CHAPTER 4

THE REGIME-SWITCHING MODEL

4.1 INTRODUCTION

This chapter presents the structure and the empirical results of the BFAP sector model with a redesigned model specification for the white maize, yellow maize and wheat industries. A switching mechanism has been introduced in this version of the sector model that can switch between alternative model closure techniques. The structure of the model is based on a thorough understanding of the functioning of markets as well as the theoretical foundation, as presented in chapters 2 and 3. In the first section of this chapter the estimated equations are reported and discussed. This includes the parameter estimates, the calculated elasticities and a clear distinction between the alternative model closure techniques that are used for each of the commodities. A detailed discussion of the technical implementation of the switching mechanism in the model follows. The switching mechanism enables the switch between various model closure techniques, which are dictated by the equilibrium pricing conditions, as was discussed in chapter 2 and 3.

4.2 EMPIRICAL RESULTS

The equations reported in this section form the new maize and wheat models. The domestic supply and demand components of the existing models remain unchanged and only the explanatory variables, the parameter estimates and the elasticities are reported for these components. Only the economic significance of the existing equations is taken into consideration and not the statistical significance. The estimated results of the redesigned price and trade equations include the parameter estimates, p-values, R^2, Durban Watson statistics (DW), and the elasticities. The elasticities were calculated at the mean values of the corresponding variables. In order to better understand and interpret the economic significance of the variables used in the equations, a definition of all the variables is included with every equation. The focus of the discussion of the results falls on the economic significance of the equations and how the results relate to the existing literature and the explanation of the functioning of the markets in chapter 2. The results are organised by categories of demand, supply and model closure, and not by commodity.

4.2.1 DOMESTIC SUPPLY

The total grain area harvested represents the sum of the area harvested for all six crops in the model. It is modelled (equation 4.1) as a function of the weighted sum of expected real gross market returns for all six crops, rainfall in the summer production area that influences the decision to plant, and the real price of fuel. Real gross market returns are weighted according to the commodities' share of the total area harvested.

Equation 4.1: *Total grain area harvested (Thousand hectares)*

Explanatory variable	Parameter	Elasticity
Intercept	4264.9	
LAG(G6REGMW)	0.710	0.22
RASAD	1.575	0.12
RFUEL	-466.40	-0.11
SHIFT98	-733.13	

Variable name	Definition	Units
G6REGMW	Weighted sum of expected real gross market return – 6 crops	R/ton
RASAD	Rainfall: summer grain area decision	mm
RFUEL	Real fuel price index	Index
SHIFT98	Indicator variable equal to 1 from 1998 onwards	

The price elasticity of 0.22 implies that if the weighted sum of expected real gross returns for all six crops increases by 10 percent, the total area harvested increases by 2.2 percent. Similarly, a 10 percent increase in rainfall in the specific months that influence the decision to plant will increase the area harvested by 1.2 percent and a 10 percent increase in the real price of fuel will decrease the area harvested by 1.1 percent. SHIFT98 was introduced in the equation to capture the large shift of marginal land out of crop production in the first production season after the deregulation of the markets in 1997. The shift implies that 733 000 ha were lost to grain production for reasons not explained by changes in gross market returns.

All the crops in the model are expressed as a share of the total grain area harvested and estimated as behavioural equations, except for white maize. Since the deregulation of the markets, white maize has made up approximately 40 percent of the total grain area harvested. The white maize area harvested is equal to one less the sum of the area shares for the remaining crops. Therefore, the area shares for yellow maize and wheat will be presented first before the white maize area share is presented.

The yellow maize area harvested share of the total grain area harvested is modelled as a function of the ratio of the real expected gross market return for yellow maize divided by the sum of the expected gross market return for the remaining five crops. The estimated signs of the parameters comply with *a priori* expectations and the elasticities show that the yellow maize area harvested share is inelastic. This complies with recent stable trends in the yellow maize area harvested.

Equation 4.2: *Yellow maize share of total grain area (percentage)*

Explanatory variable	Parameter	Elasticity
Intercept	0.15	
LAG(YMRGMSA)	0.06754	0.37

Variable name	Definition	Units
YMRGMSA	Yellow maize expected real gross market return / Sum of 5 grains expected market return	Percentage

The yellow maize area harvested is calculated in the form of an identity that relates the share of yellow maize area harvested to the total grain area harvested.

Equation 4.3: *Yellow maize area harvested (thousand hectares)*

YMAHSA = G6AHSA*YMAHSH

Variable name	Definition	Units
YMAHSA	Yellow maize area harvested	Thousand hectares
G6AHSA	Total grain area harvested	Thousand hectares
YMAHSH	Yellow maize area harvested share	Percentage

The wheat area harvested in South Africa can be split up into two main production regions, namely the summer and the winter rainfall regions. Although the summer rainfall region also includes the wheat area harvested under irrigation, the nature of the commodities that can be used for substitutes is very similar to those of the dryland summer area harvested. Wheat summer area harvested share (WSAHSH) is estimated as a function of the expected real gross market returns for wheat divided by the sum of the expected real gross market returns of the remaining five crops in the model.

Equation 4.4: *Wheat summer area share of total grain area (percentage)*

Explanatory variable	Parameter	Elasticity
Intercept	0.05201	
LAG(WRGMSA)	0.0416	0.57

Variable name	Definition	Units
WRGMSA	Wheat expected real gross market return / Sum of 5 grains expected market return	Percentage

Wheat winter area harvested share (WWAHSH) is estimated as a function of the expected real gross market returns for wheat divided by the sum of the expected real gross market returns of the remaining five crops in the model and the real carcass price for mutton. SHIFT01 is included to account for the shift of area out of wheat production since 2001.

Equation 4.5: *Wheat winter area share of total grain area (percentage)*

Explanatory variable	Parameter	Elasticity
Intercept	0.058	
LAG(WRGMSA)	0.01513	0.35
RMUAPSA	-5.96E-06	-0.17
SHIFT01	0.00966	

Variable name	Definition	Units
WRGMSA	Wheat expected real gross market return / Sum of 5 grains expected market return	Percentage
RMUAPSA	Real mutton auction price	c/kg
SHIFT01	Indicator variable equal to 1 from 2001 onwards	

The own price elasticities in the summer and winter share area?? equations clearly illustrate the different characteristics of wheat production in the two regions. Although both estimated elasticities are fairly inelastic in reflecting steady cropping mix between grains and oilseeds, the elasticity in the summer rainfall area is almost twice as large as the elasticity in the winter rainfall area. The reason for this is that the farmers in the summer rainfall region have more commodities to choose from, which can be planted instead of wheat. The farmers in the winter rainfall region only have a few options and are often caught up in a fixed rotational cropping programme, which makes it more difficult to respond to price changes. The real price of mutton is also included in the winter rainfall area harvested, since sheep production forms an integral part of the rotational cropping system.

The area harvested for wheat in the summer and winter region is calculated as the area harvested share times the total grain area harvested.

