Domestic Wheat Demand in a Deregulated Environment: Modeling the importance of quality characteristics

Submitted by

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ABSTRACT

The implementation of the Marketing of Agricultural Products Bill, 1996, and the tariffication of agricultural goods in accordance with the Marrakesh Agreement has significant implications for the domestic wheat industry. The new regulations challenge the ossified single-channel fixed price marketing structure of the past and expose domestic producers and processors to increased price volatility, a higher risk exposure and regional and international competition for a market share. The focus of the new marketing system is that of demand; a substantial shift from the producer orientated system of the past. A consequence is the ascendancy of quality as a determinant of wheat demand. Past models of deregulation and trade liberalisation have ignored the role wheat quality will play in influencing the competitiveness of producers in relation to both domestic and international producers. Thus, a demand orientated cost minimising non-linear programming model (Input Characteristic Model) is developed which evaluates the demand for different wheat sources as a function of their quality characteristic levels, characteristic variances and prices. The quality characteristic data for the different sources of wheat were obtained from quality analyses done by the Wheat Board. Through the use of the dual and the inclusion of international sources of wheat, a set of regional prices for domestic wheat is determined. Using these prices, the response in demand for wheat to a number of market scenarios such as regional production variations, regional price variations and quality characteristic variations, are simulated. The results of the simulations suggest that a tariff of 66% as proposed by the Wheat Forum in 1994 overprotects the industry and will lead to substantial increases in bread prices. Further, the Western Cape faces a quality constraint in terms of its ability to compete with international and domestic wheat sources. Protection through tariffs is only a short term solution and a substitution towards higher quality wheat or other crops is necessary. Lastly, the importance placed on wheat quality data, a reliable grading system, accurate price, production and quality predictions and research into improving wheat cultivars suggests the need for continued involvement in the wheat industry by institutions such as the Wheat Board.

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Chapter 1

INTRODUCTION

The implementation of the Marketing of Agricultural Products Bill, 1996, and the tariffication of agricultural goods in accordance with the Marrakesh Agreement signifies major changes for domestic agriculture, both within the confines of the South African borders and in relation to the international market. The stable relationships of the past have been replaced with an uncertainty of how domestic agriculture will respond to the new dynamics and what the implications for the broader economy will be.

Aggregate analysis of the implications of the emerging market structure is made difficult by the heterogeneity of agricultural products and their diversity in terms of comparative advantage; the influence of the various institutional structures inherited from past statutory marketing interventions (marketing schemes and control boards); and the strength of downstream linkages with the processing sectors. In addition, the international environment for each product has its own unique characteristics with respect to price flows, trade agreements and political sensitivity. It is thus best to focus on a single commodity chain and evaluate the impact on all levels of the marketing chain from production to consumption.

The wheat sector provides an interesting case study of deregulation and trade liberalisation given wheat's considerable contribution towards field crop production, its extensive use of land (especially in the Western Cape), its importance as a staple food and its role as a primary input into the baking and milling industry. Changes in wheat production will have sizable impacts on the government's agricultural related concerns such as food security, land reform, the agricultural trade balance and industrial development.

This dissertation attempts to discern how past marketing arrangements will adjust to the new milieu and the implications this will have on the production and processing sectors of the wheat industry. The emphasis on liberalised markets challenges the ossified marketing relationships established under the single-channel fixed price *Winter Cereal* scheme. The emergence of new opportunities and constraints will influence the interaction of market agents as they attempt to link raw material production to consumer needs. Through an overview of the wheat industry and an analysis of the Marketing of Agricultural Products Bill, 1996, Chapter 2 describes the development of a *demand orientated* wheat marketing system. Whereas in the past producers were secured an outlet for their produce, their ability to sell wheat in the future will depend on the extent to which it satisfies the processing and consumer sector's wheat quality requirements.

Consumer demands for high quality bread translates into the demand for wheat by the milling sector that contains those wheat characteristics (end-use characteristics) necessary for the production thereof. Because wheat is heterogeneous in these characteristics, differential prices and demand relationships will emerge under deregulation for different sources of wheat. Given the significant quality differentials amongst the wheat producing regions of South Africa, the impact of trade liberalisation and deregulation will vary amongst regions.

The focus on wheat demand as a function of quality and price necessitates the development of alternative models from the supply orientated trade models of the past. This is done in Chapter 3 with a theoretical exposition of an Input Characteristic Model (ICM) that captures the demand requirements of the consumer sector. The ICM is a cost minimising non-linear programming model that evaluates the demand for different wheat sources as a function of their characteristic levels, characteristic variances and prices. By including international wheat sources and breaking down domestic wheat production into its respective regions, the regional dynamics initiated by deregulation and trade liberalisation can be captured.

The development of an ICM to estimate the effects of trade liberalisation and deregulation on the domestic wheat industry is done in Chapter 4. A significant part of the chapter is devoted to determining "demand derived" prices reflective of the characteristic composition of each domestic wheat source are determined. These prices form the basis from which sensitivity analyses are performed to evaluate the reaction in demand to fluctuations in regional prices, production and characteristic variance. The sensitivity analyses enable a deeper understanding of regional wheat demand under a liberalised and deregulated market. Numerous policy suggestions follow.

Chapter 2

MARKETING SYSTEMS: THE LINK BETWEEN PRODUCTION AND CONSUMPTION

1. INTRODUCTION

Because the Marketing of Agricultural Products Bill, 1996 entails a restructuring of agricultural marketing it is necessary to delve into what constitutes a marketing system. Three elements play an important role in shaping the character of a marketing system: *production*, *consumption* and *government intervention*.

A food marketing system is best conceptualised as "*the physical and economic bridge which links raw material production and consumer food purchases*" (Jaffee, 1995: 21). The marketing process involves all the transactions, resource flows (such as finance), information flows and product flows that smoothly co-ordinate agricultural consumption and production decisions in terms of quantity, quality, time and place. The marketing process further has to stimulate production at the farm level and enhance demand for the final good. To function effectively the market system gives rise to an organisational structure comprised of institutions such as co-operatives, agricultural banks, traders and transport networks that are moulded around the particular characteristics of the *production* and *consumption* sectors of the commodity chain.

A third factor influences the form of the organisational structure: government policy. Government interventions - for reasons such as the provision of public goods and the realisation of objectives such as food self sufficiency, price stability and increasing farmer incomes - regulate the linkages between consumers and producers. This involvement is not neutral and is often biased towards the protection or favouring of certain sectors within the commodity chain. This bias can be termed *market orientation*.

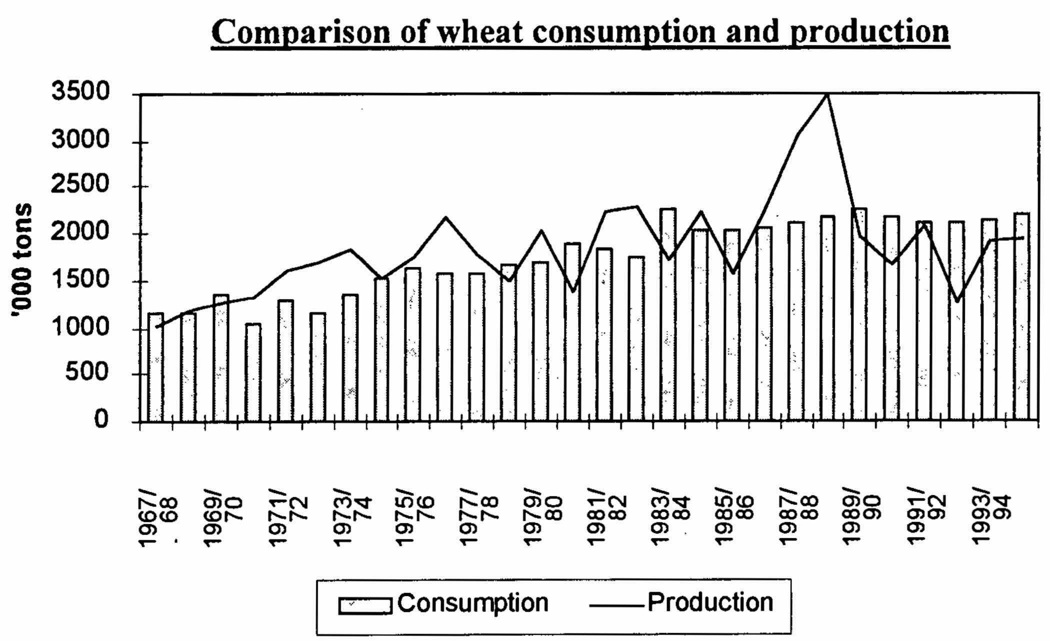
An analysis of marketing systems in terms of consumption, production and market orientation gives insight into the forces governing interaction between agents within the commodity chain. It thus provides a useful conceptual framework for evaluating the changes induced within the wheat sector by the implementation of the Marketing of Agricultural Products Bill, 1996. In this chapter the framework is used to pick out the key domestic features of past wheat production and consumption and the regulated market linkages of the single-channel fixed price system. The Marketing of Agricultural Products Bill, 1996 is then introduced and discussed with the aim of proposing a model that integrates some of the key features of the new milieu.

2. CHARACTERISTICS OF THE DOMESTIC WHEAT INDUSTRY

2.1 Production

Figure 1 shows the trends of domestic wheat purchases by the Wheat Board and domestic wheat consumption since 1968. Both consumption and production grew strongly to the mid-1970s at which time production growth slowed. The continued strong growth in consumption until the mid-1980s could not always be met by domestic production resulting in shortfalls being imported. Although consumption growth has slowed over the past decade, the necessity for imports has increased because of a declining trend in production since the mid-1980s. In recent years domestic consumption requirements (approximately 2.1 million tons) have consistently exceeded domestic production placing South Africa firmly into the camp of net importers.

FIGURE 1



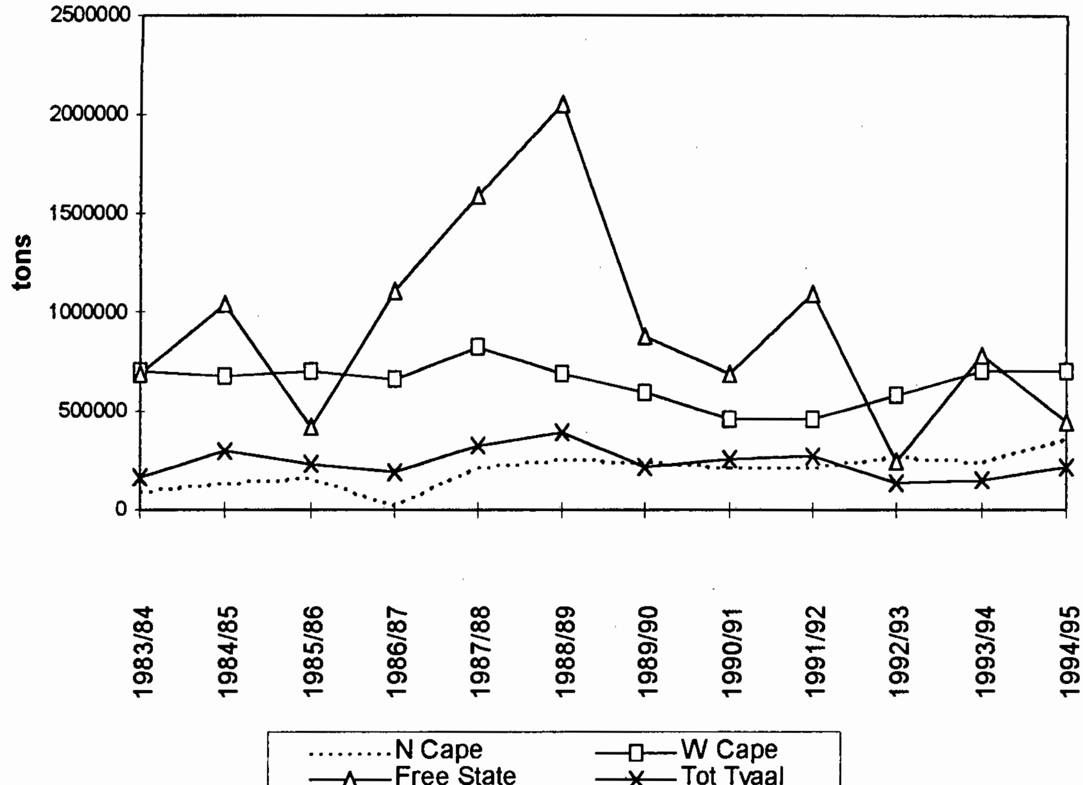
Source: Directorate of Agricultural Trends (1995)
Note: Production is taken as the Wheat Board purchases and consumption is gross human consumption (both in 1000t).

