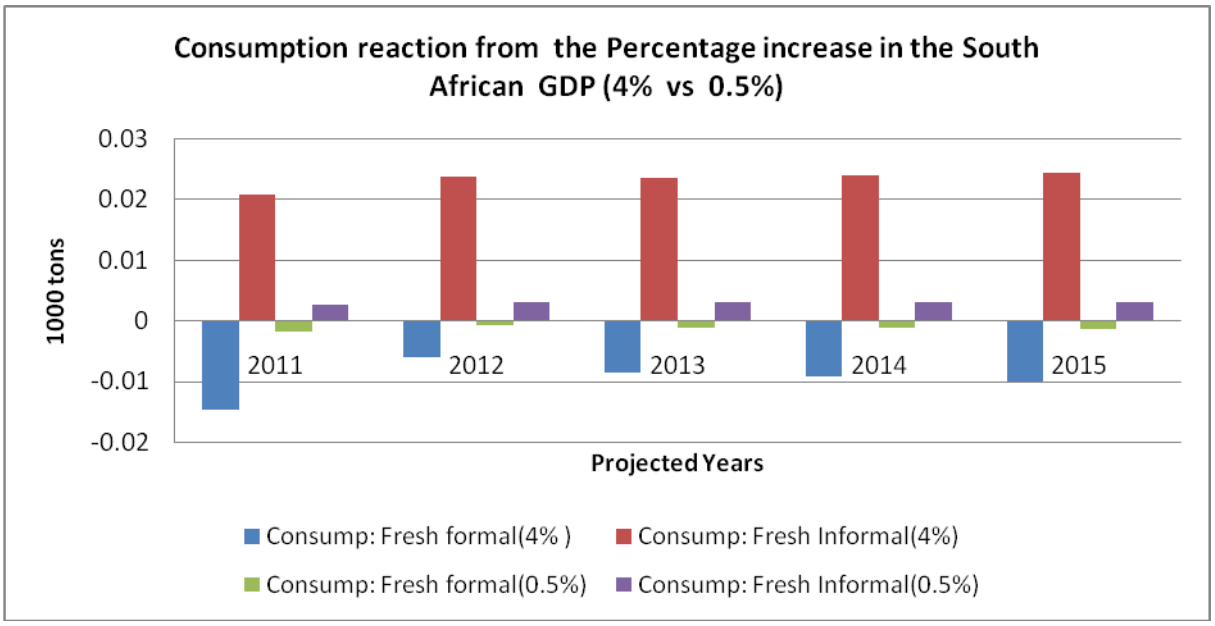

Figure 5.6: Consumption reaction from the 4% vs. 5% GDP increase

The consumption of seed potatoes starts to grow in 2012 and it continues at an average of 0.18 % throughout the projected years. The consumption of seeds also increases but its reaction starts in 2011. The total increase in the consumption of seeds, potato for processing and informal markets leads to the overall increase in the seed and national market price of fresh potatoes. Below is Figure 5.7 that compares the price effect of the two scenarios:

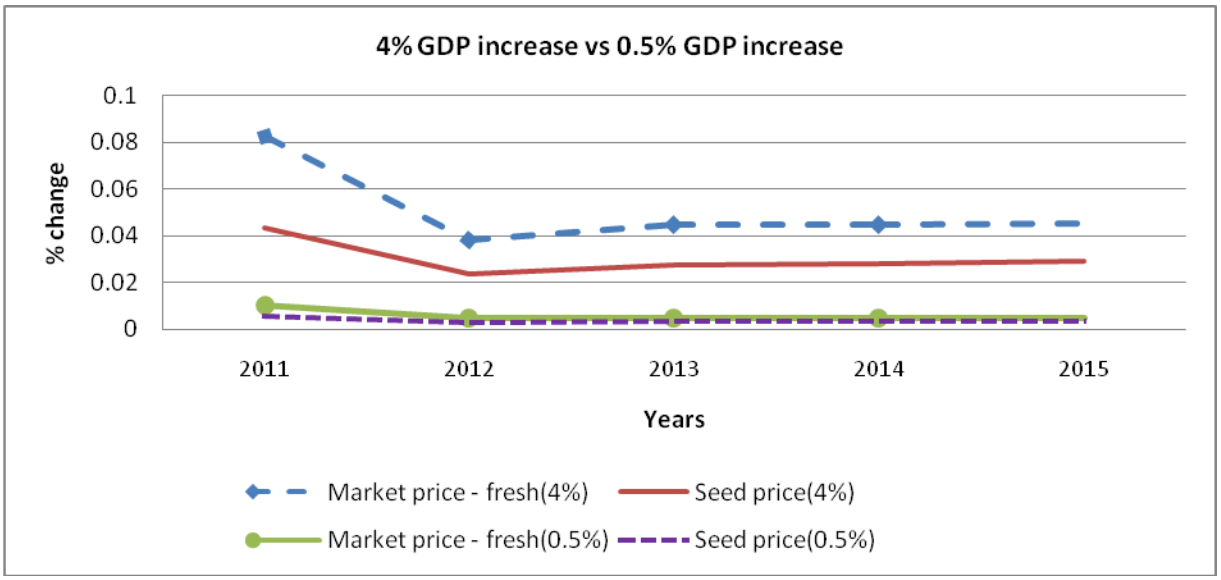

Figure 5.7: Impact of GDP increase on potato seed and fresh potato market prices

The total demand of potatoes in 2012 is at 0.10% for the 0.5% scenario and 0.84% in the 4% GDP increase scenario. This increase in demand is accompanied by the total increase in the supply of potatoes in both scenarios which comes as a result of the increase in the per capita disposable income.

5.4 CONCLUSION

This chapter focused on the baseline projection of the potato industry from 2011 to 2015. The results were presented graphically and in tables, where market prices for all regions are projected to increase from 2011-2015. Area harvested shows a significant decline in Limpopo, the Eastern Free State and Sandveld area; at 680 000, 730 000 and 502 000 hectors respectively in 2011.

Two scenarios were evaluated (tested). Scenario one was the reduction in the Limpopo yield by 20% in 2011 to evaluate the impact in other regions. Scenario two was to increase the per capita GDP by 4% and 0.5% to evaluate the impact of the stronger against the weaker economic growth rate on the potato market after the recession. The model was solved and the results were then compared to the initial baseline which was produced without any changes in the economy and the production environment.

The results of the responsiveness of the variables from the reduction of Limpopo yield by 20% indicate a decrease in national potato production by 3.75% in 2011. The initial impact is felt within Limpopo, whereby production decreases by 20.55% (8345.63 thousand 10kg bags) for fresh potatoes. In responding to the decline in production, the Limpopo market price of fresh potatoes increases by 14.36% in 2011. The area planted increases in 2012 to address the limited production of the previous year and increased 2011 potato prices leads to the decrease in the price of potatoes in the same year. This reaction results in the consumers buying more potatoes than anticipated. The consumption of fresh potatoes in the informal markets increases by 0.47% while that of fresh potatoes in the formal markets increases by 2.43% for 2012.

The scenario where there is a steady and continuous increase of 4% and 0.5% of the per capita GDP leads to various responsiveness of the variables. It is evident that an increase in per capita income of low income and middle income potato consumers leads to different responses towards the consumption of the commodity. Consumption of fresh formal potatoes decreases by 1.46 % and for fresh informal potatoes increases by 2.08%. The initial consumption response is higher in both markets but eventually its rate declines from 2012 to 2015 for the formal markets. The informal markets show a continuous increase in consumption with the increase in GDP. The consumption of seed potatoes does not respond to the shock in 2011 because the planting has either occurred or is in process.