Equation 4.6: *Wheat summer area harvested (Thousand hectares)*

$$WSAHSA = G6AHSA*WSAHSH$$

Variable name	Definition	Units
WSAHSA	Wheat area harvested	Thousand hectares
G6AHSA	Total grain area harvested	Thousand hectares
WSAHSH	Wheat summer area harvested share	Percentage

Equation 4.7: *Wheat winter area harvested (Thousand hectares)*

$$WWAHSA = G6AHSA*WWAHSH$$

Variable name	Definition	Units
WWAHSA	Wheat winter area harvested	Thousand hectares
G6AHSA	Total grain area harvested	Thousand hectares
WWAHSH	Wheat winter area harvested share	Percentage

Since the deregulation of the markets, white maize has made up approximately 40 percent of the total grain area harvested. The white maize area harvested share is equal to one minus the sum of the area shares for the remaining crops. Given parameters in the other share equations, the white maize share of total area harvested will increase when white maize prices increase, and decrease when other crop prices increase.

Equation 4.8: *White maize share of total grain area (percentage)*

WMAHSH = 1-
(YMAHSH+WSAHSH+WWAHSH+SSAHSH+SGAHSH+SBAHSH)

Variable name	**Definition**	**Units**
YMAHSH	Yellow maize area harvested share	Percentage
WSAHSH	Wheat summer area harvested share	Percentage
WWAHSH	Wheat winter area harvested share	Percentage
SSAHSH	Sunflowers area harvested share	Percentage
SGAHSH	Sorghum area harvested share	Percentage
SBAHSH	Soybeans area harvested share	Percentage

Given parameters in the other share equations, the white maize share of total area harvested will increase when white maize prices increase, and decrease when other crop prices increase. The white maize area harvested equation is derived by multiplying the area harvested share by the total grain area harvested. This identity can be presented as follows:

Equation 4.9: *White maize area harvested (thousand hectares)*

WMAHSA = G6AHSA*WMAHSH

Variable name	**Definition**	**Units**
WMAHSA	White maize area harvested	Thousand hectares
G6AHSA	Total grain area harvested	Thousand hectares
WMAHSH	White maize area harvested share	Percentage

In order to estimate total production, the area harvested for each crop is multiplied by yield. White maize yield is estimated as a function of rainfall and a trend variable. The rainfall variable used in the model reflects the regions and specific months that influence the area planted and the production of white maize. Initially, the expected price of white maize was included in the equation, but the coefficient turned out to be statistically insignificant. In South Africa, mainly white maize grown under irrigation has sufficient upward potential that one would expect farmers to respond to higher price expectations by increasing the level of inputs. Limited observations and the preponderance of weather impacts on yields make it difficult to identify price effects on yields. A dummy variable (indicator variable) was introduced in 1992 to capture the effect of the worst drought in the history of maize production in South Africa.

Equation 4.10: *White maize yield (t/ha)*

Explanatory variable	Parameter	p-value	Elasticity
Intercept	0.0111		
RASPRD	0.0030	*	0.62
TREND	0.0567	*	0.38
DUM92	-1.253	*	

Variable name	Definition	Units
RASPRD	Rainfall summer grain production	Mm
TREND	Trend variable; 1979 = 1 and 2014 = 36	
DUM92	Indicator variable equal to 1 in 1992, 0 otherwise	

White maize production is an identity equal to the area harvested multiplied by the yield.

Equation 4.11: *White maize production (thousand tons)*

WMPROSA = WMAHSA*WMYSA

Variable name	Definition	Units
WMPROSA	White maize production	Thousand tons
WMAHSA	White maize area harvested	Thousand hectares
WMYSA	White maize yield	t/ha

Equation 4.12 illustrates the estimation of yellow maize as a function of rainfall and a trend variable. As is the case with white maize, no statistically significant relationship could be established between expected prices and yield. Although the average yield for yellow maize and white maize over the past decade has been approximately the same (2.94 t/ha), the yellow maize yield is more sensitive to rainfall with an elasticity of 0.82 compared to 0.63 in the case of white maize. An all-time record yield of 4.37 t/ha is estimated for the current season (2004/05) by the Crop Estimates Committee (CEC). This follows a yield of 3.73 t/ha in the previous season.

Equation 4.12: *Yellow maize yield (t/ha)*

Explanatory variable	Parameter	Elasticity
Intercept	-3.21	
RASPRD	0.0036	0.82
LNTREND	1.33	1.55

Variable name	Definition	Units
RASPRD	Rainfall summer grain production	mm
LNTREND	Logarithmic trend variable	

Yellow maize production is estimated as the yellow maize area harvested multiplied by the yellow maize yield. Equation 4.13 presents this identity.

Equation 4.13: *Yellow maize production (thousand tons)*

$$YMPROSA = YMAHSA*YMYSA$$

Variable name	Definition	Unit
YMPROSA	Yellow maize production	Thousand tons
YMAHSA	Yellow maize area harvested	Thousand hectares
YMYSA	Yellow maize yield	t/ha

In the case of wheat, the existing model distinguishes between wheat yields in the summer rainfall region and winter rainfall region. Equation 4.14 and 4.15 suggest that yields in the winter rainfall area are more sensitive (elasticity = 0.56) to rainfall than yields in the summer rainfall area (elasticity = 0.23). These elasticities comply with *a priori* expectations since wheat in the winter rainfall region is only grown under dryland conditions, whereas in the summer rainfall region wheat is also produced under irrigation.

Equation 4.14: *Wheat summer yield (t/ha)*

Explanatory variable	Parameter	Elasticity
Intercept	0.12849	
RAWSPRD	0.00402	0.23
LNTREND	0.54991	0.71

Variable name	Definition	Units
RAWSPRD	Rainfall wheat summer production	Mm
LNTREND	Logarithmic trend variable	

DUM97 is included in the winter yield equation to capture the effect of a drought in this region in 1997.

Equation 4.15: *Wheat winter yield (t/ha)*

Explanatory variable	Parameter	Elasticity
Intercept	0.239302	
RAWPRD	0.004595	0.56
LNTREND	0.071472	0.09
DUM 97	-0.485678	

Variable name	Definition	Units
RAWPRD	Rainfall wheat winter production	Mm
LNTREND	Logarithmic trend variable	
DUM 97	Indicator variable equal to 1 in 1997, 0 otherwise	

Wheat production is an identity equal to the area harvested multiplied by the yield. Over the past three seasons farmers in the summer rainfall area have produced 66 percent of all wheat produced locally. This percentage has been as high as 75 percent and as low as 58 percent.

Equation 4.16: *Wheat summer production (thousand tons)*

WSPROSA = WSAHSA*WSYSA

Variable name	Definition	Unit
WSPROSA	Wheat summer production	Thousand tons
WSAHSA	Wheat summer area harvested	Thousand hectares
WSYSA	Wheat summer yield	t/ha

Equation 4.17: *Wheat winter production (thousand tons)*

WWPROSA = WWAHSA*WWYSA

Variable name	Definition	Unit
WWPROSA	Wheat winter production	Thousand tons
WWAHSA	Wheat harvested in winter rainfall area	Thousand hectares
WWYSA	Wheat winter yield	t/ha

4.2.2 DOMESTIC DEMAND

Domestically, white maize is used for food, seed and animal feed. . Total domestic demand equals domestic use plus ending stocks. Equations 4.18 and 4.19 present the human and feed consumption estimations for white maize. Seed consumption makes up approximately five percent of the market and the reported data are unreliable. For this reason, the model does not estimate a category for seed use.

