CHAPTER 1
INTRODUCTION

1.1 BACKGROUND

Over the past decade economic literature has studied the transmission of prices between spatial markets and analysed the extent to which markets are integrated. According to the basic principles laid down by the theory of the law of one price when trade occurs between two markets, the markets are integrated and the difference in the prices equals the transaction costs to move the goods between those markets in the long run (Goodwin, Grennes and Wohlgenant, 1990). The equilibrium price in the smaller market can be estimated as a function of the equilibrium price in the dominant market, the exchange rate and the transaction costs. As soon as the difference in the market prices becomes less than the transaction costs, trade is discontinued and the markets are no longer integrated (Sexton, Kling and Carmen, 1991). The market equilibrium (equilibrium price) is then a function of the domestic supply and demand factors in each market respectively. Thus, the formation of prices, also referred to as the equilibrium pricing condition (Barrett, 1999) in a specific market, changes as the market switches between different market regimes. According to Barret (1999), if a commodity moves from a non-tradable (importable) to an exportable (non-tradable) equilibrium, the correlation between the parity price and the local market prices should jump from (to) zero to (from) significantly positive, to (from) one if the law of one price holds strictly.

From a modelling perspective, the technique that is used to “close” a simultaneous or recursive simulation model determines the manner in which market equilibrium is achieved in the model. Many different model closure techniques exist. The choice of closure technique will depend on the equilibrium pricing condition in a specific market, specifically on which market regime prevails in the market. Models used in policy evaluation usually either ignore the possible existence of more than one market regime using just a single linear method of price determination based on average effects, or incorporate highly stylised components that may not reflect the complexities of a particular market. This implies that the estimated price transmission elasticity is likely to be moderate, understating the true elasticity when supplies are either large or small relative to domestic demand, but overstating the true response when domestic supply and demand are in balance. Although these models may appear statistically sound, they could present a simplification of the price-formation process. Colman (1995) noted that the concept of an elasticity of price transmission needs to be treated carefully. In particular, equating perfect price transmission with an elasticity of one only makes sense if all duties and transport costs are proportional to price. Barrett and Li (2002) referred to the "messy character of market relationships" arising from treating price transmissions mostly as a linear phenomenon. Balcombe (2003) more recently raised the concern that parameters in transmission equations do not correspond to the structural parameters which they are thought to represent. He also noted that theoretical models often contain either assumptions that are not met in practice, or identification conditions that cannot be established by examining the data alone. This comment is especially relevant in the Southern African markets where price relationships often indicate no opportunity for arbitrage and trade still occurs between the nations. This point will be discussed further in chapter 2.

In South Africa only a handful of studies have addressed price transmission and price formation in the agricultural market, and even fewer studies have addressed these issues within a partial equilibrium framework. Schimmelpfennig, Meyer, Beyers and Scheepers (2003) undertook one of the most recent studies on price transmission and presented an Error-Correction-Model (ECM) of the short- and long-run equilibrium between the world price of maize, the local producer and consumer price of maize, and the exchange rate. Although this study focused on long- and short-term shocks in the maize market, the switch of trade regimes[1], which determines the equilibrium pricing condition, was not taken into account and just a single method of price determination based on average effects was represented in the model. The study was also not undertaken within a partial equilibrium framework. Meyer and Kirsten (2005) presented the price-formation process

[1] For the period of the study (January 1998 – January 2002) the local maize market switched from an export parity regime, to near-autarky, to import parity.

in the wheat industry within a partial equilibrium framework, but did not address the possibility of a switch in market regimes.

Switching market regimes are a reality and the challenge is to apply econometric principles and applications to provide reliable simulation results of reality. This study proposes an approach that allows the incorporation of features of regime switching in a multisector commodity level model which capture salient features of the South African market and are therefore able to produce more reliable projections of the evolution of the sector under alternative shocks.

1.2 PROBLEM STATEMENT AND JUSTIFICATION OF RESEARCH

With the abolition of the agricultural marketing boards in 1997 a major shift took place in the price formation of South African agricultural commodities (Kirsten and Vink, 2000). The agricultural market division of the South African Futures Exchange (SAFEX), which was established in 1996, became the primary price-formation mechanism for wheat and maize. The shift from a regulated towards a free market essentially implied that price formation moved from a single-channel marketing system, where prices were set by the marketing boards, to an environment where prices are formed by fundamentals in the marketplace. Over the past eight years role players had to adapt to this new marketing environment where domestic markets are to a large extent integrated with world markets. For literally all of the grains and most of the livestock commodities, South Africa can be regarded as a "small nation" in terms of world production, consumption and trade. Therefore, role players participating in commodity markets essentially operate in an open economy of a small nation; "open" due to the ambitious deregulation of agricultural markets and "small" due to the fact that South African commodity markets do not significantly influence world price levels. South Africa is relatively small in the world market, but not so small as to have no impact.