Consumption at the informal market has a positive response while at the formal market decreases regardless of the magnitude of the GDP growth. The variation on these markets is mainly attributed from the relative sizes of its own price elasticity and its income elasticity. The increase in potatoes demanded results from the increase in per capita GDP; which in turn leads to the increase in the price of potatoes generally – hence a continuous increase in the area planted and production in the following year.

The following chapter provides the conclusion to this study. It will highlight the objectives of the study and the findings, and whether or not the hypothesis is true. The concluding chapter will also highlight future studies that should be undertaken to augment the practicality and applicability of the model in the producers, processors and policymakers' decision-making. This will indicate possible sectors that were not considered in this study which can improve the quality of the model. It will suggest, to those interested in continuing their studies in this field, the relevant and necessary issues to the sector that could be addressed to enable further detailed research of other variables and related/affected sectors that should be utilised in building such models

CHAPTER 6

SUMMARY AND CONCLUSIONS

6.1 SUMMARY

The general objective of the dissertation was to develop a system of equations with the ability to simulate the dynamic interaction between production and consumption on a regional level for potato producers, policy makers and wholesalers. The specific objectives were to estimate area planted, yield, per capita consumption, and net export at a regional level; and to determine price and income elasticity of demand as well as price elasticity of supply. The objectives included the making of projections regarding the supply and demand of potatoes in South Africa and the impact analysis of the economic and environmental changes in the industry from 2011 to 2015.

The initial part of the dissertation discussed the situational overview and the background of the potato industry. The subsequent chapters involved the development of the econometric model, where the industry structure and functions were depicted by a means of a flow diagram. Presenting and understanding the structure was essential in this study, as it assisted in the building of a sound econometric model. The initial phase in developing the model was to estimate single equations. Following their evaluations, the equations were then connected and linked into one system. Endogenous variables were then simulated and plotted over time to determine the tracking or systematic movement ability of the model; thereby capturing its turning points. The final step in developing the model was the model closure and the generation of the impact multiplier; the multiplier being essential in indicating changes that occur in the endogenous variables as a result of shocking the exogenous variables in the model.

The study then underwent the process of making the baseline projection. Projected values for the baseline were obtained from the BFAP model. Assumptions were made about economic and macroeconomic environments; which resultantly reflected the baseline projection's uncertainties. The final part of the study focused on scenarios, where scenarios were evaluated to assess the uncertainties of the projections. Scenarios evaluated the potential impact from shocking the projected exogenous variables, through a comparison of the results obtained under each scenario with the baseline projections. There were two types of scenarios; namely a short-term which was a once-off 2011 reduction in Limpopo yield and its effect, and a long-term effect which continued throughout the projected period. The first scenario analysis concerned the reduction of the Limpopo yield by 20%, with other factors remaining constant. The impact on prices, consumption, and response by other regions towards the shock were then evaluated. The second scenario concerned an increase in the per capita GDP by 4% and 0.5% up to the year 2015, i.e. a long-term shock after the recession. The scenarios were evaluated considering all recent trends in the economy (after the recession) to provide the modeller with quantitative evidence which may be valuable in the decision-making process by the people that will utilise the model; which can be utilised interchangeably to evaluate the "*what if?*" question.

For a model to be sound and effective, the modeller is required to have a detailed understanding on the decision-making behaviour of the consumers and the producers in the industry they operate in. The modeller is further required to have background knowledge on how the industry is structured and how it functions. This knowledge assists in the selection and combination of the variables that are valuable in the industry. After the estimation, the modeller works closely with the industry specialist to ensure the reality of the model. The information required to develop this model was insufficient. For a model to provide better movement, it needs to have time series data of at least 15 to 20 years; whereas the time series data in this case was from 1997 to 2010, which is only 14 years. Further, as potatoes are both vegetables and carbohydrates, it was required for other sectors to be included in the model; such as vegetables (for example as cabbage and onions) – which have substitution effects, as indicated by the industry specialist, as well as meat (for example as mutton) and processed starch (for example pasta, bread and rice) – which are understood to be the complements. The

fact that South Africa imports frozen potatoes at relatively insignificant volumes may mean that variables such as the exchange rate, world prices, and fuel prices influence the local potato price and the volume of produce imported.