The existing sector model estimates two categories for the domestic consumption of yellow maize, namely human consumption and feed consumption. Total domestic demand is calculated as domestic consumption plus ending stocks. Equations 4.22 and 4.23 present the human and feed consumption estimations, and equation 4.25 presents the function for ending stocks. Whereas white maize is mainly consumed in the human market, on average only 6 percent of all yellow maize has been consumed in the human market over the past five years. Yellow maize is the dominant feed grain in the South African feed market.

Wheat is consumed domestically for food, seed and feed. The total domestic demand for wheat is calculated as the sum of domestic consumption plus ending stocks. Seed consumption makes up less than five percent of the market and the reported data are unreliable. For this reason, the model did not estimate a category for seed use.

Human consumption was estimated as *per capita* consumption. White maize *per capita* consumption is defined as the white maize gross human consumption divided by the population and was estimated in equation 4.18 as a function of the real white maize SAFEX price, the real wheat SAFEX price, and the real *per capita* gross domestic product and a dummy variable for 1992.

Equation 4.18: *White maize human consumption (kg/capita)*

Explanatory variable	Parameter	Elasticity
Intercept	99	
RWMPPSA	-0.02	-0.16
RWPPSA	0.008	0.09
RPCGDP	-0.00072	-0.14
DUM92	-56.77	

Variable name	Definition	Units
RWMPPSA	Real white maize SAFEX price	R/ton
RWPPSA	Real wheat SAFEX price	R/ton
RPCGDP	Real *per capita* gross domestic product	R'000 / capita
DUM92	Indicator variable equal to 1 in 1992, 0 otherwise	

The fact that white maize is the staple food of South Africa creates numerous *a priori* expectations about the elasticities. If all the variables were in nominal terms, the homogeneity condition would not have been satisfied because the sum of the price and income elasticities does not equal zero. However, the variables are in real terms and therefore the homogeneity condition is not violated. This is because the implicit elasticity with respect to the price deflator is equal to the negative of the sum of the price (own and cross) and income elasticities. The sum of elasticities equals -0.21 (-(-0.16+0.9-0.14), therefore the price deflator (proxy for inflation) elasticity is 0.21. The deflator has exactly the opposite impact because it is below the line. If we increase all the prices and income by 10%, it implies that inflation also increases by 10% and the total effect is zero (-0.21 + 0.21). If the equation was in nominal terms and the total elasticity was -0.21, the homogeneity condition would be violated and a 10% increase in prices and income would decrease human consumption by 2.1%.

The own-price, cross-price, and income elasticity can all be classified as inelastic. The negative real income elasticity of -0.14 indicates that white maize is an inferior product. The negative income effect implies that price inflation has a positive effect on white maize consumption, if nominal income and nominal maize and wheat prices are held constant. This implies that as general inflation increases, so the human consumption of white maize increases. The estimation shows that white maize competes with wheat in the human consumption market, with a cross-price elasticity of 0.09. With the severe drought in 1992, only yellow maize was imported and the human consumption of white maize dropped from an average level of approximately 80 kg/capita to only 26 kg/capita. A dummy variable is included in the estimation to capture this effect.

Per capita consumption of yellow maize is defined as the gross human consumption of yellow maize divided by the population. It was estimated in equation 4.19 as a function of the real yellow maize SAFEX price, a shift variable in 1999, and a dummy variable in 1992 to capture the effect when only yellow maize was imported to supplement domestic drought-stricken supplies of white maize. Previous estimations did not find any statistical significant relationship between level of income and consumption of yellow maize in the human market. This complies with *a priori* expectations. The limited use of yellow maize in the human market can only be explained by the own price of yellow maize with an elasticity of -0.153.

Equation 4.19: *Yellow maize human consumption (kg/capita)*

Explanatory variable	Parameter	Elasticity
Intercept	4.445	
YMPPSA	-0.00109	-0.153
SHIFT99	1.7026	
DUM92	52.029	

Variable name	Definition	Units
YMPPSA	Yellow maize SAFEX price	R/ton
SHIFT99	Indictor variable equal to 1 from 1999 onwards	
DUM92	Indicator variable equal to 1 in 1992, 0 otherwise	

Per capita consumption of wheat is defined as the gross human consumption of wheat divided by the population and was estimated in equation 4.20 as a function of the real wheat SAFEX price, the real white maize SAFEX price, and the real *per capita* gross domestic product. The function is estimated in real terms and therefore also complies with the homogeneity condition. The signs of the estimated parameters follow *a priori* expectations. A negative own price elasticity and a positive income elasticity suggest that wheat is a normal product. Shift90 is used to illustrate the structural shift in the wheat consumers' market that took place in 1990 when the bread subsidy was terminated and the Wheat Board no longer regulated the price of bread.

Equation 4.20: *Wheat human consumption (kg/capita)*

Explanatory variable	Parameter	Elasticity
Intercept	63.1	
RWPPSA	-0.01	-0.194
RWMPPSA	0.008	0.062
RPCGDP	0.0005	0.130
SHIFT90	-11.3	

Variable name	Definition	Units
RWPPSA	Real wheat SAFEX price	R/ton
RWMPPSA	Real white maize SAFEX price	R/ton
RPCGDP	Real *per capita* gross domestic product	R'000 / capita
SHIFT90	Indicator variable equal to 1 from 1990, onwards	

It is important to note that equation 4.18 shows that white maize is an inferior product. Thus, the human consumption market for white maize and wheat differs and wheat can almost be classified as the "luxury" product compared to white maize; not "luxury" in the strictly theoretical sense where the income elasticity has to be larger than one, but luxury compared to white maize. *Per capita* consumption of wheat has increased over the past five years, while the *per capita* consumption of white maize has decreased. It can be argued that white maize is the staple food of South Africa, but as *per capita* income rises and the rate of urbanisation increases, wheat (in the form of bread) is the preferred product because of less preparation time. A detailed analysis and comparison of the human consumption patterns of white maize and wheat falls beyond the focal area of this study and is recommend for further research.

On average, less than ten percent of local consumption of white maize is used for animal feed, which implies that the major portion of South African white maize is used for human consumption. White maize will only be used for animal feed if it is sufficiently cheaper than yellow maize to compensate for the additional supplements that have to be included in the ration if white maize is fed. Industry experts currently estimate this margin to be between R40/ton and R50/ton. In the years when large surpluses of maize are being produced, white maize tends to be cheaper than yellow maize. However, if there is a shortage of white maize in the food market, white maize can trade at significantly higher prices than yellow maize.

Synthetic parameter estimates are imposed for all feed consumption equations in the existing sector model. It is worth pointing out that symmetry was imposed. In other words, while the parameter estimates are "made up", they are made up in a manner that is not arbitrary and is actually consistent with some aspects of theory. White maize feed consumption is modelled as a function of total demand for maize feed, the real price for white maize, and the real price of a number of substitute feed grains. The total maize feed demand is derived from the level of livestock production and the inclusion rate of white maize in the rations of the various feeds. The own price elasticity of -1.36 indicates that the demand for white maize feed is elastic. The price of yellow maize also has a large impact on the demand for white maize feed..