Regional production and volatility

The breakdown of national production into its constituent regions in Figure 2 reveals that, in most years, the Free State is the dominant wheat producer, with the Western Cape, Northern Cape and Transvaal following in order of size. Between the 1985/86 and 1994/95 seasons the Free State produced on average 44.7% of total wheat production while the Western Cape, Transvaal and Northern Cape produced 30.5%, 11.5% and 10.7% of total production, respectively.[1]

FIGURE 2

Regional wheat production in South Africa



Source: Wheat Board.
Notes: Total Transvaal includes Mpumalanga, Northern Province, Eastern Transvaal and Gauteng. The values for Eastern Cape and Natal are not included as they constitute less than 5% of total production.

A greater concern than the level of production is the volatility of this production. From Figure 1 and Figure 2 it is clear that both regional and national production is highly volatile. De Kock

[1] Note that these values are distorted by the exceptionally high levels of Free State production during 1987/88 and 1988/89.

(1991), in a breakdown of production variation into sub-regions (see Table 1), notes that between 1970 and 1990 the Eastern Free State, Rest of Free State and the Swartland displayed the greatest variation in production with coefficients of variation of 44.5%, 46.1% and 38%, respectively. The Ruens and former Transvaal have lower, yet still large, coefficients of variation (26% and 32.1%, respectively). Although volatility of regional production is in most cases greater than national volatility, the regions tend to cancel each other out lowering the coefficient of variation for South Africa as a whole (27.6%) (Van Zyl and Niebuhr, 1991: 168).

TABLE 1

Variations in regional wheat production, 1970 to 1990

Region	Coefficient of variation (%) Volume	Area	Yield
Swartland	38.0	11.8	14.8
Ruens	26.0	15.4	18
Eastern Free State	44.5	10.7	38.5
Rest of Free State	46.1	32.8	36.1
Former Transvaal	32.1	46.8	35.8
South Africa	27.6	13.7	22.5

Source: De Kock (1991)
Note: Coefficient of variation is only a rough indicator of variation. Problems arise when used on non-stationary or skewly distributed data.

The volatility of wheat production in South Africa is due to economic factors and the climatic and agronomical features of the different regions. Variations in volume can be broken down into two sources: variation in area planted and variation in yield (see Table 1). Variation of the former captures a combination of expectation-induced changes as farmers react to expected prices of all possible production goods and expected climate.[2] High wheat prices and favourable weather patterns will positively affect area planted. Variation in yield represent the climatically induced effects on final output.

These factors underlie the volatility of production within the Western Cape and Free State. As a result of shallow lands the Western Cape necessitates adequate rain prior to planting with properly distributed and timeous follow-up rains during the growing season. Although the area

[2] Although weather patterns can never be determined with certainty, the distribution of weather patterns can be estimated and the probability of occurrence and magnitude can be captured within a confidence interval (Hill *et al*, 1982: 13).

is not stricken with droughts, the soil conditions make production volumes vulnerable to climatic changes. The more volatile production in the summer rainfall areas (Free State and Transvaal) is predominantly caused by greater fluctuations in rainfall from year to year (Agrocon, 1993: 25). This is reflected in the significantly larger variation in yield in these areas. An expectation-induced component reflected in the variation of area planted may also underlie the differences in production variation. Within the Free State the high cross price elasticity of supply between wheat and maize (- 1.40) can cause significant movement out of wheat and into maize production in response to small increases in the maize price (Van Zyl and Niebuhr, 1991: 172). In contrast, the limited substitution opportunities within the Western Cape entail greater production stability in response to price changes. In conclusion, the analysis of regional production suggests that production in the Free State is relatively more risky than in the Western Cape.

Regional protein content and volatility

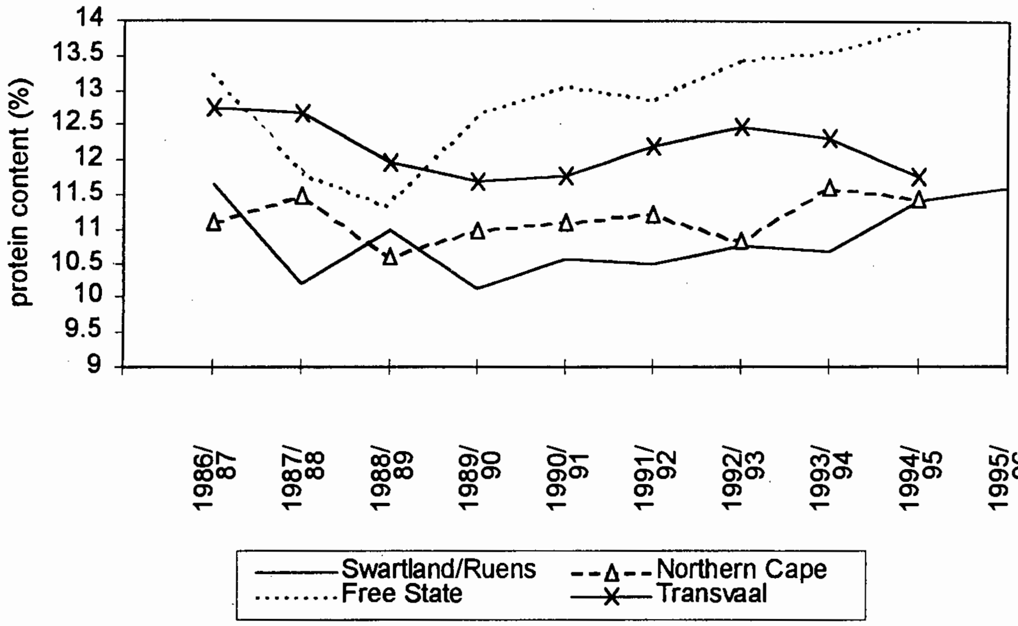
The analysis of regional wheat production is not sufficient to capture the complexity of the production side and needs to be substantiated with an overview of the quality of each source of wheat. A crucial, if not the primary, concern in the wheat sector is the baking quality of wheat. Wheat is primarily utilised in its processed form - flour - for the production of bread. The production of bread is highly influenced by the protein content and quality of the wheat source which play a key role in determining bread volume and bread quality.[3] Protein quality is difficult to measure, but the high degree of correlation between protein quality and protein content implies that the latter serves as a good proxy (Vet, 1995: 13). Both the scale of bread production and the technology used necessitate a high degree of specificity with respect to protein quality (thus protein content). For example: wheat flour with a protein content outside of a 10% to 13% band causes disruptions in the baking process and necessitates costly adjustments to make the wheat flour suitable for bread production (Vet, 1995: 13). As the protein content of flour is usually 1% less than the wheat from which it is milled, the protein content band for wheat is between 11% and 14%. In the case of brown bread, which requires a slightly higher protein content, the lower limit for wheat should be 12%.

[3] During the moistening of flour the protein forms a visco-elastic mass called gluten which retains the gas released during fermentation and causes the bread to rise. In brown bread it also binds the bran so that it does not crumble when cut (Effective Farming, 1991: 31).

The protein content of wheat in South Africa is not uniformly distributed with Western Cape wheat characterised by a lower protein content than the interior regions.

FIGURE 3

Regional variations in wheat protein content



Source: Wheat Board.
Notes: Values are aggregates for the region as a whole and have been calculated using the quantity delivered as weights. Protein measured at 12% moisture basis.

As indicated in Figure 3, the protein level of Free State and Transvaal wheat regularly exceeds the minimum requirements of 12% and it is only during the above-middle rainfall periods (during 1987/88 and 1988/89 season) that it falls below 12%. The Western Cape is strongly contrasted as the protein content of Swartland and Ruens wheat consistently falls below 11%. This is particularly severe for the Swartland - the dominant producer in the region - which had an average protein content of 10.7% between 1980/81 and 1994/95. Depending on the year, the distribution of protein content indicates that between 20% and 48% of the Swartland and Ruens wheat receipts have a protein content of less than 10%. The quantity of wheat receipts exceeding a desirable level of 12% protein content is extremely low and varies between 5% and 20% of total receipts.

The variation in protein content between years is also a matter for concern. Protein quality is governed by genetic inheritance, but variations in quality are predominantly determined by environmental factors such as the quantity of nitrogen fertiliser, time of application, plant sickness, drought and rain, and drowning during different growth stages (McDonald, 1994: 22). Research by the Small Grain Centre in Bethlehem indicates that the cultivar is only responsible for 3% to 4% of variation in quality, while environmental effects are responsible for 80% of the variation (Van Lill, 1992: 15).

Of the environmental factors it is important to discern whether climatic or managerial practices underlie the quality variations. This will indicate the extent to which variations in protein quality can be minimised through improved managerial skills. An analysis of the Figure 2 and Figure 3 suggests that climatic factors dominate. A strong negative correlation between rainfall and protein levels is reflected in the Free State during the wet seasons of 1987/88 and 1988/89 and the drier early 1990s. A similar correlation is apparent in the Western Cape region. This suggests that there are serious limitations to lowering variations in quality through improving managerial practices. In the long run it may be possible to breed and substitute other cultivars with higher protein contents and lower variations.