Due to this new and dynamic agricultural environment, role players must almost continuously make decisions concerning their respective pricing, distribution and production policies.. Decision makers not only require the basic fundamental market information, for example crop estimates, stock levels, trade flow and domestic and foreign prices, they also need to understand what impact a shift in the basic market fundamentals could have on the market place. Commodity modelling can be regarded as one of the tools that process basic fundamental market information and, therefore, can play an important role in assisting role players in decision making, especially when it is applied to scenario planning and forecasting. The fact that price formation has changed so drastically in the South African commodity markets has major implications for all basic econometric modelling techniques that involve price formation, integration and market equilibrium in the South African commodity markets.

The determination of domestic prices is dictated by a country's specific trade and policy regimes. These regimes determine how domestic market prices are integrated with world market prices. Most econometric simulation models do not distinguish between the various trade regimes present in a specific commodity market and estimate the critical relationships between parity and domestic prices as an average over the trade and policy regimes. Figure 1.1 presents three regimes where the formation of prices differs fundamentally.

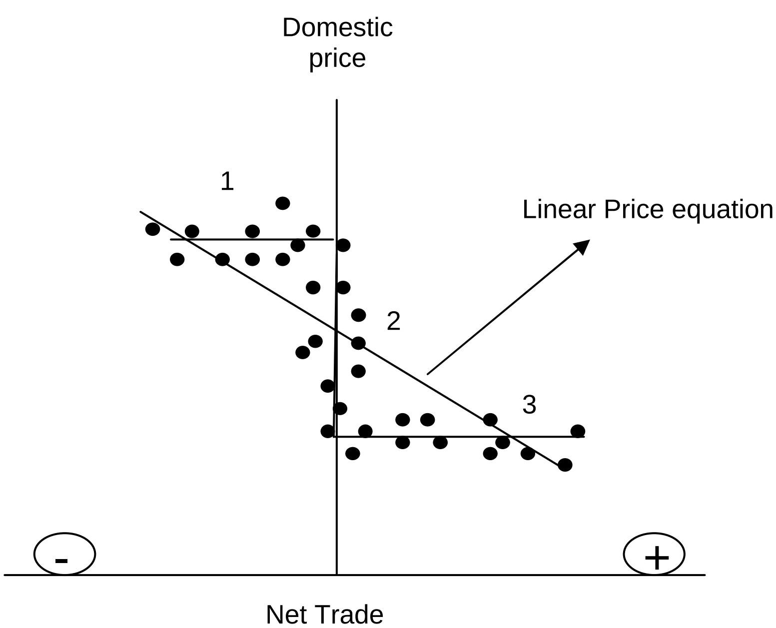

Figure 1.1 Three different market regimes

These regimes are summarised as follows:

Regime 1: Import parity

If domestic prices are high enough, the country is a net importer and the domestic price is a function of the world market price. As imports increase, so the domestic supply increases. Under this scenario one expects a high rate of transmission from the world price to the domestic price. One would especially expect the market price in South Africa to move with the price in exporting countries, plus the cost of shipping commodities to South Africa and any import taxes. Since South Africa is regarded as a small nation, the world price will not be significantly affected by South African imports.

Regime 2: Autarky

If domestic prices are in the middle range, in other words between import and export parity, domestic prices are determined by fundamental factors in the local market. Hence, in this region prices are largely disconnected from world market prices. The dictionary definition of autarky refers to an economic policy or situation in which a nation is independent of international trade and not reliant on imported goods.

Regime 3: Export parity

If domestic market prices are low enough, the country is a net exporter and the domestic price is again a function of the world market price. In this scenario, the domestic prices are again integrated with world market prices and the rate of transmission from world prices to the domestic market price is high. One would expect domestic market prices to be closely related to the price paid in importing countries, less relevant transportation costs and taxes.

Figure 1.1 shows that if the domestic price is estimated as a linear function of the world price, the critical relationship between the dependent and independent variables is estimated as an average over the three regimes. Hence, the equation does not capture the three distinct regimes where price formation differs fundamentally. Many of the econometric price transmission models face this problem. Although these models may appear statistically sound, they present a simplification of the price formation process.

This point was clearly illustrated when the stochastic projections by the South African grain, livestock, and dairy sector model, developed by Meyer and Westhoff (2003), overestimated the white and yellow maize price levels for the 2005 production season by more than 20 percent. In this season, the maize market moved from import parity levels to a situation closer to export parity levels within a matter of two months. Various scenarios were tested with the model and even when the latest crop estimates by the National Crop Estimates Committee (CEC) were introduced in the model, the model still overestimated prices by an unacceptably high margin. The levels of exports were overestimated, which occurred mainly because of the model structure. In the model, white and yellow maize exports and imports are estimated as a linear function of domestic consumption, production and the world price. In reality, export demand is expected to be small and inelastic when domestic supplies roughly match local demand, but much more price responsive when surpluses build up and prices fall to export parity levels.