Equation 4.21: *White maize feed consumption (thousand tons)*

Explanatory variable	Parameter	Elasticity
Intercept	120.0	
MFDISA	0.15	0.92
RYMPPSA	1.00	1.08
RWMPPSA	-1.20	-1.36
RWPPSA	0.05	0.08
RSGPPSA	0.05	0.05

Variable name	Definition	Units
MFDISA	Total maize feed demand	Thousand tons
RYMPPSA	Real yellow maize SAFEX price	R/ton
RWMPPSA	Real white maize SAFEX price	R/ton
RWPPSA	Real wheat SAFEX price	R/ton
RSGPPSA	Real sorghum market price	R/ton

Approximately 85 percent of all feed grain consumed in the South African feed market is yellow maize. The substitute feed grains are white maize, wheat and sorghum. As was explained in the previous section, ,white maize only competes with yellow maize if the price differential is large enough and the wheat and sorghum feed markets are very small.

As in the case of white maize, synthetic parameter estimates are imposed on the yellow maize feed consumption estimation that is presented in equation 4.22. Yellow maize feed consumption is modelled as a function of the total maize feed demand, the real price for yellow maize, and the real price for the substitute feed grains. The total demand for maize feed is derived from the level of livestock production and the inclusion rate of yellow maize in the rations of the various feeds. The own price elasticity of -0.65 implies that feed demand is inelastic and downward sloping. Since the yellow maize feed market is approximately five times larger than the white maize feed market, it is plausible that the demand for white maize is far more price sensitive than the yellow maize market. As expected, an almost unitary elasticity (elasticity = 1) has been imposed for the yellow maize feed consumption with respect to the total maize feed demand.

Equation 4.22: *Yellow maize feed consumption (thousand tons)*

Explanatory variable	Parameter	Elasticity
Intercept	500	
MFDISA	0.9	1.15
RYMPPSA	-2.9	-0.65
RWMPPSA	1	0.23
RWPPSA	0.15	0.05
RSGPPSA	0.09	0.02

Variable name	Definition	Units
MFDISA	Total maize feed demand	R/ton
RYMPPSA	Real yellow maize SAFEX price	R/ton
RWMPPSA	Real white maize SAFEX price	R/ton
RWPPSA	Real wheat SAFEX price	R/ton
RSGPPSA	Real sorghum market price	R/ton

On average, less than two percent of the local consumption of wheat is used for animal feed, which implies that the major portion of South African wheat is used for human consumption. Wheat will only be used for animal feed if the price of lower-quality wheat competes with the price of yellow maize in the feed market. This occurs mainly in the Western Cape feed market, since no yellow maize is produced in this province and all the maize has to be transported from inland regions or be imported. Despite the fact that the animal feed market is very small, the existing model estimates a feed demand category, mainly to capture cross-substitution effects between yellow maize and wheat. Synthetic parameter estimates are imposed on the wheat feed consumption equations. Wheat feed consumption is modelled as a function of the total wheat feed demand, the real price for wheat, and the real price for a number of substitute feed grains. The total feed demand is derived from the level of livestock production and the inclusion rate of wheat in thevarious feed rations.

With an own price elasticity of -2.12, equation 4.23 shows that wheat feed demand is the most sensitive of the three commodities with respect to a shift in the own price. Taking into consideration that the wheat feed market is the smallest of the cereal feed markets, the elastic downward sloping demand curve is plausible.

Equation 4.23: *Wheat feed consumption (thousand tons)*

Explanatory variable	Parameter	Elasticity
Intercept	20	
WFDISA	1	1.07
RYMPPSA	0.15	1.26
RWMPPSA	0.05	0.43
RWPPSA	-0.155	-2.12
RSGPPSA	0.005	0.04

Variable name	Definition	Units
WFDISA	Wheat feed demand index	R/ton
RYMPPSA	Real yellow maize SAFEX price	R/ton
RWMPPSA	Real white maize SAFEX price	R/ton
RWPPSA	Real wheat SAFEX price	R/ton
RSGPPSA	Real sorghum market price	R/ton

If one assumes that all feed grains are homogeneous, that there are no restrictions on availability of any of the feed grains and the price that the feed miller is paying is actually the price that we are estimating, then we expect that the sum of the price parameter estimates has to equal zero. This is based on the principles of cost minimisation by the feed miller. If all prices increase by the same amount, and all the assumptions hold, then there should not be any impact on the consumption of feed. However, when these assumptions do not hold, we tend to focus more on the sum of elasticities. The sum of the price elasticities for white maize (-0.15), yellow maize

(-0.35) and wheat feed demand (-0.38) show that the demand for feed decreases if all the prices for grain are increasing. Thus, all three equations are downward sloping. Compared to yellow maize, feed demand for white maize and wheat is almost twice as elastic as yellow maize feed demand. As previously explained, this can be expected since the white maize and wheat feed markets are very small and volatile.

Total domestic use for maize and wheat is an identity defined as the *per capita* consumption times total population, plus feed and seed consumption. Seed consumption is very small relative to human and feed consumption. Hence, it is not estimated as a behavioural equation and is treated as an exogenous variable. Equations 4.24 through 4.26 present the domestic use of maize and wheat respectively.

Equation 4.24: *Domestic use of white maize (thousand tons)*

WMDUSA = WMPCCSA*POP + WMFCSA + WMSCSA

Variable name	Definition	Units
WMDUSA	White maize domestic use	Thousand tons
WMPCCSA	White maize *per capita* consumption	Kg/capita
POP	Population	Millions
WMFCSA	White maize feed consumption	Thousand tons
WMSCSA	White maize seed consumption	Thousand tons

Equation 4.25: *Domestic use of yellow maize (thousand tons)*

YMDUSA = YMPCCSA*POP + YMFCSA + YMSCSA

Variable name	Definition	Unit
YMPCCSA	Yellow maize *per capita* consumption	Kg/capita
POP	Population	Millions
YMFCSA	Yellow maize feed consumption	Thousand tons
YMSCSA	Yellow maize seed consumption	Thousand tons

Equation 4.26: *Domestic use of wheat (thousand tons)*

WDUSA = WPCCSA*POP + WFCSA + WSCSA

Variable name	**Definition**	**Unit**
WPCCSA	Wheat *per capita* consumption	Kg/capita
POP	Population	Millions
WFCSA	Wheat feed consumption	Thousand tons
WSCSA	Wheat seed consumption	Thousand tons

In equation 4.27 white maize ending stocks are modelled as a function of the lagged ending stocks, production less net exports, and the inverted real white maize price. Domestic production and net exports remain crucial factors that determine the level of ending stocks, but the impact of speculative stocks increases rapidly as market players become more acquainted with the elements of a free market environment. The estimated price elasticity indicates that, all else being equal, ending stocks decrease as prices increase. In 2002 the white maize price surged to record levels, but stock levels still increased sharply. Not only was the 2002 crop larger than the previous year, but due to a sharp depreciation in the exchange rate and looming crop failures in neighbouring states, prices increased above import parity levels. Many grain traders and producers increased speculative stocks as they expected prices to move even higher with a weaker exchange rate. Some traders even imported white maize to sell at higher prices in the domestic market. A dummy variable was introduced in the model to represent this shock.