The factors mentioned above enabled the model to perform a complete analysis and the ability to illustrate the reality of the South African potato industry.

6.2 CONCLUDING REMARKS AND RECOMMENDATIONS

Refer back to the main objectives of the study which intends to develop a model that has the ability to simulate the dynamic interaction between production and consumption on a regional level for potato producers, policy makers and wholesalers in South Africa. And that the model should further be utilised in analysing the impact of possible changes in the potato industry as result of macroeconomic and other external shocks.

Finding of the study

Firstly; generally market equilibrium is reached at a point when the difference between the net exports demand and the exports supply is zero, or when demand and supply are equal. The results in the study shows that domestic price and quantity demanded with the supply of net exports actually determine market equilibrium price and the decision to export in the South African potato industry. It can be concluded then that the near autarky situation is the only manner in which the South African market equilibrium conditions apply to the net export position.

Secondly; the model has successfully simulated the actual trends (real) of the potato industry. In that on all the graphs illustrated in the study the estimated production, consumption and prices for potatoes has captured the flow of the actual over time. The estimates were further used to establish the baseline projections. The model managed to simulate the behaviour of the potato industry through the estimated consumption, production and prices relations and interactions

Later on; the study undertakes two scenarios to evaluate the model's ability to project possible shocks which might come as a result of macro-economic and environmental changes. From the exercise, it is evident that there exist relations between regions in that the shock in one region (Limpopo) affected the other regions (production, prices and eventually consumption). This response supports the information from literatures and the industry expects that potatoes are grown throughout the country and are sold among the regions hence regions are highly depending on each other. From the results, it can be said model is able to respond to the main challenge encountered by the role players in the industry which is the lack of understanding the industry behaviour. The results also confirm that the model can be utilised to assist in the decision making and develop precautionary measures and strategies for the possible environmental impacts.

It is finally of importance to take note that, although potatoes industry is influenced by other forces not considered in the study, such as meat industry, vegetable industry and consumption patterns in each region versus the national consumption, It would be beneficial and valuable for future studies to model the regional consumption of potatoes, in a manner similar to the production of potatoes, focusing on the fresh potatoes at formal and informal markets, processed potatoes and seed potatoes. Those studies could be undertaken in order to evaluate scenarios such as the impact macro-economic factors excluding GDP have on potato production and consumption. Addition to these scenarios, South Africa needs a study that will focus on the import of frozen potatoes to the country and the impact of exchange rate (decrease or increase) on the processed potatoes. It is further recommended that the future studies should be linked with other sector models in order to improve and simulate relations between the potato sector and other sectors, thereby reflecting the actual economy.