2.2 Consumption

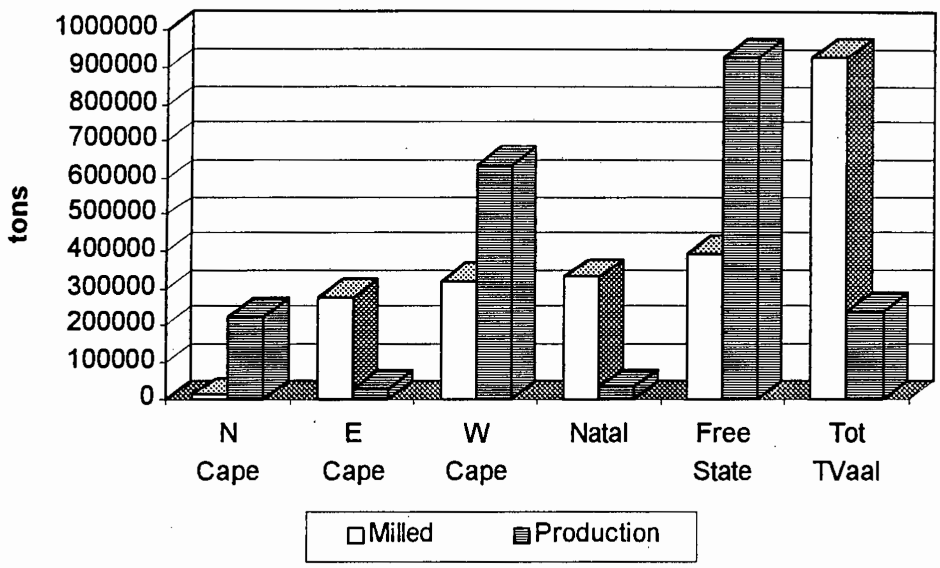
Regional milling

So far the discussion has focused on the production side of the wheat chain; an analysis of wheat demand is required. The primary source of demand for wheat is the milling sector which produces flour for further processing downstream. Small quantities of surplus wheat are utilised as feed grains, although these make up an insignificant amount and can be ignored. The flour produced is used downstream in the bread, confectionery, factory biscuit and private/informal baking sectors. Five types of flour are produced by the milling sector for use within these baking sectors: cake flour, white bread flour, brown bread meal, whole-wheat flour and semolina. Bran is a by-product of the milling process and constitutes a significant component of the milling sector's total output (20% in 1994/95). Consumption of bread flour dominates, with a 77.7% share of total flour consumption in 1994/95. In the past this share was higher, but the rise in cake flour consumption to 21% in 1994/95 has encroached on this level.

As milled wheat is distributed locally for the production of baking goods, the regional breakdown of wheat milled can serve as a proxy for regional consumption. To analyse the relationship between regional wheat production and consumption between 1985/86 and 1994/95, average regional wheat production and clean wheat milled are compared in Figure 4.

FIGURE 4

Regional production and consumption, average 1985/86 to 1994/95



Source: Wheat Board.
Notes: The phenomenal Free State harvests during 1987/88 and 1988/89 bias the Free State average upwards.

As can be seen, the Western Cape, Northern Cape and Free State are surplus producing areas while the Eastern Cape, Natal and total Transvaal are net 'importers' of wheat. The Transvaal area (mainly Gauteng) consumes 41% of total clean wheat milled, but only produces 25.7% of its milling requirements. Although the shortage is preferably sourced from the Free State (due to its high quality), the ability to consistently satisfy excess demand from this source is hampered by the variability of Free State production and the consumption requirements of Natal. In only 4 of the 10 seasons did surplus production in the Free State satisfy excess demand in the Transvaal. Only during the two phenomenal harvest years of 1987/88 and 1988/89 did the Free State manage to supply both Natal and the Transvaal with wheat. In the remaining years the shortage had to be sourced either from the Western and Northern Cape or the foreign market.

2.3 Discussion

The analysis of the production and consumption of wheat has highlighted a few important aspects of the domestic wheat industry that will affect the wheat marketing system.

- Firstly, the primary source of wheat demand is the interior, whereas the dominant producers are the Western Cape and the Free State. As South Africa is not self sufficient in production in most years, the international market is also an important supplier of wheat. Given the different geographical locations of production and consumption, distribution of wheat from the source of supply to the source of demand is central to the marketing system.
- A second factor is the quality of domestic wheat production. Wheat is predominantly used for the production of bread necessitating a high quality wheat. Free State wheat regularly meets the quality requirements, but is insufficient to consistently match the shortage in the Transvaal and Natal. The Western and Northern Cape regions are alternative sources of surplus wheat, but their wheat is of an inferior quality. How wheat is allocated and priced in terms of quality will be an important factor in the marketing of domestic wheat.
- A third factor is the variability of wheat production and wheat quality, especially with respect to the Free State. What spin-offs these have for the sourcing and pricing of wheat is also an important consideration.

These distinctive characteristics of the domestic wheat sector will influence the manner in which wheat is marketed in South Africa. The next section deals with how the regulated wheat marketing scheme dealt with the above mentioned characteristics and the issue of *market orientation*.

3. WHEAT MARKETING UNDER REGULATION

Insight into the marketing of domestic wheat can be gained through a structured analysis of: (a) the process whereby processor's requirements in terms of wheat quantity and quality are met, and (b) the determination of wheat prices. The first point is essentially a distributional problem concerned with how market structures and relationships emerge to overcome shortages and surpluses. The second point is related to the first as price is normally the outcome of the attempt to solve the distributional problem. By focusing on these two points the dynamics and *orientation* of the marketing system can be highlighted. This section focuses on the past regulated marketing structure in terms of these two points with the aim of establishing the context to contrast the future deregulated and liberalised environment.

3.1 Winter Cereal Scheme

Brief historical overview

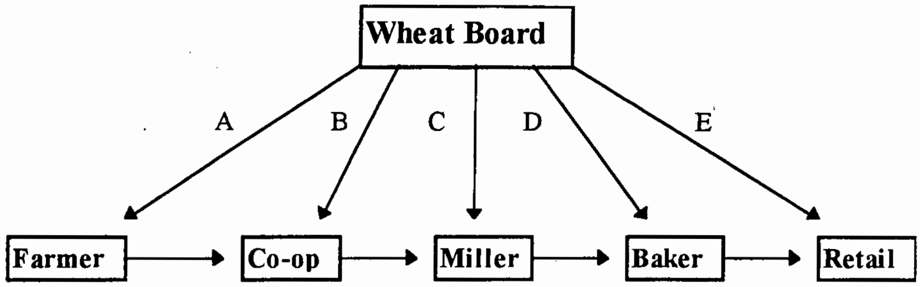
The mid-1930s was a period of intense change in the wheat industry. Pressure for regulation during this period was predominantly related to the pricing of wheat. A shortage of cost effective storage facilities drove down prices at the commencement of the season as freshly harvested wheat flooded the market. The pressure to regulate price fluctuations and to compensate co-operatives, grain traders and producers for the losses incurred in storing and marketing wheat led to the *Wheat Industry Control Act, 1935*. The inability of this regulation to promote price stability and narrow the gap between producer and consumer prices led to stricter regulations being imposed under the *Wheat Control Scheme, 1938*, (established in terms of the Marketing Act, 1937). This regulation set the foundations for the single-channel fixed price marketing system, imposed under the *Winter Cereal Scheme, 1949*, and administered by the Wheat Board, that has prevailed since (Wheat Board, 1949: 3; 1993a:1).[4]

The Wheat Board acted as an umbrella organisation, not actively engaging in the production and processing of wheat, but regulating the activities within and between agents of the food commodity chain. Its composition was biased in favour of wheat producers with a representation of 8 members in comparison to single representatives for non co-operative millers, co-operative millers, processors of barley and oats, bakers of wheaten and rye bread and consumers. A schematic representation of the powers invested in the Wheat Board is given in the diagram and table of Figure 5.

[4] Since the replacement of the 1937 Marketing Act in 1968, the Winter Cereals Scheme was promulgated by Proclamation R.162 of 1974 in terms of Marketing Act, 1968 (Act 59 of 1968), as amended.

FIGURE 5

Schematic representation of the Wheat Board functions



Stage	Relation to Wheat Board
Farmer **A**	• fixation of producer price (subject to approval by Minister of Agriculture until 1994/95) • prohibited to sell wheat to parties other than the Board by way of the Board's agents. Exemption granted for seed use and other specialty products
Co-operative and. other agents **B**	• co-operatives perform handling functions on behalf of the Board purchasing, grading, storing and dispatching) which they are accordingly remunerated • Prohibit to sell and set the price of wheat other than the Board has specified • Board acts as guarantor for Land Bank loans taken to pay for wheat
Miller **C**	• allocation of wheat of different qualities • voluntary market sharing among millers • restrictive registration of millers (until 1986/87) • milling capacity restrictions until 1986/87 • payment of administration levy (until 1989) • fixed prices for semolina, bran, flour (until 1991) • subsidies on flour and meal used in the manufacture of bread until 1977. Only white bread flour, brown bread meal and wholewheat meal in packings of 5kg and smaller, subsidised afterwards • classification, packing and marking requirements
Baker and confectioners **D**	• restrictive registration of bakers and confectioneries (confectioneries until 1977 and bread bakers until 1991) • oven capacity restrictions (confectioneries until 1977 and bread bakers until 1991) • voluntary market sharing • fixed prices for standard regulated bread (until 1991) • bread subsidy (until 1991) • regulation governing the types of bread (till 1991) • classification, packing and marking requirements
Retailer **E**	• retail margin (until 1991) • baking restrictions for super bread (until 1986)

Source: Wheat Board Annual Reports (various years)

As indicated in the table all market transactions such as wheat sales, pricing, distribution, storage and bread and flour production (prior to 1991) were controlled by the Wheat Board. Regulation extended to the international market with quantitative controls administered by the Wheat Board. In 1991 budgetary pressures, a new market orientated ethos and administrative difficulties culminated in the termination of bread subsidies, restrictive registration, price control and the quota system within the processing sector. Control over the distribution and pricing of wheat from farm-gate to mill-door was retained.

Distribution

The single-channel system effectively ossified the distribution links between producers, appointed agents (predominantly co-operatives) and millers. All wheat other than seed wheat and wheat for specialty products (biscuits and specific cultivars for animal feed) had to be sold to appointed agents where it was graded, handled and stored. These agents in turn sold the wheat to designated millers, chosen in terms of a distributional procedure that:

a. minimised the inward railage price of millers; and
b. allocated the same percentage of different classes, subclasses and grades of wheat to mills in the same areas (Wheat Board, 1989/90).

The objective of these distribution policies was to co-ordinate the allocation of wheat to ensure that each mill would receive its *pro rata* share of the different grades of wheat at a minimum total transport cost. The procedure of distribution was also a means to overcome problems associated with the high variability of wheat quality both within regions and between regions (SACB, 1989:5). Nevertheless, this policy was not entirely successful as millers in the low quality coastal regions were at a distinct disadvantage compared to the interior mills who had access to higher quality wheat. Bakers using the Western Cape wheat were and are forced to use expensive additives to improve the baking quality of the flour (Wheat Focus, 1993: 23).

The ability of the Wheat Board to bear the risk of volatile production and quality depended partly on the use of the international market as a source (outlet) for shortfalls (surpluses). Quality considerations were not a constraint as the higher domestic price made the importation of high protein wheat an attractive and profitable (for the government) option. An anomalous situation did exist during surplus years when the government had to offload excess wheat on the international market at a considerable loss. The rigid structure of distribution and the approach to the international market implied that volatility of domestic production was not born by the domestic producer and/or consumer, but was transferred to the international market.

Pricing and grading

A complex system of price control affected the production, milling, baking and retailing components of the wheat industry. Prior to 1988 the domestic producer price was set on a cost plus basis. According to the fixed price system, all producers received the same price for each grade of wheat irrespective of where they were situated. Cross subsidisation was therefore practiced (Wheat Board, 1993: 28). Those producers situated in the outlying areas were subsidised by those closer to the milling centres. After 1988 the cost plus pricing system was replaced by a more market orientated approach which devolved some of the transport costs and "losses" that arose from surplus production to the producer (Wheat Board 1993a: 10).[5] The change in pricing system did not end cross subsidisation as the contribution towards transport by the Southern surplus areas did not fully cover the transport price differential.[6]

The Wheat Board agent was responsible for the delivery to the nearest railage point where a free on rail (f.o.r) price was fixed, after which the miller bore the cost of transport. The f.o.r system was advantageous for the outlying producers as the cost of transporting their wheat to the market was passed on to the millers. The millers also contributed towards marketing costs (financing and insurance of stocks) and Wheat Board administration levies. After 1988 producers were liable for these expenses as well.