Equation 4.27: *White maize ending stocks (thousand tons)*

Explanatory variable	Parameter	Elasticity
Intercept	-1363.9	
LAG(WMENDSA)	0.4	0.59
(WMPROSA – WMNESA)	0.21	1.32
1/RWMPPSA	334637	0.84
DUM02	1181	

Variable name	**Definition**	**Units**
WMENDSA	White maize ending stocks	Thousand tons
WMPROSA	White maize production	Thousand tons
WMNESA	White maize net exports	Thousand tons
RWMPPSA	Real white maize SAFEX price	R/ton

Yellow maize ending stocks are estimated as a function of the beginning stock (lagged ending stocks), yellow maize production, and the real yellow maize SAFEX price. Industry experts are of the opinion that the level of speculation on yellow maize stocks is far lower than on white maize stocks. Yellow maize stocks have over the past five years comprised only 33 percent of total maize stocks. Yellow maize production is the key driver of stock levels, with an elasticity of 2.15. If the yellow maize price increases by 10 percent, yellow maize stocks decrease by 10.05 percent, which implies that yellow maize stocks are basically unitarily elastic and downward sloping.

Equation 4.28: *Yellow maize ending stocks (thousand tons)*

Explanatory variable	Parameter	Elasticity
Intercept	-280.43	
LAG(YMENDSA)	0.15	0.24
YMPROSA	0.287	2.15
RYMPPSA	-0.65	-1.05
SHIFT97	290.0	

Variable name	Definition	Units
YMENDSA	Yellow maize ending stocks	Thousand tons
YMPROSA	Yellow maize production	Thousand tons
RYMPPSA	Real yellow maize SAFEX price	R/ton
SHIFT97	Indicator variable equal to 1 from 1997 onwards	

In equation 4.29 wheat ending stocks are estimated as a function of the lagged ending stock, production plus imports, and the real wheat SAFEX price. With an own price elasticity of -0.69, the results suggest that the demand for wheat ending stocks is downward sloping and inelastic towards the price. If the sum of wheat production and imports increases by 10 percent, wheat ending stocks increase by 6.2%. Over the past three seasons ending stocks have remained fairly constant and not nearly the same amount of speculation is present in the wheat ending stock market as is the case in the white and yellow maize ending stock markets. This is because South Africa is a net importer of wheat and the level of stocks is mainly determined by pipeline requirements.

Equation 4.29: *Wheat ending stocks (thousand tons)*

Explanatory variable	Parameter	Elasticity
Intercept	180	
LAG(WENDSA)	0.50	0.624
WRPDSA+ WISA	0.10	0.624
RWPPSA	-0.24	-0.696

Variable name	Definition	Units
WENDSA	Wheat ending stocks	Thousand tons
WRPDSA	Wheat production	Thousand tons
WISA	Wheat imports	Thousand tons
RWPPSA	Real wheat SAFEX price	R/ton

4.2.3 MODEL CLOSURE

In chapter 2 it was determined that the South African white maize market trades under all three market regimes, yellow maize trades under near-autarky and import parity, and wheat only trades under import parity.

Equations 4.30 and 4.31 represent the required equations to close the white maize model under near-autarky, and equations 4.32 through to 4.35 represent the model closure under the import and export parity market regimes. When the market is in near-autarky, net exports are estimated as a behavioural equation and prices are used to close the model. In equation 4.30 net exports of white maize are modelled as a function of the production divided by consumption and the ratio of the white maize SAFEX price over the average of the white maize import parity and export parity price. The annual production-consumption ratio is used in the monthly model by keeping the ratio constant for all the months of a specific year.

Under strict autarky, no trade occurs as domestic markets fluctuate between import and export parity. However, chapter 2 explains that under near-autarky, regional demand driven by weather, location and quality concerns of genetically modified imported maize from non-African destinations causes limited trade with neighbouring countries. With only limited trade taking place, it can be expected that statistically the equation will not perform well. The estimation results indeed prove this with an R^2 value of only 0.21, an F-value of 2.15, and a DW of 0.638. The p-values suggest that the production-consumption ratio is statistically more significant than the ratio of prices. The estimated parameter signs comply with *a priori* expectations, capturing the positive relationship between the level of net exports and domestic production, and the negative relationship between net exports and the domestic price. The elasticities show that net exports are price inelastic (-0.607), but elastic (2.207) towards the production-consumption ratio. At this point it is important to mention that equation 4.30 presents the equation where the monthly parameter estimates have already been converted for the annual simulation model. The annual parameter estimates are calculated from the monthly estimated elasticities and the annual averages for the respective variables for the period 2000-2005. As already mentioned in chapter 2, this was the period that was used for the monthly estimations as well. The principle of Least Squares (Gujarati, 1995) is now applied and an intercept term is chosen for the annual model that makes the sum of all error terms for the period 2000-2005 equal to zero.

Equation 4.30: *White maize net exports (thousand tons): Near-Autarky*

Explanatory variable	Parameter	p-value	Elasticity
Intercept	-622.02		
WMPROSA / WMDUSA	1745.01	0.082	2.207
(WMPPSA / (WMIMR+WMEXA / 2))	-586.40	0.343	-0.607

R^2 = 0. 212 DW = 0.63 F-value = 2.15

Variable name	Definition	Units
WMPROSA	White maize production	Thousand tons
WMDUSA	White maize domestic use	Thousand tons
WMPPSA	White maize SAFEX price	R/ton
WMIMR	White maize import parity – Randfontein	R/ton
WMEXA	White maize export parity – Africa	R/ton

The P-Q diagram in chapter 3 can be used as a graphic depiction of this equation. Section "*ij*" of net export demand graphically depicts this net export demand equation. The section "*ij*" clearly illustrates that under autarky conditions net export demand is expected to be inelastic; in the case of white maize -0.607.

Equation 4.31 illustrates the market clearing identity where the new equilibrium price equals the old equilibrium price plus excess demand. The model solves for market equilibrium with the help of the Gauss-Seidel algorithm and the new market equilibrium is reached when the export demand equals zero. Equation 4.31 illustrates the equilibrator in a purely technical sense. The equilibrator is based on the closing identity as presented in equation 3.32[1] and the market equilibrium price is reached once excess demand is zero

Equation 4.31: *Real white maize SAFEX price (R/ton) – Autarky equilibrator*

Variable name	**Formula**
Beginning real white maize price	1. = LAG (RWMPPSA)
White maize net export demand	2. = WMNESA
White maize export supply	3. = WMPROSA + LAG(WMENDSA) - WMDUSA – WMENDSA
White maize excess demand	4. = 2-3
New real white maize producer price	5. = LAG (RWMPPSA) + Excess demand

Under the import parity regime domestic prices are determined by behavioural price linkage equations. Price linkage equations are most appropriate when domestic markets are integrated with world markets with continuous trade flow. Under these conditions, the law of one price suggests that the correlation between the world price and the domestic price equals one. In equation 4.32, the real domestic white maize price is estimated as a function of the real import parity price in Randfontein. The model performs well with a R^2 of 0.81 and a price transmission elasticity close to 1 at 0.916. As mentioned in chapter 2, in the case of imports a transmission elasticity smaller than one is plausible because we expect the domestic price to be higher than the world price before transport costs are paid (Brooks and Melyukhina, 2005; Sharma, 2002). This equation clearly suggests that if the domestic market is trading under an import parity regime, the domestic market is well integrated with the world market. Because trade is only perfectly elastic at import or export parity if a number of assumptions hold that may not be true in the South African case, like the assumptions that products are homogenous, net export demand was included in the estimations but proved to be statistically insignificant. Therefore, when the market is trading under import parity, the domestic market price is only modelled as a function of the import parity price.