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APPENDIX A

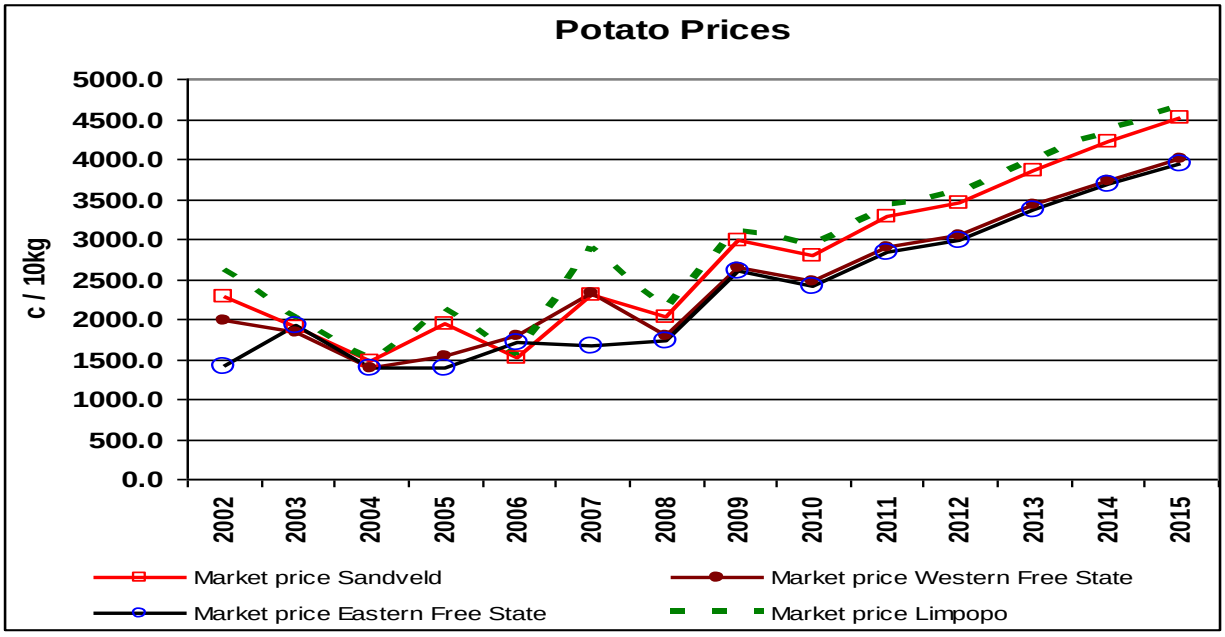
Table A1.1: Commodity Balance Sheet

National potatoes	Units	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Total Area	1000ha	58.648	55.147	53.872	56.68	53.193	53.786	47.123	49.427	52.161	50.297	51.171	54.028	50.222273
Total Production	1000 tons	1666.1049	1637.3587	1639.8856	1743.8385	1589.0452	1602.0363	1449.6456	1564.387	1724.2017	1716.4536	1859.0366	1919.6278	2069.7173
Average Yield	t/ha	28.408554	29.690802	30.440407	30.766381	29.8732	29.785376	30.763017	31.650455	33.05538	34.126362	36.329886	35.53024	41.211144
Potatoes Import	1000 tons	0.036738	0.121033	0.01143	0.305219	1.536513	0.010624	0.004322	0.000963	0.008451	24.75	55.9	16.131855	0
Total Supply	**1000 tons**	**1666.1416**	**1637.4797**	**1639.897**	**1744.1437**	**1590.5817**	**1602.0469**	**1449.65**	**1564.388**	**1724.2101**	**1741.2036**	**1914.9366**	**1935.7597**	**2069.7173**
Consump: Fresh formal	1000 tons	821.73688	748.75446	724.88868	816.34413	755.81143	739.9526	577.62954	523.1069	571.33597	585.33517	669.9	670.07344	784.27568
Consump: Fresh Informal	1000 tons	291.99884	338.5728	329.27877	308.61916	281.04404	277.16171	294.48	418.85103	512.06205	499.80173	513.31	508.07229	524.86964
Consump: Processing	1000 tons	219	234.74063	250.761	278.1176	256.186	270.445	284.602	309.65641	328.05	316.83	330.26	385.65199	447.75165
Consump: Processing - local& imports	1000 tons	219.03674	234.86166	250.77243	278.42282	257.72251	270.45562	284.60632	309.65737	328.05845	341.58	386.16	401.78384	447.75165
Consump: Seed	1000 tons	233.36914	215.29069	223.60516	220.75757	196.00368	208.47694	172.53409	183.20299	206.75235	203.75952	214.62066	238.92403	221.11221
Potatoes per capita consump	kg/capita	32.83985	32.070947	30.97339	32.595952	29.692156	28.934156	25.478323	26.974468	30.353903	30.485404	33.17907	33.298386	36.88871
Domestic Use	1000 tons	1566.1416	1537.4796	1528.545	1624.1437	1490.5817	1496.0469	1329.25	1434.8183	1618.2088	1630.4764	1783.9907	1818.8536	1978.0092
Potatoes Export	1000 tons	100	100	111.352	120	100	106	120.4	129.5697	106.0013	110.7263	130.93568	116.90605	91.708123
Potatoes Net Export	1000 tons	99.963262	99.878967	111.34057	119.69478	98.463487	105.98938	120.39568	129.56874	105.99285	85.9763	75.03568	100.77419	91.708123
Total Demand	**1000 tons**	**1666.1416**	**1637.4796**	**1639.897**	**1744.1437**	**1590.5817**	**1602.0469**	**1449.65**	**1564.388**	**1724.2101**	**1741.2027**	**1914.9263**	**1935.7597**	**2069.7173**