A grading system with differential prices exists as a means of identifying the commercial value of various quality grades of wheat. The evaluation of wheat quality is complicated as the notion of 'quality' is subjective and is dependent on the desired functional properties of wheat (Fowler and Priestley, 1991a). Different objectives between and amongst the various stages of the commodity chain entail a wide spectrum of desired functional properties. Farmers desire a grading system that emphasises yield. Millers desire wheat that has a high flour yield of good colour and emphasise factors such as hectolitre mass, percentage damaged kernels, percentage foreign matter and flour ash as important determinants of quality.[7] Bread bakers are interested in the production of a high quality *consistent* bread that has good volume and texture. Modern

[5] These are losses arising from having to export wheat at a lower price than the domestic purchasing price.

[6] The price differential is minimal and only valued at R18 during the 1995/96 season. This is considerably less than the real transport differential.

[7] Flour ash and hectoliter mass serve as indicators of the quantity of flour that can be extracted from the kernel. The higher the hectolitre mass the greater the quantity of flour that can be extracted and the greater the potential profits. The other factors such as foreign matter, damaged kernels and moisture content reflect the quantity of clean wheat that can be milled. These are accounted for in the grading system by a set of specified constraint levels.

day industrial production of bread has raised the importance of wheat that produces flour with a high water absorption, reasonably short mixing time and a good tolerance to variations in processing (Irvine, 1975: 118). It has also increased the specificity of flour characteristic requirements making continuing uniformity of flour quality more important. Thus, bakers desire a grading system that signifies the value of a wheat source in terms of those wheat characteristics crucial to the baking process(these characteristics will be termed end-use characteristics). The different prioritisations of quality characteristics can signify a conflict of interest in the pricing structure of the grading system. However, a consistency in the evaluation of quality is required since the producer and the miller are inseparable from the baker's conception of wheat quality, because their output is a crucial input in the baking industry.

Within South Africa different grades of wheat are largely based on differentials in hectolitre mass, with sub-classes within these grades dependent on protein content. The emphasis on hectolitre mass has favoured millers and producers and not bakers who emphasise wheat quality. Deregulation of the processing industry in 1991 and a greater awareness of consumer needs has shifted the perception of quality towards encompassing those functional properties desired by the consumer (Fowler and Priestley, 1991a:35 ; Simondsen, 1996). Although the greater emphasis on quality in the wheat grading table since November 1991 reflects this trend, many millers still argue that the differentials between grades and especially sub-classes (protein) do not adequately reflect the true value of different qualities of wheat (More, 1994: 11).

3.2 Discussion

The Winter Cereal Scheme dealt with the domestic wheat production and consumption characteristics by ossifying the links between wheat producers and millers. By regulating the allocation and pricing of wheat, market responses (in terms of prices and quality requirements) to changes in production and consumption were dampened. The use of the international market as a residual market facilitated the regulation of the domestic wheat industry because it enabled the Wheat Board to dissipate the effect of supply or demand shocks without influencing price.

The orientation of the wheat marketing system has been strongly favourable to producers who dominated membership of the Wheat Board and who have been assured a secure outlet for their production at a fixed price. The processing industry, on the other hand, has been locked into purchasing domestic wheat at stipulated prices and from stipulated sources. This has restricted the ability of the millers to respond to changing consumer requirements by adjusting wheat purchases and sourcing from the international market. The effect is that lower quality bread is produced; the burden of which is borne by the consumer. The pricing system has protected the outlying producers with the f.o.r milling price and has cross subsidised the Western Cape farmers. These costs have been transferred to the processor who has to bear larger than otherwise costs. Finally, the focus of the grading system has been primarily producer orientated and it is only recently that the importance of the consumer has been recognised.

The Winter Cereal Scheme has not been entirely detrimental to the processing sector. The controversy surrounding the 1991 deregulation of an extensive array of interventions within the processing sector (subsidisation, restrictive registration, market sharing and price control) suggests vested interests of the dominant baking and milling groups. Control over the allocation and pricing of wheat reduced the sourcing and pricing responsibility of millers and limited their risk exposure. Domestic millers have also been protected from international competition by quantitative controls on flour imports. However, subsequent to deregulation of the processing sector in 1991, millers have been in the anomalous position of selling their product in a deregulated consumer driven market, while having to source their inputs from a regulated producer orientated market.

All these stable relationships are set to change with the implementation of the Marketing of Agricultural Products Bill, 1996.

4. DEREGULATION AND TRADE LIBERALISATION

4.1 Marketing of Agricultural Products Bill, 1996

The old system of control is set to change with the implementation of the Marketing of Agricultural Products Bill, 1996, and the tariffication of agricultural goods in accordance with the Marrakesh Agreement. The replacement of Act 59 of the Marketing Act, 1968 under which the *Winter Cereal*

Scheme falls entails a complete restructuring of agricultural marketing within South Africa. According to the draft of the Marketing of Agricultural Products Bill, 1996, two major conclusions can be drawn:

1. no provision is made for a statutory one-channel system as is present in the wheat industry; and
2. statutory levies can be imposed to a maximum of 5% of the producer price.

These points signify the deregulation of control exerted by the Wheat Board in the marketing of wheat. This does not imply that all statutory controls have immediately become void with the passing of the new act, since provision is made for a gradual phasing out of existing regulation. The new Bill also makes provision for private marketing organisations such as pooling arrangements, but stipulates that participation be voluntary. Although the Bill takes the sole power to import and export away from the Wheat Board, it does make provision for the Minister of Agriculture to prohibit the importation and exportation of agricultural goods, but only after consultation with the Cabinet. This does place substantially greater restrictions than before on the powers of the National Agricultural Marketing Council (NAMC) (previously known as the National Marketing Council) to influence trade flows.

The provisions imply that, in the short term, effective changes in the marketing structure may be minimal. This is presently apparent within the wheat industry where participants have agreed to retain the one-channel marketing system for the 1996/97 season and have submitted this request to the Minister of Agriculture for approval. In the long term the new Bill signals a strong move towards a deregulated environment. This move will have major implications for the wheat producing sector.

4.2 Implications

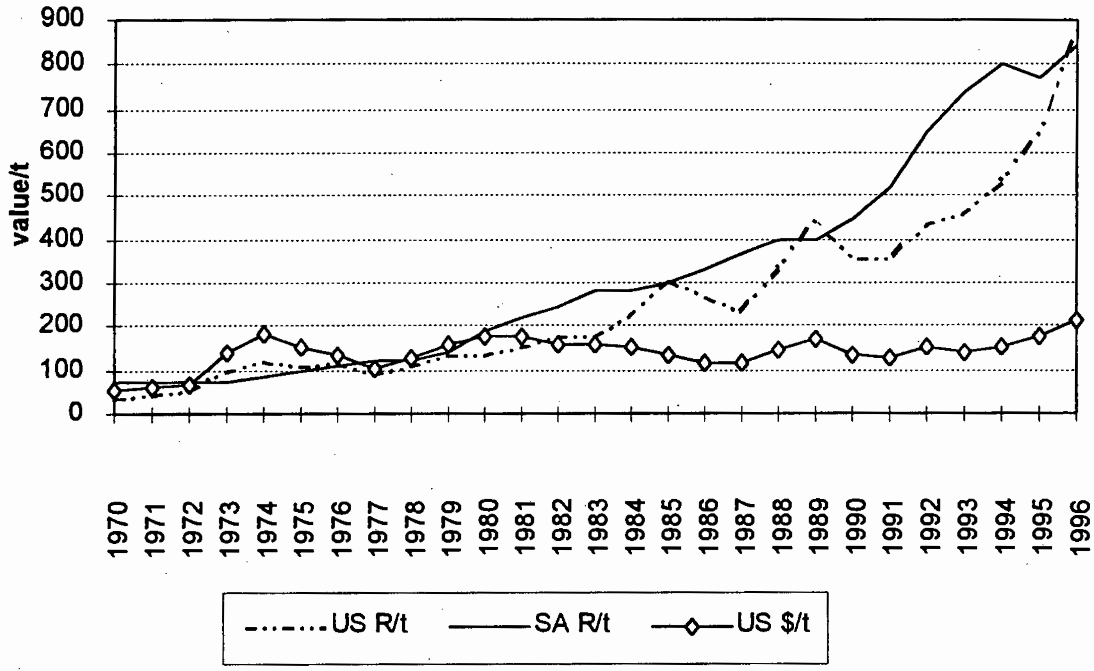
Deregulation and tariffication alters the entire nature of the past marketing system, in particular: the interaction between processors and producers; the formation of prices; inter-regional distribution and pricing of wheat; and market orientation.

Price setting

The past system of control isolated domestic price formation from the international market, leading to a situation in which domestic prices exceeded import parity prices for most years.[8] This is clearly demonstrated in Figure 6.

FIGURE 6

Comparison of domestic and international wheat prices



Source: Directorate of Agricultural Trends (1995), USDA internet site.
Note: U.S. wheat price is for Hard Red Winter, f.o.b, ordinary protein.

Tariffication takes control over domestic price setting from the Wheat Board and places it in the hands of the international market. South Africa's minor role in the international wheat market (0.3 %) entails that in future it will be a price taker with domestic prices converging to international prices. This does not imply that domestic prices will be the equivalent of international prices as other factors such as tariffs, transport costs, insurance and harbour fees will force a price gap between the two. It is more appropriate to talk about import and export parity prices which are the effective prices paid for by processors or received by producers once the marketing costs have been added to (subtracted from) the international price. South Africa's status as net importer

[8] This does not imply that domestic prices were totally divorced from happenings in the international market. Bell (1996: 84) notes that it was the decline in world prices in real terms that lay behind the worsening terms of trade experienced by domestic wheat producers.

should place pressure on domestic prices to converge on the import parity ceiling. During export years the export parity price will serve as the floor. The implications are as follows:

From Figure 6 it can be seen that full trade liberalisation during the 1980s and early 1990s would have resulted in a drop in domestic wheat prices. Recently world wheat prices have surged upwards as a consequence of a low world stock- consumption ratio and this conclusion is no longer applicable. The duration of these high international prices is not certain and is dependent on the production response by the major producers such as Canada, US, Australia and Argentina. With changes in the US farm policy permitting greater flexibility in the choice of product, one can expect production of the dominant wheat exporter to increase in response to higher international prices. If an increase in world production drives down prices, domestic farmers may find their profit levels being squeezed.

A further concern is the importation of price volatility from the international market.[9] To test this contention two different measures of relative volatility were calculated according to methods used by Krueger *et al* (1988: 265) and Wilson (1971). These are given in Table 2.

TABLE 2

Price stabilisation under the *Winter Cereal Act*

Source of calculation	Percentage reduction in fluctuations
Krueger et al (1988)[a]	
1970 - 1996	31.5 %
Wilson (1971)[b]	
1970 - 1996	32.1 %

Source: Directorate of Agricultural Trends (1995), USDA internet site. Data used is same as in Figure 6.
Note: (a) Ratio of the standard deviation of the real SA producer price for wheat with the standard deviation of U.S. real wheat prices (deflated by CPI).
(b) Ratio of average absolute growth rates of South Africa to those of U.S..