Exactly the same principle can be illustrated by another practical example. Assume that a severe drought reduces the domestic production in a small nation. If the model structure is set up in such a way that the domestic price is directly linked to the world price, then the drought will have no impact on the local market price for a small nation. However, if the model is set up to solve the price within the domestic market, and therefore take the local production and consumption levels into account, then the drought will have an effect on the local market price, but with no guarantee that prices will be bound by important import parity levels.

In essence, it is clear that a distinction needs to be made between the term "endogenous" in a statistical sense and "endogenous" in a market-related sense. A price can be modelled as a function of world prices, which implies that the price is a behavioural equation in the system of equations and, therefore, endogenous in a statistical sense. However, this price is predetermined by the world price and is therefore not solved endogenously in the domestic market by means of supply and demand.

Market integration, equilibrium pricing conditions and formation, and price transmissions have been researched over many years. The formation of prices in a specific market changes as the market switches between different trade and policy regimes. To the author's knowledge, Barrett (1999) conducted the only study where the shift in equilibrium pricing conditions has been introduced in a partial equilibrium framework. However, no regime-switching methodology was applied in the study and model closure under the shifting equilibrium pricing conditions was not addressed. Chapter 2 reviews further studies that utilised threshold models and parity bound models, to accommodate the discontinuities of trade. Some of these studies have applied regime-switching techniques and others have considered transaction flow, but no study has addressed model closure techniques within large multi-market models under switching trade regimes. Without the correct structure and closure, even models that appear to exhibit good econometric properties will not be able to generate reliable estimates of endogenous variables. This study incorporates a range of techniques and principles to develop a partial equilibrium model that can be applied to real market and policy analysis under market switching regimes.

1.3 STATEMENT OF HYPOTHESIS

Typically, studies on price transmission, integration, and market equilibrium revolve around single equation parameter estimates for prices and transaction costs in different regions. For theses studies hypothesis testing normally does not pose any difficulties and can be implemented with a high level of efficiency. However, Barrett (2001) does mention that it is unclear how one aught to interpret rejections of the hypothesis that, for example, international agricultural markets are in competitive equilibrium, given uncertainties like variable trade policies.

Working with system of equations makes hypothesis testing a daunting task. Apart from identities, the multi-market model that is applied in this study consists of 126 behavioural equations. Naturally, one can design a hypothesis test for each coefficient, estimated within the system of equations, but the practicality and usefulness of this exercise is highly questionable. Furthermore, statistical hypothesis testing cannot be undertaken in those cases where synthetic modelling techniques are applied in big multi-market commodity models. As previously stated, this study presents the structure and closure of an econometric regime-switching model within a partial equilibrium framework that has the ability to generate reliable estimates and projections of endogenous variables under market-switching regimes. A number of statistical criteria, like Thiel's inequality coefficient (Thiel's U Statistics) for example, can be applied to test hypotheses on the statistical performance of the model. However, even if the model performs well by standard statistical measures, it still does not imply that the model is able to handle real-world issues and shocks. For the purposes of this study it is therefore appropriate to design a hypothesis around the real-world issues rather than the statistical performance of the model. This study sets out to test the following hypothesis:

With the correct model structure and closure, a combination of modelling techniques can be applied to develop a simulation model that has the ability to generate reliable estimates and projections of endogenous variables under market-switching regimes.

The methodology that will be applied to test this hypothesis is discussed in the following section. Hypothesis testing with regards to the statistical performance of the model falls beyond the scope of this study.

1.4 OBJECTIVES AND METHODOLOGY OF THE STUDY

The objectives of this study can be arranged into two main groups: Firstly, the development of a multisector commodity level model that is able to generate reliable estimates and projections under switching market regimes and secondly, the practical implementation and application of this model to examine real-world issues.

The primary objective of this study is to redesign the model specification and closure of the white maize, yellow maize, and wheat industries in the existing South African grain, livestock and dairy multisector commodity model, in order to accommodate the switching between various market regimes. The first version of the South African grain, livestock and dairy model was developed and operationalised by Meyer and Westhoff in 2003 (Meyer and Westhoff, 2003). It can be classified as a large-scale multisector commodity level simulation model and in total, six crops, five livestock and five dairy commodities are included in the current version of the model (table 1.1). The model is maintained within the Bureau for Food and Agricultural Policy (BFAP) at the University of Pretoria.