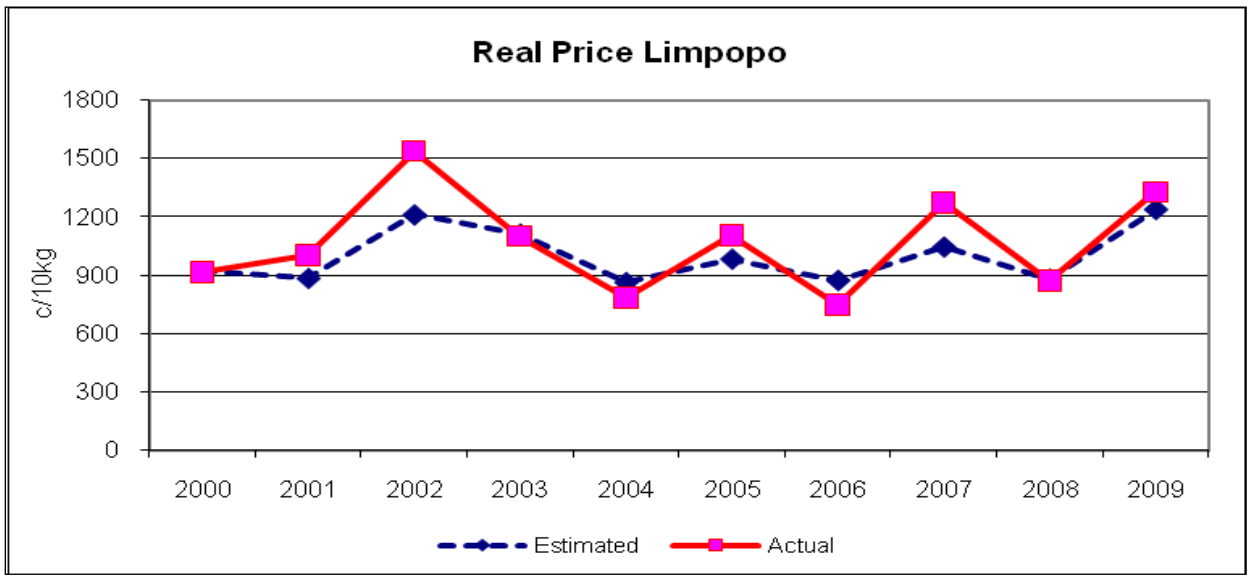
Source: BFAP, 2011

APPENDIX B

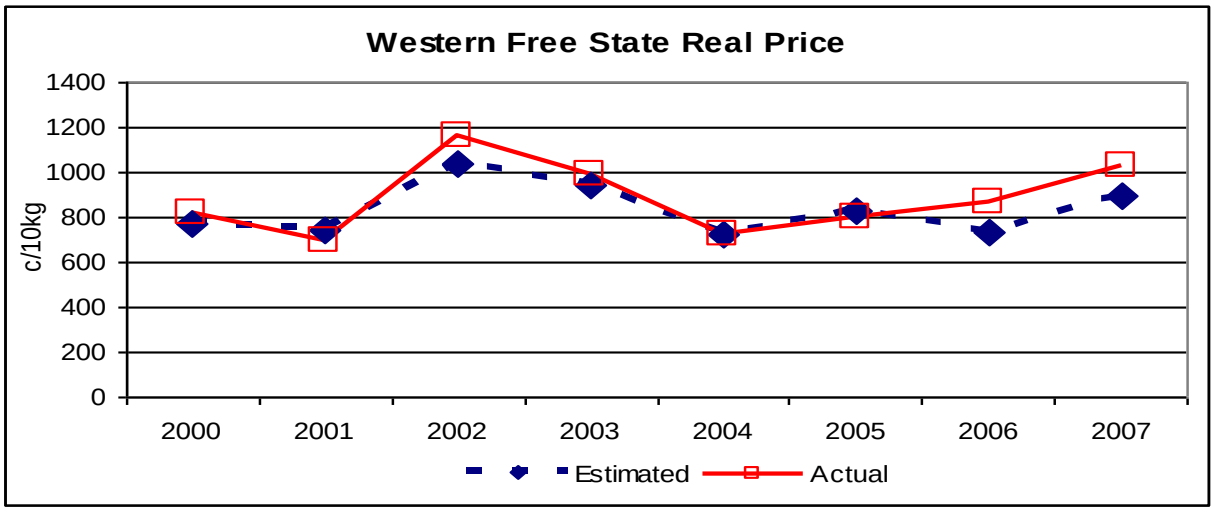
Prices, production trends and consumption over time