From the table it is clear that between 1970 and 1996 domestic wheat pricing regulations were effective in reducing producer price variability with respect to international prices by approximately 32%. Trade liberalisation entails greater price fluctuations than in the past.[10]

[9] Volatility in the international market arises from the high concentration of countries in the export and import market; the use of extensive subsidies and protection by countries to insulate domestic production from international price and production trends; and the use of the international market as a residual market for domestic surpluses. See Edwards (1996) for a brief discussion on the source of international wheat price volatility.

Volatility of prices does not pose a problem as long as it is expected and farmers and millers can hedge themselves against loss. A greater concern is *uncertainty* in price movements: price changes arising from events that cannot be foreseen (Hill *et al*, 1982:13). This is a major concern in the international wheat market which is vulnerable to politically induced changes by China and the former Soviet Union, who together make up 33% of world wheat imports (Ahmadi-Esfahani and Jensen, 1994: 62 ; Valdes and Zietz, 1995: 915). Estimation of price movements is made difficult by the uncertainty surrounding their domestic agricultural policies, their trade policies as well as the commitment to their GATT obligations. A second factor influencing the uncertainty of price movements is the domestic exchange rate. Fluctuations in the exchange rate directly affect the import parity price of international wheat and thus the competitiveness of South African production. The influence of exchange rates has recently been exemplified in the recent bout of depreciations that have boosted the rand price of international wheat upwards.

A final implication is that domestic prices will vary within the year. In the past prices were stable throughout the year because a fixed single price was set.[11] In future, the domestic price will be influenced by the monthly changes of international prices.

Market orientation

Deregulation and trade liberalisation signal a move from a *supply* orientated focus to a *demand* orientated focus. Deregulation and trade liberalisation release the processors (the demand side) from obligatory domestic market purchases. This removes the secure outlet and price that the past system guaranteed to domestic producers. Market power shifts from the producer to the processor as the collective legislated voice of the producer follows the demise of the Wheat Board. The implications for the producer and consumer are vast:

Firstly, the producer is no longer ensured a secure outlet for his or her product and will be exposed to a degree of *demand risk*. Negotiations on price and quantity will be conducted between individual farmers/co-operatives and individual millers. The ability of a farmer/co-

[10] The results are consistent with those of Krueger *et al* (1988: 265) who note that direct interventions were effective in reducing producer price variability by 63% for wheat exports in Argentina and on average 46% for wheat imports in other countries.

[11] The base price was fixed throughout the year, but this price did change slightly as storage and financing costs accumulated the longer the wheat was stored.

operative to sell their wheat will be dependent on the desirability of this wheat not only relative to the international market, but relative to other domestic producers. One can, therefore, expect a rise in intra- and inter-regional competition for a market share, effectively putting an end to the fixed price system of the past. Farmers more distant from the market (such as Western Cape) will have to bear the increased burden of their greater transport costs.

Secondly, an increased emphasis will be placed on wheat quality. Continued control over the production and distribution of wheat has prevented the filtering down of quality requirements from the consumer to the producer. With deregulation the demand for wheat will be a 'derived demand' as it will be dependent on the volume of wheat consumed. This in turn is a function of the price and the *quality* of the end-product (predominantly bread). Increased competition among bakers for market share will develop a consumer dictated definition of quality in which certain "end-use performance characteristics" of wheat essential for the production of good quality bread become the object of demand for wheat. The ability to sell one's wheat will no longer be a certainty, but will be dependent on the extent to which it satisfies the quality requirements of the processing sector. This development will adversely affect the Western Cape which produces a lower quality wheat.

A related consideration is the consistency of wheat quality. The bulk of domestic bread is produced in plant bakeries, 90% of which is produced using the Chorleywood Bread Process. The increased consumer demand for consistent quality as well as the high degree of specificity of the industrial bakeries necessitates a consistency of wheat flour. This consistency translates into a consistency of the "end-use characteristics" of the flour.

Wheat, as noted, is not a homogenous input, but is heterogeneous in its quality characteristic composition. To produce a satisfactory flour, the miller has the option of blending different varieties of wheat to meet the baking requirements. Their estimations of the variation of the characteristics will also play a role in the choice of the wheat blend. The greater the characteristic variance the greater the risk of producing poor quality bread. This risk can be interpreted as a cost for the following reasons:

a. Unsatisfactory bread not sold by retailers is returned to the baker (De Villiers, 1996).
b. Inconsistency of the final product affects consumer demand for that *brand* of bread. Since 1991 there has been a steady rise in the importance of brand names in the bread and flour markets. Any adverse perceptions of a brand may significantly affect its future demand.

c. Characteristic variance affects production costs as it necessitates adaptations in the baking process to compensate for the divergence from the expected value. As production volumes are large any unexpected changes (such as lower than expected protein contents) in wheat quality that alters the baking and/or mixing times will cause expensive bottle-necks in the production line (Wessels, 1989: 27).

Because of its importance to the baking process, characteristic uncertainty will play a considerable role in determining the competitiveness of domestic producers.[12]

Increased risk

Deregulation and trade liberalisation will induce a considerable degree of flux and risk into the wheat industry. The past approach to the international market and the certainty of demand for domestic production (implied by the single-channel system) limited some of the risk exposure of producers and processors. Producers had a secure outlet for their production irrespective of the volume and quality produced. Millers did not have to face risks associated with procurement such as the rescinding of contracts, unexpected quality deterioration and shortages as the Wheat Board provided a secure source of wheat supply. The ability of the Wheat Board to bear the risk of volatile production and quality depended partly on the use of the international market as a source (outlet) for shortfalls (surpluses). Volatility of production was transferred to the international market and was not borne by the domestic producer and/or consumer.

In future the producers, millers and consumers will have to bear the risk of volatile production, quality and prices. This will have substantial cost implications in the production, marketing and the processing of wheat. On the production side, price and volume volatility widen the range of income fluctuations and increases the risk of production. Farmers also face the risk of producing an inferior quality wheat and receiving a lower than expected price for their crop. On the marketing side, volatility of production places stress on the smooth functioning of the transport, storage and handling processes of the marketing chain. This increases marketing costs, worsens price fluctuations and leads to a lower than optimal investment in marketing

[12] Larue and Laplan (1990: 417) note that characteristic uncertainty regarding the quality of imported wheat encourages domestic producers to increase wheat production.

facilities (Binkley, 1983). Finally, on the processing side, because wheat is the primary input any changes in price, supply and quality of wheat directly affect production costs and output price. In slightly differentiated product markets such as the flour and bread market unexpected cost changes can significantly affect the competitive advantage of competing food manufacturers (Hayenga, 1979: 353). These costs will be transferred to the consumer leading to higher than otherwise prices.

4.3 Estimation of deregulation and trade liberalisation

Estimation of the effects of trade liberalisation and deregulation is made complex by dynamics such as price and production volatility discussed above. Nevertheless, a number of papers have attempted to do so through comparisons of competitiveness using complex linear programming models. In this section the results and implications of these papers are discussed.

Defining competitiveness

The extent to which domestic wheat producers will be affected by deregulation and trade liberalisation is dependent on the 'competitiveness' of domestic production. In standard international trade competitiveness is synonymous with comparative advantage. The usefulness of this notion of competitiveness is limited in the real world in which protectionist policies and massive subsidies often override comparative advantages arising from different productive resources. An alternative definition of competitiveness is "*the ability of a country to achieve a market share*" (Perkins, 1987: 17 as cited by Ortmann and Rask, 1988a: 17). Thus, an increase in exports would indicate a rise in competitiveness, and *vice versa*. The attractiveness of this definition to the international wheat market is its recognition of the role of extra-production factors such as government policy (taxes, subsidies, export incentives) which have dominated the allocation of world market shares of wheat. Although this notion of competitiveness is useful in the analysis of world markets and the role played by the dominant producers, its applicability to South Africa is limited given the negligible role it plays in the international wheat market (0.3 % of world output). South Africa's concern is one of supply, but not excess supply. A third definition focuses on the "cost-competitiveness" of production - "*...the ability of a country to compete with another in terms of the production and marketing costs of agricultural commodities*" (Ortmann and Rask, 1988a: 18). Production and marketing costs incorporate the influence of levels of natural endowment and technology as well as the distortions introduced in the factor market by government interventions. Analysis in terms of cost-competitiveness of production is informative as it illustrates relative ability of countries to withstand international price changes and still remain profitable.

Cost competitiveness

Comprehensive comparisons of production and marketing costs of international and domestic wheat have been performed by Ortmann and Rask (1988a, 1988b), Effective Farming (1993) and Willemse (1993). Their analyses shows that the cost competitiveness of South African farmers during the 1980s was poor and that it worsened considerably during the early 1990s. According to the Effective Farming (1993) comparison cost per ton in South Africa (R486.67/t) is greater than the U.K (R372.67/t), U.S.A (R302/t), Canada (R295/t), Australia (R219/t) and Argentina (R190.45/t), often doubling their values.[13]

A comparison in terms of cost is incomplete as it ignores market price, a crucial component to overall profitability. Alternative studies by de Kock and Laubscher (1993) and Troskie *et al* (1995) compare the domestic prices with the import parity prices of foreign wheat for various years between 1970 and 1994. Troskie *et al* (1995) also compared the effective mill gate prices of surplus regional wheat with that of international wheat in the Gauteng region to illustrate the price competitiveness of domestic wheat for the interior consumer market. The results indicate that at both coastal and interior regions, domestic prices exceed the comparative delivery price of international wheat. Trade liberalisation with a zero tariff during these periods would have led to substantial reductions in domestic prices. After performing various different scenarios they conclude that a tariff level of 66% of the f.o.b price would be sufficient to protect the domestic producer in all regions.[14]

The above price and cost comparisons suggest that full trade liberalisation will adversely affect domestic production. The relatively higher cost structure of domestic producers limits their ability to absorb price decreases and price fluctuations arising from trade liberalisation and will induce an exit of farmers from wheat production.

[13] Note that the Effective Farming (1993) comparisons have been converted from cost per hectare to cost per ton.

[14] In the first scenario international prices were taken as US$ 147 per ton. In the second scenario the price effect of the USA's Export Enhancement Program was taken into account. The third scenario included a 5% rise in price in response to GATT and an exchange rate depreciation of 30%.

The problem with these analyses is that they are static and weak in incorporating dynamic changes induced by volatile exchange rates, international wheat prices and domestic production. Depreciations of the exchange rate and/or rises in international wheat prices (as experienced in 1996) increases the competitiveness of South African production. Although a depreciation of the exchange rate increase production costs by increasing the price of imported production inputs, the price protection afforded by the rise in import parity prices of international wheat exceeds these cost increases resulting in a net improvement in competitiveness.[15] A further problem with these analyses is that they identify the direction, but not the *extent* of the changes in production. They focus on a single product and cannot identify to where released resources are re-allocated.[16] A third approach deals with some of these shortcomings by utilising linear programming techniques to model the agricultural economy.

Linear programming

Linear programming models evaluate production decisions in terms of a profit maximising objective. Optimal values are determined by the interaction of the supply and demand equations for each product included in the analysis.[17] Producers weigh up production options according to their profitability relative to other products. The inclusion of price elasticities and cross elasticities implies that these decisions encompass the expected changes their decisions will have on the price and demand of that product and substitute or complimentary products. The opportunities for analysis provided by such models are immense. Their results, however, are dependent on the assumptions made and the elasticities used within the supply and demand equations. Although this only permits tentative estimations of the *level* of changes under different scenarios, the results are informative of the *direction* and *extent* of change expected.