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[1] $EXS_t = PROD_t - CONS_t - (BEGS_t - ENDS_t)$

It is important to note that equation 4.32 is actually the inverted import supply equation that is portrayed by section "*hi*" in the P-Q diagram (chapter 3) as negative export demand. In chapter 3 this section is illustrated as being very elastic, but because net exports are not included in equation 4.32, it implies that section "*hi*" is in fact infinitely elastic for white maize.

Equation 4.32: *Real white maize SAFEX price (R/ton): Import parity regime*

Explanatory variable	Parameter	p-value	Elasticity
Intercept	-6.219		
RWMIMR	0.9240	0.001	0.916

R^2 = 0. 813 DW = 2.28 F-value = 6.93

Variable name	Definition	Units
RWMIMR	Real white maize import parity – Randfontein	R/ton

Where the market trades under the export parity regime, it is expected that the domestic market is well integrated with the world market and the domestic price is a function of the export parity price. Equation 4.33 presents the results of the price linkage equation under the export parity scenario. This equation performs even better than the price linkage equation under the import parity regime and, interestingly, net exports proved to be significant and are therefore included in the model with an elasticity of -0.101. This negative relationship between net exports and the domestic prices often causes great confusion as one tends to forget that this equation is actually an inverted export demand equation. In an export demand equation the negative relationship between the domestic price and net exports can easily be explained since net exports are expected to increase as domestic prices decrease. This same negative relationship holds in the inverted export demand equation. However, it is important to keep in mind that the impact of net trade (elasticity = -0.101) on price is much lower compared to the impact of the export parity price on the domestic price (elasticity = 1.18).

Equation 4.33: *Real white maize SAFEX price (R/ton) – Export parity regime*

Explanatory variable	Parameter	p-value	Elasticity
Intercept	12.43		
WMNESA	-0.06	0.132	-0.09
RWMEXA	1.39	0.001	1.18

$R^2 = 0.934$ DW = 1.36 F-value = 84.75

Variable name	Definition	Units
WMNESA	White maize net exports	Thousand tons
RWMEXA	Real white maize export parity – Africa	R/ton

For the same reason that one expects that perfect price transmission in the case of imports implies an elasticity of less than one, in the case of exports we expect that perfect price transmission would correspond to an elasticity greater than one (1.18 in the case of white maize exports).

Again the P-Q diagram can be used for the graphic depiction of this inverted export demand equation, with the almost infinite-elastic section "*jk*" that depicts the positive level of net exports. One can obtain a good indication of the elasticity for section "*jk*" by calculating the inverted elasticity from equation 4.33 as follows:

$$\text{Export demand elasticity} = \frac{1}{-0.09} = 11.1$$

This calculation shows clearly that the net export demand is very elastic under the export parity regime.

For the import and the export parity regime, net exports are used as the closing identity for the model. Net exports are calculated as follows:

Equation 4.34: *White maize net exports (thousand tons)*

WMNESA = LAG (WMENDSA) + WMPROSA – WMDUSA - WMENDSA

Variable name	Definition	Units
WMNESA	White maize net exports	Thousand tons
WMENDSA	White maize ending stocks	Thousand tons
WMPROSA	White maize production	Thousand tons
WMDUSA	White maize domestic use	Thousand tons

In order to derive exports, imports are modelled as a function of net exports (equation 4.35) and added to net exports (equation 4.36).

Equation 4.35: *White maize imports (thousand tons)*

Explanatory variable	Parameter	p-value	Elasticity
Intercept	268.873		
WMNESA	-0.2238	0.02	-10.695

$R^2 = 0.386$ DW = 1.97 F-value = 6.93

Variable name	Definition	Units
WMNESA	White maize net exports	Thousand tons

Equation 4.36: *White maize exports (thousand tons)*

WMESA = WMNESA + WMISA

Variable name	Definition	Units
WMESA	White maize exports	Thousand tons
WMISA	White maize imports	Thousand tons

Equations 4.37 and 4.38 represent the equations required to close the yellow maize model under near-autarky, and equations 4.39 through 4.40 represent the model closure under the import parity market regime.

When the market is in near-autarky, net exports are estimated as a behavioural equation and prices are used to close the model. In equation 4.37 yellow maize net exports are modelled as a function of the ratio of the yellow maize SAFEX price over the average of the yellow maize import parity and export parity price. In contrast to white maize, no relationship was statistically determined between production, consumption and net exports. From the results below, the equation evidently also does not perform well with a R^2-value of only 0.13. A price elasticity of -0.93 also seems to be too high if one takes into consideration that under true autarky no trade occurs and prices are not influenced by the level of trade. However, industry specialists are of the opinion that the relationship between domestic and parity prices does play a major role in the trade flow of yellow maize, and not regional demand issues as was the case with white maize. Human consumption only makes up approximately six percent of total domestic consumption. Therefore, the regional demand issues in the yellow maize market are fundamentally different from those in the white maize market. Yellow maize net exports are frequently zero, whereas average white maize net exports over the past five years have been approximately 900 000 tons.

Equation 4.37: *Yellow maize net exports (thousand tons): Near-autarky*

Explanatory variable	Parameter	p-value	Elasticity
Intercept	207.09		
(YMPPSA/(YMIMD+YMEXA/2))	-144.84	0.16	-0.93

$R^2 = 0.13$ DW = 1.074 F-value = 2.19

Variable name	Definition	Units
YMPPSA	Yellow maize SAFEX price	R/ton
YMIMD	Yellow maize import parity – Durban	R/ton
YMEXA	Yellow maize export parity – Africa	R/ton

If one relates these results to the P-Q diagram, it implies that section “*ij*” of export demand is actually more elastic towards the domestic price than is illustrated by the diagram. Theory suggests that export demand under autarky should be perfectly inelastic. However, with an elasticity of -0.93, net export demand for yellow maize under the near-autarky regime is almost unitarily elastic. Since the statistical performance of this model is so weak, the performance evaluation of simulation results in chapter 5 will determine if this equation is behaving correctly under various scenario analyses.

The yellow maize price equilibrator is based on the same principles as the white maize equilibrator. Equation 4.38 illustrates the equilibrator in a purely technical sense. This is the market clearing identity for yellow maize where the new equilibrium price equals the old equilibrium price plus export demand. The new market equilibrium price is reached when the export demand equals zero.