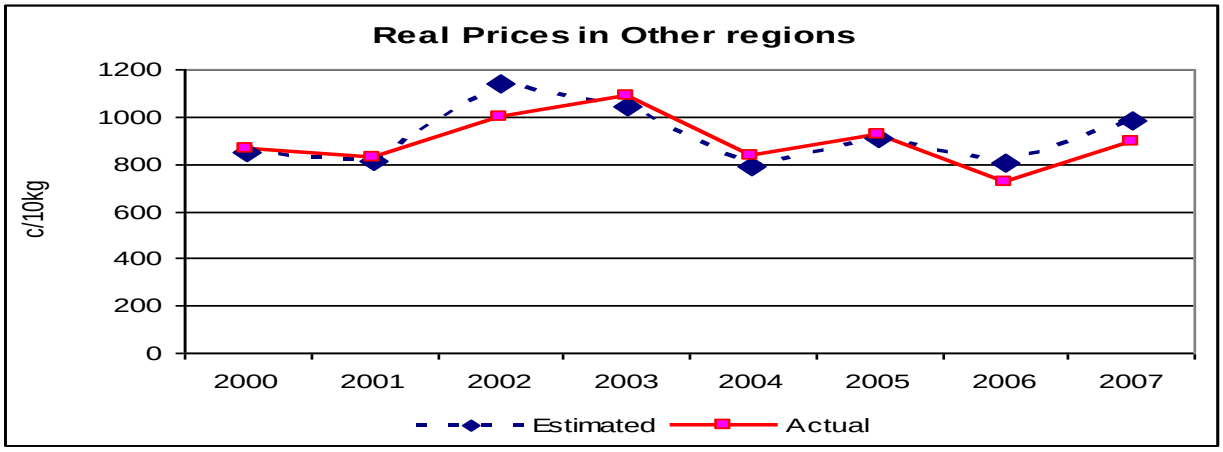
Figures A2.1: The projection of Sandveld, Eastern Cape, Western Free State and Limpopo potato market price, 2002-2015.