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[15] According to Van Schalkwyk *et al* (cited in Troskie *et al*, 1995: 5) a depreciation of the rand by 10, 20 and 30 percent increases wheat production costs by 4.3%, 8.5% and 12.8%, respectively. These depreciations, however, raise the import parity price 9.4%, 19% and 28%, respectively, resulting in a net increase in protection.

[16] The comparisons are not entirely uninformative. They do illustrate the extent of tariff protection required to protect domestic producers from subsidised international prices and production. This is a key issue for trade policy.

[17] Sometimes the supply equation is extended to include production risk. The models analysed in this thesis use the mean absolute deviation method (MOTAD) technique of including risk. Risk is taken as the deviations of gross income per hectare from the mean. The inclusion of risk is an important consideration as it increases the cost of production and its exclusion may overestimate the value of certain resources (Van Zyl, 1995: 6). See Van Zyl (1995) for a more detailed breakdown of the linear programming models.

Sectoral linear programming models have been used in a national study of the wheat sector by Howcroft and Ortmann (1992) and in a regional study of the Western Cape by Van Zyl (1995).[18] In Table 3 the estimated effects of deregulation on wheat prices and production are given for the various regions of South Africa. Unfortunately the effects of trade liberalisation are only available for the Western Cape.

TABLE 3

Estimated results of deregulation and trade liberalisation

Region	Deregulation	
	% change Price	% change Production
Howcroft and Ortmann (1991)		
OFS/Tvl	- 14.5 %	- 3.5 %
Swartland	- 14.5 %	- 20.6 %
Ruens	- 14.5 %	- 46.3 %
Total	- 14.5 %	- 16 %
Van Zyl (1995)		
Western Cape[a]	- 5.8 %	- 25.5 %
	Trade liberalisation	
Western Cape	- 32.4 %	- 84.6 %

Source: Howcroft and Ortmann (1992) ; Van Zyl (1995).
Notes: (a) Area closely approximates the new Western Cape province. Deregulation results of Van Zyl (1995) assume the abolishment of the statutory fixed price single channel marketing system for winter grains and the floor price scheme for red meat, dairy products and eggs. The results assume a concurrent improvement in production techniques.

The deregulation scenario captures the effects of the new Marketing Act in which no statutory controls such as price fixing or marketing of domestic products is permitted. As imports are prevented the results illustrate the effect of deregulation in isolation of trade liberalisation. The effect of deregulation is a fall in wheat price combined with a reduction in wheat production. The extent of change is more severe in the Western Cape areas where Howcroft and Ortmann (1992) estimate a 20.6% and 46.3% decline in production in the Swartland and Ruens, respectively. Van Zyl's (1995) more conservative estimate (25.5%) for the Western Cape is due to a lower fall in wheat price (5.8%) than for Howcroft and Ortmann (1992) (14.5%).

The small decline in Free State wheat production (3.5%) reflects the residual nature of wheat production in this area. Production of wheat in the Free State is largely dependent on what

[18] The Howcroft and Ortmann (1992) study also appears in Van Zyl and Niebuhr (1991). The Van Zyl (1995) study forms part of Vink *et al* (1996).

happens to the price of maize (Van Zyl and Niebuhr, 1991: 40). In an additional scenario where the real price of maize fell below the free market level, wheat production rose by 26.9% in the Free State (Howcroft and Ortmann, 1992: 27). For South Africa as a whole wheat production fell by 16%.

The effect of trade liberalisation on wheat production is far more extensive and results in the decimation of 84.6% of Western Cape wheat production. Although the slight protection given to interior producers by lower transport costs should soften the blow of trade liberalisation in the Free State and Transvaal, the effect will also be significant. However, the relevancy of the trade liberalisation results, according to Bell (1996: 93), may be "... rendered entirely superfluous" with the assumption of a zero tariff. It is unlikely that such a low tariff level would be implemented as the debate on the necessary tariff level has centred around the 40% to 66% level. In addition, the model uses prices from the late 1980s in which international prices were lower than domestic prices. If the Van Zyl (1995) model were run using 1995/96 as the base year the results would be significantly different. The results of these models are thus time-specific and care must be taken when extrapolating from them.

The drastic fall in wheat production in the Western Cape drives production changes in alternative crops (Van Zyl, 1995: 25). The land freed up by deregulation is partially used up for production of barley and oats, but is primarily used for mixed farming with dairy cattle and sheep. Under trade liberalisation there is an additional increase in production of export products such as wool and mohair.

The movement out of wheat does not necessarily imply that the country is worse off after deregulation and trade liberalisation. Because linear programming models incorporate supply and demand curves, it is possible to evaluate the welfare effects in terms of the change in consumer and producer surpluses.[19] Van Zyl (1995) and Howcroft and Ortmann (1992: 26) predict an improvement in total surplus of 6% and 9%, respectively, from deregulation. Under trade liberalisation total surplus improves by 8.8%. Thus, although wheat production is adversely affected by lower output and producer prices, this loss is more than compensated for

[19] Consumer and producer surplus are abstract representations of the utility derived by consumers and producers for the consumption or production of goods at a certain price. Because wheat output and prices are determined endogenously and are therefore dependent on the changes that have happened in other sectors, it is not possible to isolate the welfare effects of the change in wheat production.

by welfare improving low consumer prices and an increase in production of substitute goods. Van Zyl (1995:24) also notes an improvement in farm employment opportunities from deregulation and trade liberalisation of 7.5% and 7.1%, respectively. The results are, thus, synonymous in their conclusion that market control adversely affects society as a whole; in particular the consumer.

The movement out of wheat and into livestock and mixed farming may have further benefits for the backwardly and forwardly linked industries. According to the mixed multipliers of Eckert and van Seventer's (1995) supply adapted input-output model wheat farming has the lowest employment multiplier of all the substitute products and a lower income multiplier than that of livestock.[20] Although the input-output model is a demand-driven model and does not reflect changes in employment or income from changes in supply the multiplier values suggest that any movement away from wheat farming to livestock is likely have positive consequences for employment and income.[21]

Other studies question the conclusiveness of these positive results. A linear programming modeling of a typical farm in the Swartland by Troskie *et al* (1995: 16) reveals that the income effect of the substitution towards small stock numbers is negative. Bell (1996: 94) argues that the 30% to 40% collapse in farm values predicted by Van Zyl (1995) and Howcroft and Ortmann (1992: 28) conflicts with the contention that the levels of agricultural value added remain constant. In an earlier paper Howcroft and Ortmann (1990: 398) confirm that the simulated land rents (in terms of productive value) of the regulated scenario represent the actual land values. The decline in land rents in their later model, suggests a fall in productive value which contrasts with the optimistic predictions of welfare and employment improvements. Further, the results of Van Zyl (1995) include the effect of an improvement in

[20] Input-output models conventionally convert exogenous changes in final demand into changes in endogenous production on the basis of existing expenditure patterns for the endogenous variables (Vink *et al*, 1996: 57). The models generally assume fixed prices and perfectly elastic supply responses (i.e. excess capacity) to changes in demand; an unrealistic assumption in agriculture where supply is inelastic. Eckert and van Seventer (1995) turn the model 'on its head' to one in which production output and not final demand is determined exogenously. This enables the imposition of inelastic supply constraints to the model which reduces the magnitude of the income, output and employment multipliers (called mixed price multipliers). The mixed price employment multiplier for wheat is 16.94; for horticulture between 84 and 147; and for livestock between 40 and 70. These values show the proportional change in employment nationally as result of R1 million in additional final demand received by Western Cape producers (Eckert and van Seventer, 1995: 6). The mixed income multiplier of wheat is approximately 23% less than that of livestock.

[21] Eckert and van Seventer (1995) do attempt to adapt the conventional input-output model to a supply driven model. The usefulness of this model is limited given the additional limitations that are made. They also only look at the backward linkages which ignores the significant downstream wheat processing industry.

production techniques which may significantly distort the results. In conclusion, it is apparent that changes in wheat production should have a positive effect on employment, but it is unclear what the net benefit in terms of income may be.

4.4 Discussion

Because linear programming models are parsimonious, simplified assumptions have to be made. This necessarily results in inherent structural problems when trying to estimate real world activity. The above models are not immune from criticisms related to simplification. The country or regions are assumed to be homogenous with common production and transport costs. The elasticities used and the risk coefficients are derived using aggregated variables. These assumptions and aggregated values are modeling necessities against which not much can be done.

The models, however, face a more fundamental problem: *an inadequate representation of demand for wheat*. As discussed in the previous section, deregulation and trade liberalisation signal a move from a *supply* to a *demand* orientated focus. The prioritisation of the consumer raises quality considerations to the forefront of demand. By only focusing on price elasticity of demand and not on quality differentials, the linear programming models assume a homogenous quality of wheat. This enables them to derive a common demand elasticity for wheat from the demand elasticities for bread that are used in the model. In reality wheat is not a homogenous product and is differentiated according to its quality characteristics. Thus millers do not face a single source of wheat, but an array of options in order to satisfy their quantity and quality requisites. The demand for each wheat source is a function of its price and quality characteristics as well as the prices and qualities of alternative wheat sources. The existence of substitute wheat sources requires the inclusion of substitution elasticities in the demand equation for wheat.[22] A further factor influencing demand is the technical structure of the baking and milling process as this will determine the quality parameters that need to be satisfied. As the choice of technology has been influenced by the past system of control, its inclusion as a source of differentiation of demand for wheat is an important consideration.

[22] Van Zyl (1995) has not included substitution elasticities (or cross price elasticities of demand) in his model. Howcroft and Ortmann (1992) included the cross price elasticity of demand between wheat and maize.

Recognition of quality as a differentiating factor of demand is important in the domestic wheat industry where Western Cape wheat and Free State wheat differ substantially in terms of their quality compositions. The failure to incorporate this fact may have led Howcroft and Ortmann (1992) to overestimate demand for Western Cape wheat and underestimate demand for Free State wheat.

The inclusion of quality has implications for the derivation of endogenous wheat prices and the choice of a substitute international wheat. Prices reflect the valuation of the wheat by both the demander (consumer) and the supplier (producer). As mentioned the valuation of a wheat source is dependent on its quality composition relative to the price-quality relationship of alternative sources of wheat. By not focusing on quality differentials, the linear programming models assume perfect substitutability between the different wheat sources. As result common endogenous prices and price changes (e.g. the 14.5% fall in prices in the Howcroft and Ortmann (1992: 24) for each wheat source are derived.[23] Perfect substitutability between domestic and international wheat is also assumed in the Van Zyl (1995) results of trade liberalisation. Trade liberalisation exposes the domestic market to an array of alternative wheat sources, each with a unique price-quality relationship. The market price of domestic wheat under trade liberalisation will be a function of the extent to which it satisfies the demand requisites of the baking and milling industry relative to a *bundle* of international wheat sources. The choice of a single international substitute as done by Van Zyl (1995) fails to recognise the array of choices facing millers and bakers and the fact that it is the combination together that will determine the price of domestic wheat.

The demand orientation of the new marketing system has implications for the choice of modeling techniques. The supply orientated linear programming models are primarily interested in determining optimal production decisions. The demand curve is subsidiary to the supply decision as it is solely used to determine the relevant price level. During the system of regulation this assumption was appropriate as the processing industry had to conform to domestic production decisions. With deregulation the 'tables are turned'. Prices in future will

[23] Howcroft and Ortmann (1992: 23) note that the price is an average for the whole of South Africa and that price differences will arise due to differential transport costs. Nevertheless, the assumption of constant average quality for each region still holds.

be *demand driven* and not *supply driven* as is assumed in their models. This necessitates a refocussing of the modeling technique that captures the characteristics of demand.