Equation 4.38: *Real yellow maize SAFEX price (R/ton): Near-Autarky equilibrator*

Variable name	Formula
Beginning real yellow maize price	1. = LAG (RYMPPSA)
Yellow maize net export demand	2. = YMNESA
Yellow maize export supply	3. = YMPROSA + LAG(YMENDSA) - YMDUSA – YMENDSA
Yellow maize excess demand	4. = 2-3
New real yellow maize producer price	5. = LAG (RYMPPSA) + excess demand

Under the import parity scenario, prices are linked to the world market by means of a price linkage equation, allowing net exports to be determined as the difference between supply and demand at those prices. Equation 4.39 shows that under import parity conditions the law of one price holds with the elasticity (1.064) basically equal to one. This function can also be interpreted as the inverted import supply function that is represented by section "*hi*" (negative net export demand, therefore, imports) of net export demand in the P-Q diagram (figure 3.3). As was the case with white maize, net trade in yellow maize was included in earlier versions of the model, but proved to be statistically insignificant and was dropped from the equation. This implies that yellow maize imports (section "*hi*") are perfectly elastic when the market trades under the import parity regime. Equation 4.39 performs very well with a high R^2 value and F-value.

Equation 4.39: *Real yellow maize SAFEX price (R/ton): Import parity regime*

Explanatory variable	Parameter	p-value	Elasticity
Intercept	-24.47		
RYMIMD	1.066	0.001	1.06

R^2 = 0. 979 DW = 1.21 F-value = 344.93

Variable name	Definition	Units
RYMIMD	Real yellow maize import parity – Durban	R/ton

Net exports are used as the closing identity for the model under the import parity regime. As mentioned previously, yellow maize exports have shrunk drastically in recent years and over the past three years South Africa has in fact been a net importer of yellow maize. Early projections suggest that a reasonable surplus will be produced in the current season and net exports will be positive. Net exports are calculated as follows:

Equation 4.40: *Yellow maize net exports (thousand tons)*

YMNESA = LAG(YMENDSA) + YMPROSA – YMDUSA - YMENDSA

Variable name	**Definition**	**Units**
YMNESA	Yellow maize net exports	Thousand tons
YMENDSA	Yellow maize ending stocks	Thousand tons
YMPROSA	Yellow maize production	Thousand tons
YMDUSA	Yellow maize domestic use	Thousand tons

Yellow maize imports are directly related to net exports in equation 4.41. The equation performs very well and shows a strong relationship between imports and net exports. Eighty-three percent of any change in net trade is reflected in imports.

Equation 4.41: *Yellow maize imports (thousand tons)*

Explanatory variable	**Parameter**	**p-value**	**Elasticity**
Intercept	534.287		
YMNESA	-0.83383	0.001	-2.71
SHIFT02	-295.895	0.073	
DUM94	1750.31	0.001	

$R^2 = 0.967$ DW = 1.35 F-value = 89.5

Variable name	**Definition**	**Units**
YMNESA	Yellow maize net exports	Thousand tons
SHIFT02	Indicator variable equal to 1 from 2002 onwards	
DUM94	Indicator variable equal to 1 in 1994, 0 otherwise	

Exports can now be derived as an identity (equation 4.42) by adding imports to net exports.

Equation 4.42: *Yellow maize exports (thousand tons)*

YMESA = YMNESA + YMISA

Variable name	Definition	Units
YMESA	Yellow maize exports	Thousand tons
YMISA	Yellow maize imports	Thousand tons

Of the three crops included in this study, the wheat model has the most basic structure with model closure only set up to solve for prices under an import parity market regime, allowing net imports to be calculated as the difference between domestic supply and domestic demand. This makes South Africa a net importer of wheat with the domestic markets integrated with world markets and, according to the law of one price, a coefficient of one is expected in the linear price transmission equation if all the elements in the import parity calculations are in the same units.

Equation 4.43: *Real wheat SAFEX price (R/ton): Import parity regime*

Explanatory variable	Parameter	p-value	Elasticity
Intercept	38.54		
RWIMR	0.87	0.001	0.93
SHIFT 02	37.11	0.001	

$R^2 = 0.92$ DW = 1.2 F-value = 237.92

Variable name	Definition	Units
RWIMR	Real wheat import parity – Randfontein	R/ton
SHIFT 02	Indicator variable equal to 1 from 2002, onwards	

Equation 4.43 relates the wheat SAFEX price to the import parity price of hard red winter wheat at Randfontein, and results suggest a price transmission elasticity of 0.93. As mentioned previously, in the case of imports a transmission elasticity smaller than one is plausible because we expect the domestic price to be higher than the world price before transport costs are paid (Brooks and Melyukhina, 2005; Sharma, 2002).

Chapter 2 (figure 2.3) shows that the wheat SAFEX price traces the import parity price of hard red winter wheat very closely. A shift is included in the equation to capture the structural shift that occurred in the wheat market in 2002. Whereas the domestic price traded below the import parity price before 2002, it has been trading correctly at import parity levels for the past three years. This structural shift can be explained by the sharp depreciation in the rand together with a short maize crop in the Southern African region, which led to a sharp increase in the maize prices. Farmers in the summer rainfall region substituted wheat for maize; hence, domestic production of wheat decreased and large volumes of wheat had to be transported inland to the main consumption hub, Gauteng, lying next to Randfontein. Whereas South African wheat farmers have on average produced 78 percent of domestic use over the past five years, the sharp decrease over the past three years in the area planted to wheat in the summer rainfall region has resulted in farmers only supplying 64 percent of domestic use.

The origin of imports also plays a major role since the quality of the wheat is largely determined by the origin. Argentinean wheat is, for instance, regarded in the domestic market as lower-quality wheat and is mixed into the "grist" of wheat that is used in the milling and baking process. Depending on the season, Argentinean wheat can be imported more cheaply into South Africa than American hard red winter wheat. The distinction between origins of imports goes beyond the scope of this study.

Since South Africa is a net importer of wheat, net imports are used as the closing identity for the model. Net imports are calculated as the difference between total domestic consumption plus ending stocks, and total production plus beginning stocks.

Equation 4.44: *Wheat net imports (thousand tons)*

WNISA = WDUSA + WENDSA - LAG(WENDSA) - WPROSA

Variable name	Definition	Units
WNISA	Wheat net imports	Thousand tons
WDUSA	Wheat domestic use	Thousand tons
WENDSA	Wheat ending stocks	Thousand tons
WPROSA	Wheat production	Thousand tons

Exports are estimated as a function of net imports. Equation 4.45 shows that exports decrease by 13.7 percent if net imports increase by 10 percent.

Equation 4.45: *Wheat exports (thousand tons)*

Explanatory variable	Parameter	Elasticity
Intercept	220.63	
WNISA	-0.11	-1.37

Variable name	Definition	Units
WNISA	Wheat net imports	Thousand tons

Wheat imports are calculated as wheat net imports plus wheat exports.

Equation 4.46: *Wheat imports (thousand tons)*

WISA = WNISA + WESA

Variable name	Definition	Units
WISA	Wheat imports	Thousand tons
WNISA	Wheat net imports	Thousand tons
WESA	Wheat exports	Thousand tons

4.3 THE REGIME-SWITCHING MECHANISM

This section explains the technical introduction of the mechanism or selector in the model that determines the switch between various model closure techniques, which are dictated by the market regime. The white maize model consists of a selector that can switch between three different model closure techniques' namely model closure under import parity, export parity and near-autarky. The selector in the yellow maize model can switch between model closure under import parity and near-autarky. No selector is introduced in the wheat model since this model only closes under the import parity market regime.