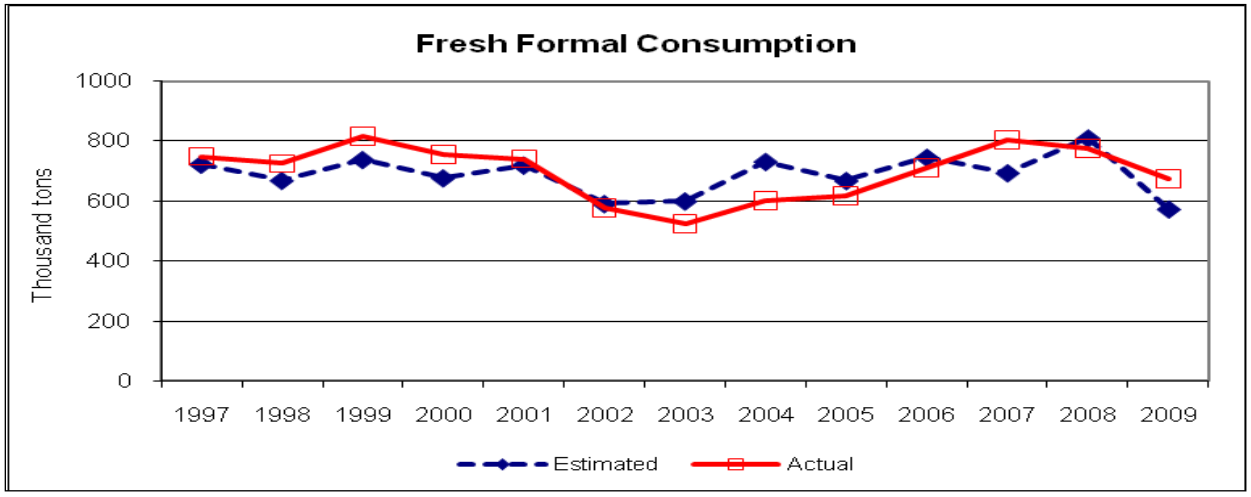
Figures A2.2: Real potato prices in Limpopo region, 2000 to 2009



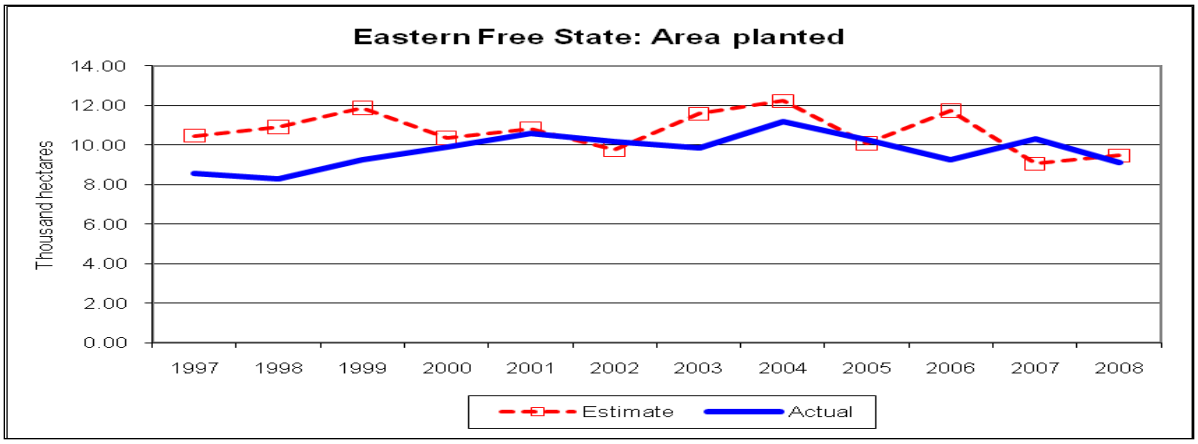
Figures A2.3: Western Free State real potato price, 2000 to 2007



Figures A2.4: Real potato prices Other regions, 2000 - 2007



Figures A2.5: Formal Fresh potato consumption, 1997 - 2009



Figures A2.6: Eastern Free State: Area planted, 1997 - 2008