The focus on demand necessitates a redefining of competitiveness. Competitiveness is not necessarily defined in terms of production capabilities, but is the *ability of suppliers of wheat in a country to compete with alternative sources of supply in terms of demand-derived characteristics*. The focus on demand highlights an important area of needed research: the derivation of 'demand driven' prices in a deregulated and trade liberalised agricultural sector. The sensitivity of demand around these prices will also reveal the degree of substitutability between the different sources and the shape of the demand curves facing different production areas in South Africa. A further desired outcome is an analysis of how demand and prices for different wheat sources reacts to the unique regional production features such as volatility of supply. The following chapter deals with the development of a model capable of realising some of these requirements.

Chapter 3

MODELING WHEAT QUALITY CHARACTERISTICS

1. INTRODUCTION

The essential problem in evaluating the effect of deregulation and liberalisation is an inadequate representation of the demand for different sources of wheat. This inhibits the determination of the 'true' prices or 'demand derived' prices of domestic wheat sources relative to international wheat. Once 'derived demand' prices are established for domestic wheat, it will be possible to evaluate the effect of the new marketing system on the wheat industry.

The task of finding derived demand prices can be accomplished through the use of the Input Characteristic Model (ICM) as used by Ladd and Martin (1976) and adjusted by Wilson and Preszler (1992) to account for technical coefficient uncertainty. The focus of this chapter is the development and theoretical exposition of an ICM that can be utilised for the South African situation. The chapter consists of two parts, the first of which gives a brief overview of the input characteristic approach and discusses its relevance to this study. The second component is an in-depth theoretical and mathematical exposition of the ICM. This will be couched in terms of a simplified wheat example and will be substantiated with non mathematical discussions.

2. INPUT CHARACTERISTIC MODEL

2.1 Overview

The ICM is a variant of a neo-classical theory of the firm that evaluates demand for inputs as a function of their internal characteristics. The approach is founded in the view that goods are collections of characteristics and that the price of a good is a function of the quantity of characteristics contained within it. Agents associate implicit prices to these attributes (defined as hedonic prices) which are "revealed to economic agents from observed prices of differentiated products and the specific amounts of characteristics associated with them" (Rosen, 1974: 34). The view is especially applicable to heterogeneous goods, such as wheat, in which characteristic composition plays an important differentiating role. In this approach the consumer derives utility from the intrinsic characteristics of a product and not from the product *per se* (Veeman, 1987: 538).

A well known advocate of the 'product characteristic approach' is Lancaster (1967) who analysed consumer choice based on the attributes of a good rather than the commodities themselves. A shortcoming of Lancaster's model is the sole focus on consumer demand for characteristics. Rosen (1974) extended this analysis to include the supply of consumer goods as a function of their implicit characteristics and established a competitive equilibrium theory of hedonic functions. These theories were essentially part of the emergence of a 'household production theory' (Veeman, 1987: 538) that focused on demand and supply of final goods. The ICM as developed by Ladd and Martin (1976) differs from these approaches by taking the firm as the unit of analysis (and not the consumer) and looking at demand for *inputs* as a function of their characteristics. The focus is not on utility, but on revenue and profits. Firms utilise characteristics as an input into production in a manner that maximises profits. Firms will associate implicit values to those characteristics that provide revenue. The price the firm is willing to pay for a heterogeneous input will thus be a function of the characteristic composition of that good. A structural relationship between market price and characteristics (known as a 'hedonic price function') is assumed to exist.

Numerous studies have used hedonic price functions to evaluate the value of the various wheat quality characteristics.[24] Most of the studies have concerned themselves with the export market of wheat (possibly due to the importance of quality specifications in the determination of the export price), but their orientations have differed. A study by Uri *et al* (1994) of the US Federal Grain Inspection Service's grading of wheat exports indicated that of the standard grading criterion (test weight, dockage, moisture content, percentage foreign material, percentage shrunken and broken kernels, and protein content) only test weight and protein content are consistently valued by the market. Similarly, studies by Veeman (1987) and Larue (1991) including wheat exports from other major exporters confirm the importance of protein

[24] An abundance of other applications of the characteristic approach also exist, such as Brorsen *et al* (1984) in valuing rough rice; and Ladd and Suvannunt (1976) in modeling consumer good characteristics; Charnes *et al* (1952) in the blending of aviation gasoline; Panne and Popp (1963: 405) in determining the optimal composition of cattle feed; Ladd and Martin (1976) in the evaluation of corn grading system; Waugh (1928) in valuing vegetables; and Triplett (1986) in the adjustment for quality changes in price indexes.

content in determining wheat prices. Larue's (1991) results, however, suggest that test weight is not significant in explaining price variations.

Larue (1991) confirms the earlier contention that the valuation of wheat characteristics is dependent on its end-use. He notes that protein content negatively affects the price of biscuit wheat which uses a soft low protein wheat, but positively affects the price of bread wheat in which a higher protein content is required. Thus, in the modeling of wheat, one must ensure that wheat is differentiated by end-use. The pooling of different wheat types may obscure the specificity of the results.

An additional study, and one that this thesis follows closely, by Wilson and Preszler (1992) utilised an input characteristics approach to discern sources of comparative advantage between different international wheat sellers. Their approach differed from the above analyses as more attention was placed on the functional characteristics required for high quality bread production (those characteristics for which protein content is a proxy). Their model evaluated the impact on demand of characteristic level and variance, both of which are important in determining market share. It was determined that increased characteristic variance altered the market share and increased the cost of producing a suitable blend of flour for bread production.

In conclusion, the substantial evidence supports the contention that wheat prices are related to characteristic composition. To find a derived demand price of domestic wheat, one, therefore, has to determine the structural relationship between wheat characteristics and price. The following section clarifies this relationship through a mathematical discussion and then develops a non-linear programming model to estimate domestic wheat prices.

1.2 The hedonic function

In standard neoclassical theory of the firm, profit maximisation ensures that the price of an input is equal to its marginal revenue product. In terms of the production of flour, this relationship can be represented as:

(1) $$p.\frac{\partial F(v_i)}{\partial v_i} = r_i : \quad i = 1, \ldots\ldots n;$$

where $\frac{\partial F(v_i)}{\partial v_i}$ represents the marginal product of the i th wheat and non-wheat source v_i; p is the price of flour; and r_i is the price of the i th wheat and non-wheat input. Equation (1) states that profit maximising firms utilise inputs to the point where the 'value marginal product' of each input equals its price (Varian, 1984: 22).[25] This is intuitive as a firm will continue to utilise an input in the production process so long as the return in terms of revenue exceeds the price paid for the input.

The problem with this approach is that it assumes a homogenous input as the basic element. Within the baking industry it is the quality characteristics (end-use characteristics) within the wheat input that are of primary concern. An alternative theoretical approach is to analyse the demand for inputs as a function of their characteristics. This approach is known as the Input Characteristic Model (ICM) and is clearly set out in Ladd and Martin (1976). The approach replaces the homogenous input with the characteristic as the basic element of the model. Output is represented as:

(2) $$q = F(x_{j.q}): \quad j = 1, \ldots\ldots m;$$

where q is output and $x_{j.q}$ is the total quantity of the j th characteristic used in its production. The equation states that output is a function of the total quantity of characteristics found within it. The difference from the neoclassical firm model can be clarified by way of an example. In the neoclassical firm model the output of a car is a function of the inputs such as tires, motor, chassis and seating. Together these inputs constitute the car. With the ICM the emphasis is not placed on the inputs as such, but the characteristics within these inputs; such as the maximum power and torque of the engine, the road grip of the tires in wet and rain, the stiffness, strength and shape of the chassis, and the upholstery and comfortability of the seating. By illustrating the car as a composition of characteristics the diversity and substitutability of cars is exemplified. Similarly, the approach is useful in the analysis of bread. In order to produce good bread that does not crumble when cut, that has consistency of texture, that rises sufficiently and that has a long shelf life, the baker utilises a blend of flour that contains specified quantities of certain characteristics found within wheat. Thus, the

[25] Equation (1) represents the first order condition to the profit maximisation problem. To ensure that this point is the profit maximising point the second order condition must be satisfied. This states that the matrix of second derivatives of the production function must be negative semidefinite at the optimal point (Varian, 1984: 22).

primary input in the production of bread is not so much wheat, but the characteristics within wheat.

The characteristic approach yields the following price-input relationship ('hedonic function') that differs from equation (1) and which is derived in Appendix A.1:

$$(3) \qquad r_i = p\sum_{j=1}^{m}(\partial F/\partial x_{j.q})(\partial x_{j.q}/\partial v_i)\ ;^{26}$$

where $(\partial x_{j.q}/\partial v_i)$ is the marginal yield of characteristic j to production from the i th input; $(\partial F/\partial x_{j.q})$ is the marginal physical product of one unit of characteristic j; and $p(\partial F/\partial x_{j.q})$ is the value of the marginal product of the j th characteristic. This latter relation is similar to the "value marginal product" of the input in neoclassical firm theory. In the ICM it is interpreted as the "marginal implicit" price paid for the j th characteristic used in the production of q. It represents the value that one unit of the j th characteristic adds to the price of the i th input. This equation states that the price of each input is equal to the sum of the implicit prices of the input's characteristics multiplied by the marginal yield associated with each of those characteristics.

We are able to simplify this equation further. If we assume that the marginal yield of each characteristic per input is constant ($\partial x_{j.q}/\partial v_i = x_{ji}$ = constant) and let $p(\partial F/\partial x_{j.q}) = \mathrm{A}_j$ equation (3) can be rewritten as:[27]

$$(4) \qquad r_i = \sum_{j=1}^{m}\mathrm{A}_j x_{ji}\ ;$$

where x_{ji} is the quantity of characteristic j in input i and A_j = the implicit price.[28] What are the implications of this approach? Equation (4) states that assuming competitive markets,

[26] Note the similarity with equation (1). $\frac{\partial F}{\partial v_i} = \sum_j(\partial F/\partial x_{j.q})(\partial x_{j.q}/\partial v_i)$ as result of the chain rule on a compound function. I am assuming the second order conditions for profit maximisation hold.

[27] This merely implies that the quantity of each characteristic in each input is constant, i.e. an extra unit of the same wheat input will increase the quantity of protein by the same amount as the previous unit of that wheat input.

[28] The model assumes that the relationship between input price and the summation of value of marginal yields is linear. This is debatable and will be discussed later. The equation also assumes that the implicit price of the characteristic is constant, in other words that the marginal product of the characteristic is constant. See Ladd and Martin (1992: 23) on a non linear implicit price.

wheat will be demanded to the point where its price will equal the value of the characteristics contained within it. If one were able to determine the implicit prices of each characteristic (A_j), one would be able to calculate the 'true' competitive price of different sources of wheat.[29] The ICM provides a method of conceptualising demand and input prices that takes cognisance of the inherent quality characteristics.