Figure 4.1 presents the regime selector graphically and shows clearly how the domestic price can fluctuate between the export parity price (lower band) and the import parity price (upper band). The simple construction shows that the mean parity price anchors a symmetric band with a width equal to transaction costs included in the calculation of the import and export parity prices as presented in chapter 2.

Theoretically speaking, an arbitrage opportunity for importing (exporting) should only surface if the domestic market-clearing price is greater (less) than or equal to the import (export) parity prices. If the domestic market price is trading between the import and export parity prices, no opportunity for arbitrage should exist and therefore no trade should occur. However, since some level of trade does occur under what this study refers to as near-autarky, the switch between the different model closure techniques cannot be based on the level of trade flow but on the level of the domestic market-clearing price. In other words, the selection of an alternative model closure technique for a specific commodity is triggered by the level of the domestic market-clearing price. For example, if South Africa has a short crop due to a drought, the equilibrium pricing conditions will solve for a market-clearing price closely equal to the import parity price as grain is imported into the country. Now an alternative model closure technique is triggered and the selector will switch to the appropriate model closure.

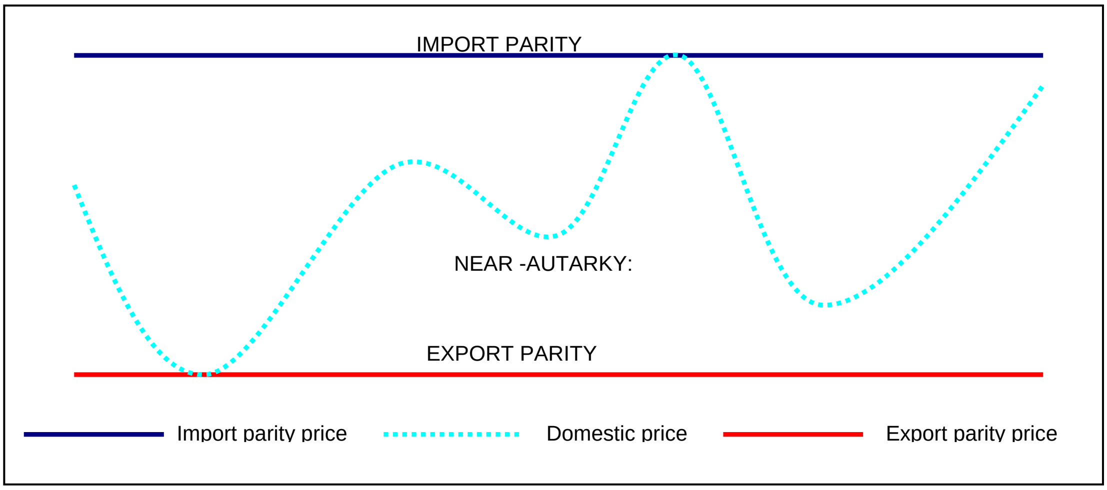

Figure 4.1: The regime selector

When the model is solved and the iteration process starts, it begins with the domestic price set to the average of the import and export parity price solving using the near-autarky closure. The model explores the price space bound by import parity and export parity. In other words, the model solves under near-autarky until the prices that are solved in the iteration process move to the import or export parity boundary, at which stage a new model closure technique is triggered and the model switches to close the industry either by means of net imports or net exports. This mechanism is established through a range of *if*-statements in Excel. The inclusion of the regime-switching technique sharply increased the number of iterations necessary for the model to reach equilibrium in all markets.. After resetting itself, the new sector model reaches equilibrium in all the commodity markets after approximately 3000 iterations.

Alternative market equilibriums can now be simulated for a range of alternative equilibrium pricing conditions. This will be illustrated in chapter 5. The model solves for only one market-clearing price under the appropriate model closure technique. The model also assumes a constantly changing long-run equilibrium that is defined by the relative regime probabilities. It should be clear that since the exact timing of future regime changes cannot be predicted (for example the occurrence of a drought), the long-run equilibrium can be subject to a kind of path dependency. This seems to contradict the conventional view of market equilibrium, but presents a more realistic view of economic processes and the impact of external influences on the sector.

It is important to note that the various model closures are triggered by the same set of parity prices that are used in the estimations of the various parameter estimates that are imposed in the simulation model. For example, in the white maize model the trigger mechanism for model closure under an import parity regime is based on the import parity price at Randfontein. Once the model has switched to an import parity regime, the domestic price is modelled as a function of the import parity prices in Randfontein. Although the domestic market is influenced by the import parity price at the harbours, it is actually the inland (Randfontein) import parity price that determines the upper level of the domestic prices in the case of white maize and wheat since large volumes are transported to the main inland consumption hubs. In the yellow maize market, the import parity price at Durban harbour is used for the trigger mechanism and the actual estimation.

In the white maize model, the selector is set up so that the model will close under the import parity regime if the domestic price moves higher than the import parity price at Randfontein, and the model will close under the export parity regime if the model moves lower than the export parity price into Southern African markets. For prices between these levels, the model will use the near-autarky equations. In the same fashion, in the yellow maize model the selector is set up so that the model will close under the import parity regime if the domestic price moves higher than the import parity price at Durban harbour, and for any other price the model closes under autarky. The wheat model constantly solves under the import parity regime.

4.4 SUMMARY

This chapter has postulated the structure of the redesigned commodity model that is able to generate estimates under switching market regimes. The white maize model consists of nine behavioural equations, seven identities and model closure is set up for all three market regimes. The yellow maize model consists of eight behavioural equations and six identities. Whereas the white maize model is set up to close under all three market regimes, the yellow maize model can close under autarky and the import parity regime, as South Africa has not been a significant net exporter of yellow maize since the deregulation of the markets in 1997. The wheat model consists of nine behavioural equations, seven identities and the model closes only under the import parity market regime.

The estimated price and trade equations for the various industries performed according to *a priori* expectations and a number of useful elasticities were calculated that explain the relationship between world and domestic prices, and net trade under the various trade regimes. Contrary to the theoretical principle that no trade occurs if the market is in autarky and the net export demand should be perfectly inelastic, trade occurs under what this study defines as near-autarky, and net export demand for white and yellow maize proved not to be perfectly inelastic, with estimated elasticities of -0.607 and -0.930. Under the import parity regime, net imports proved to be perfectly elastic and price transmission elasticities of 0.916 and 1.064 were estimated for white and yellow maize respectively. Under the export parity regime, net export demand for white maize proved to be very elastic (elasticity = 9.9) and a price transmission elasticity of 1.11 was estimated.

This chapter presented the performance of the single equation estimations. The true simulation capability and performance of the model will be analysed in the following chapter when the baseline projections are presented and shocks are introduced in the forecasting period. Whereas chapter 4 reported on the elasticities that were estimated by single equations, chapter 5 presents the elasticities that were generated in the dynamic, closed system of equations.