Table 1.1: Products included in the SA grain, livestock and dairy model

Cereals	**Oilseeds**	**Meat**	**Other**
White Maize	Sunflowers	Chicken	Eggs
Yellow Maize	Soybeans	Beef	Milk
Wheat		Mutton	Cheese
Sorghum		Pork	Butter
			Skimmed Milk Powder
			Whole Milk Powder

Source: BFAP baseline, 2005

The improved version of the model must be able to generate reliable estimates and projections under the three alternative market regimes introduced in figure 1.1. The re-estimation of the system of equations will combine econometric methods with simulation techniques to generate reliable projections for commodity markets. All the improvements and analysis will be undertaken within the already existing partial equilibrium framework. This model will, by design, be more rigorous than the previous model in that it emphasises price formation and correct model closure under alternative regimes.

Separate price formation blocks will be developed that include actual import and export parity price levels. The critical objective of the study is to design a “switch mechanism” that incorporates principles of threshold effects developed by Balcombe (2003), the difference between equilibrium and integration developed by Barrett and Li (2002) and the parity bounds model by Baulch (1997). The switch mechanism allows for a switch between different approaches to model closure, as markets move between import and export parity. This suggests that price transmission elasticity levels will change as markets move.

The lack of long-run time series data determines to a large extent the methodology that is followed in this dissertation. Interestingly, in their study of stochastic regime-switching models Bac, Chevet and Ghysel (2001) noted that they were hampered by relatively short data sets of *"only"* 40-50 years of data in order to conduct testing of cointegration, unit roots, or mean version. Although data on the total area planted to maize are available since the early sixties, the split between white and yellow maize area planted has only been reported since 1992. When an equation with two to three exogenous variables is estimated with only thirteen observations, many formal statistical validation procedures are difficult to apply. Brooks and Melyukhina (2005) referred to the difficulty of obtaining robust estimates without good data on both prices and traded volumes as the "fundamental dilemma", and even then the econometric techniques available may not be capable of providing accurate *ex ante* predictions of price transmission.

Since the principle objective of this study is to develop a well-behaved econometric model that is able to simulate regime switching in commodity markets, alternative estimation and validation procedures are followed in some cases to find estimates that provide an accurate prediction of reality. Where necessary, synthetic parameters are imposed to ensure reasonable model behaviour.

Although eighteen agricultural commodities are included in the model, this study only focuses on price formation and model closure in the white maize, yellow maize and wheat market. The main reason for choosing these three industries is that each industry represents a unique trade and policy environment. Furthermore, maize is the single most important agricultural commodity that influences literally all the South African field crops and livestock markets. Internationally, South Africa can be treated as a small nation with an open economy with respect to all three industries. This is, however, not the case in the Southern African region. South Africa is the largest maize producer in this region and can therefore be regarded as a large nation in the region. Variable import levies have been introduced for white and yellow maize and wheat can be imported with an *ad valorem* tariff of 2 percent, which implies that the tariff is so low that it hardly has any impact on the domestic market price. South Africa is primarily a net exporter of white maize and a net importer of wheat. In the case of yellow maize, South Africa is sometimes a net importer and sometimes a net exporter.

In summary, this study will develop alternative model closure techniques for white maize, yellow maize and wheat under the following market regimes:

- White maize: import and export parity, and autarky
- Yellow maize: import parity and autarky
- Wheat: import parity

After the model structure has been developed, model results will be validated and an illustration of the practical implementation of the model in the real market provided. Despite undertaking statistical validation procedures where possible, essentially most of the validation of the model results will be market orientated to ensure that the model simulates reality accurately. The construction of elasticity matrices and a summary table of price and trade impact multipliers will form part of the validation procedures. The usefulness of the model will be illustrated by means of scenario analyses, which will be conducted in the form of case studies that incorporate two main levels of scenarios. These levels are market-related scenarios and policy scenarios. Market-related scenarios will analyse the impact of key drivers (e.g. world prices, the exchange rate and weather patterns) on the market place. The scenario analyses of a shock in world prices will illustrate how the level of integration between domestic and world markets changes as markets shift between the various trade regimes. Policy scenarios will include shocks on the current tariff dispensations of the grains. The results of the scenario analysis will be applied to test the hypothesis of this study.

1.5 OUTLINE OF STUDY

This thesis is organised into six chapters. Following this introductory chapter, the second chapter contains a literature survey on price formation and modelling systems of equations, particularly pertaining to agricultural commodities. This chapter also includes a descriptive overview of the functioning of the white maize, yellow maize and wheat markets in South Africa. Chapter 3 introduces the theoretical foundation for the structure and closer of the model. The empirical results and performance of the single-equation estimations are reported and discussed in chapter 4. The impact multipliers and simulation results of the various scenarios generated within the closed system of equations are presented in chapter 5. A summary of the study and concluding remarks are given in chapter 6.