2 ESTIMATION

Most researchers have estimated the 'hedonic function' in equation (4) through regression analysis. By regressing input prices on characteristics, a coefficient representing the implicit price of characteristics can be derived. This is the approach that has been pursued by Uri *et al* (1994), Veeman (1987), Brorsen *et al* (1984), Ladd and Suvannunt (1976) and Triplett (1986). The implicit prices of characteristics can also be estimated via the application of duality relationships to linear programming. This is the approach that has been taken by Wilson and Preszler (1992), Charnes *et al* (1952) and Panne and Popp (1963: 405). In this thesis a simplified version of Ladd and Martin's (1976) cost minimisation blending problem will be used to derive equation (4). As the blending problem is similar to the one that will be utilised in this thesis, it will be couched in terms of minimising the cost of one unit of flour subject to a set of characteristic constraints.[30]

2.1 Linear programming method

The objective of the mill is to produce the most cost effective final product (flour) that satisfies certain baking quality constraints. To fulfill this objective the millers can choose from an array of heterogeneous wheat sources that differ in terms of their price and quality characteristics. The milling problem can be stated as:

<u>Primary A:</u>

(5) $$\min \sum_{i=1}^{n} r_i y_i$$

subject to

[29] Equation (3) implicitly assumes an internationally competitive wheat market, profit-maximisation and competitive producers using independent production processes. The applicability of these assumptions for an analysis of the wheat industry can be questioned. See chapter 3 and Appendix A.2 for a discussion dealing with these issues and a mathematical adaptation of equation (3).

[30] Strictly speaking it determines the cost of one unit of the wheat blend that will be milled into flour. The conversion from wheat to flour will be dependent on the extraction rate.

(6) $$\sum_{i} x_{ji}.v_i \geq a_{j0} : \quad j = 1,\ldots\ldots\ldots m$$

(7) $$v_i \geq 0 : \quad i = 1,\ldots\ldots n$$

In the above equations, r_i is the price of the i th wheat input; v_i is the quantity of the i th wheat input used in the production of a unit of flour; x_{ji} is the quantity of the j th characteristic in one unit of input i ; and a_{j0} is the value of the required level of characteristic j in a unit output. According to the linear programming problem, millers evaluate different sources of wheat as a function of their price relative to their characteristic composition. On the basis of this evaluation they select the lowest cost combination of wheat sources to produce a unit of flour that complies with the given quality constraints. By running the program optimal values of v_i are calculated. These values are illustrative of the relative demand or competitiveness for different wheat sources.

However, the over-riding appeal of linear programming for this thesis is found within the dual of the primary problem.

Dual A:

(8) $$\max \sum_{j=1}^{m} a_{j0}.y_j$$

subject to

(9) $$\sum_{j} x_{ji}.y_j \leq r_i : \quad i = 1,\ldots\ldots n$$

(10) $$y_j \geq 0 : \quad j = 1,\ldots\ldots m$$

The objective of the dual is to assign maximum values (y_j) to the 'characteristic requirement levels' (a_{j0}) so that the sum of the characteristics multiplied by their values do not exceed the price of the input. The solution of the dual enables the determination of the implicit prices of the characteristics.

According to duality theory, the solution of the dual yields exactly the same result as the solution of the primary, i.e. the minimum value of $\sum_i x_{ji}.v_i$ = maximum value of $\sum_j a_{i0}.y_j$.

The implicit price of a characteristic will be revealed by a change in total cost from a unit change in that characteristic. If we change a_{j0} by the amount Δa_{j0}, then from the above relationship:

(11) $$\Delta \min \sum r_i.v_i / \Delta a_{i0} = \Delta \max \sum a_{i0}.y_j / \Delta a_{i0} = y_j .$$

y_j, therefore, represents the change in the minimum total ingredient cost per unit output due to a change in the characteristic requirement level a_{j0}. It thus represents the shadow price or implicit price of the jth characteristic (Ladd and Martin, 1976: 25). What this relationship implies is that if we reduce the constraint a_{j0} by one unit, the total minimum ingredient cost per unit output will fall by y_j.

This is not the case with all characteristic requirement levels a_{j0}. Those characteristics that exceed the limit in the final solution, $\sum_i x_{ji}.v_i \rangle a_{j0}$, will have a zero implicit price as $\Delta \min \sum r_i.v_i / \Delta a_{i0} = 0$. Because these characteristics are in excess, a marginal change in the characteristic level will not affect the final solution (Dorfman, 1953 ; Baumol, 1977). For these characteristics the characteristic requirement levels (a_{j0}) are not *effective* constraints as they are implicitly satisfied when the other characteristic requirement levels are satisfied. Their levels can thus be ignored by the miller as the blend of flour has an abundance of this characteristic. In addition, the duality theorem tells us that if the optimal value of $v_i^* \rangle 0$ in the solution to 'Primary A', then $\sum_j x_{ji}.y_j^* = r_i$ .This is an exact counterpart to equation (4) and verifies the ability to derive the ICM price-characteristic relationship through linear programming.[31] These relationships will be substantiated in the next section with the aid of an economic and non-mathematical interpretation.

[31] Other conclusions of the linear programming solution are that the number of wheats used in the production of one unit of flour will never exceed the number of constraints. If the number of limited resources exceeds the number of processes then some of the resources will have imputed values of zero. If the number of processes exceeds the number of limited resources, then not all processes will be used in the optimal solution (Dorfman, 1953: 186).

2.2 Economic interpretation

The primary problem sets out to determine the allocation of different wheat sources that satisfies certain characteristic requirement levels at a minimum price. In the optimal solution all characteristic requirement levels will be at least satisfied. Some of them will be exactly satisfied and others will be exceeded. Those characteristics that are in excess do not pose an *effective constraint* on the allocation of wheat sources as a small reduction or increase of these levels will not affect the optimal solution. These characteristics are *free* goods implying that small increases or decreases will not affect the minimum price solution.

For example: a miller is not going to concern himself/herself with water absorption capacity of flour if it easily complies with their requirements in the optimal solution. On the other hand, the miller would concern himself/herself if those characteristics that just met the baker's requirements were to fall due to poorer than expected wheat qualities used in their blend. If these were to change the miller would have to alter the mix of wheat sources used in order to satisfy the requirements. As the original blend of wheat sources was the cost minimising blend, any changes will directly affect the total cost per unit output of flour. It is only by changing the requirements of the *constraining* characteristics that the cost per unit flour will be directly affected. The miller thus attributes a value to these constraining characteristics that exactly equals the change in total minimum ingredient cost per unit output arising from a change in a unit of the constraining characteristic's level. This is what is referred to in equation (11) and yields the implicit price of those constraining characteristics.

Because these constraining characteristics are those that essentially govern the cost of the unit flour, we can assign values to these. We *impute* values into the constraining characteristics so that the total sum of characteristic values in the unit flour will exactly equal the unit cost of flour. This is the role performed by the dual of 'Primary A'. It may be clearer if we regard the imputed values as *revenue*. Although the blending of the wheat sources is viewed in terms of cost minimising, it is the satisfaction of the characteristic requirement levels that permits the miller to sell the flour to the baker. Thus, the characteristics within the wheat input can be regarded as sources of revenue for the miller. The objective of the dual is to impute maximum revenues into the characteristics such that the sum of all the values of the characteristics within an input at most equate the cost of that input (Baumol, 1977: 109).

By viewing imputed values in terms of revenue, one can take the summation of the value of the characteristics as the "value marginal product" of the content of the wheat. If the total value marginal product is less than the price it implies that the cost of the wheat source is greater than the revenue derived from its contents. This implies that alternative wheat sources provide greater returns and would be used instead.[32] The constraints of the dual ensure that the price of the input can never be less than the value marginal product of its contents. This implies that for all wheat sources used, the value marginal product is exactly equal to the price of the input.[33] In other words, the dual of the linear program derives equation (4) which states that the price of a "purchased input equals the sum of the money values of the input's characteristics to the purchaser" (Ladd and Martin, 1976: 21). Thus, the linear programming model provides a means of determining the implicit cost of the constraining characteristics and the derivation of the relationship specified in equation (4).

The linear programming problem presented is not sufficient for the analysis being pursued in this study as it does not incorporate characteristic uncertainty into the model. If wheat sources exhibit uncertainty with respect to their characteristics, then a optimisation model such as 'Primary A' may occasionally yield results that do not satisfy the characteristic requirement levels. Given the high degree of specificity required by the baking industry, characteristic variance is an important risk cost to be captured by the model. The following section adapts 'Primary A' to include characteristic variance.

2.3 Characteristic uncertainty

Both Wilson and Preszler (1992) and Panne and Popp (1963) adapted the certainty constraints of linear programming problems such as 'Primary A' to include "technical coefficient uncertainty". The adaptation to include uncertainty is derived from their work.

[32] If $\sum_j x_{ji} y_j \langle r_i$ then the cost of that wheat input is higher than alternative sources of wheat containing similar characteristics and the input would not be used.

[33] The characteristic values are determined endogenously and are dependent on the wheat sources and their prices used in the blending problem. If one were to change the options of wheat sources, different implicit values may occur. If we assume competitive international forces, then implicit values of characteristics should converge to a unique values.

The problem with characteristic uncertainty is that it "affects the probability of a characteristic's actual level meeting the desired level" (Wilson and Preszler, 1992: 557). To include uncertainty the certainty constraints of 'Primary A' are converted to "chance-constraints" (Bracken and McCormick, 1968:95) given as:

$$(12) \qquad P.\left[\sum_{i=1}^{n} \bar{x}_{ji}.v_i \overset{\geq}{\underset{\leq}{}} a_{j0}\right] \geq 1-\alpha_j : \quad j=1,\dots\dots m$$

where $\bar{x}_{ji}$ is the expected yield of characteristic j in input i ; v_i is the quantity of input i ; and $1-\alpha_j$ is the prescribed probability of satisfying the bracketed constraint (the confidence interval). This "chance constraint" merely states that the total quantity of each characteristic must satisfy the characteristic requirement level with a $(1-\alpha_j)$% probability. It is not possible to solve a blending problem with constraints such as (12) so the blending model is converted from a probabilistic model to an equivalent deterministic model with non-linear constraints.

Manipulation of (12) (see Bracken and McCormick, 1968) yields the following non-linear constraint:

$$\sum_{i=1}^{n} \bar{x}_{ji}.v_i \pm \Omega(\alpha_j).\left[\sum_{i=1}^{n} \sigma^2(\bar{x}_{ji}).v_i^2\right]^{1/2} \overset{\geq}{\underset{\leq}{}} a_{j0} \; ,$$

where $\Omega(\alpha_j)$ is the standard normal distribution coefficient for α_j level of significance, and $\sigma^2(\bar{x}_{ji})$ is the variance of the yield of characteristic j in input i . In the certainty model, the objective is merely to ensure that the summation of all the characteristics are greater (less) than a_{j0}. The first term in equation (13) represents this objective. In reality characteristics are not constant and can be assumed to be normally distributed and independent of other inputs. The implication of this is that linear programming solutions that accommodate for the variance of characteristics will frequently exceed or fall short of the requirements. The conversion from a certainty constraint to a "chance constraint" adjusts the mean by adding (subtracting) a confidence interval to ensure that $(1-\alpha_j)$ % of the observations are less (greater) than the characteristic requirement a_{j0}. The second term in equation (13) performs this role.

By including uncertainty into 'Primary A', the linear programming model is adapted to the following nonlinear programming problem:

Primary B

(14) $$\min \sum_{i=1}^{n} r_i . v_i$$

subject to

(15) $$\sum_{i=1}^{n} \bar{x}_{ji} . v_i \pm \Omega(\alpha_j) . \left[\sum_{i=1}^{n} \sigma^2(\bar{x}_{ji}) . v_i^2 \right]^{1/2} \begin{matrix} \geq \\ \leq \end{matrix} a_{j0} : \quad j = 1, ... m,$$

(16) $$v_i \geq 0 : \quad i = 1, ... n$$

'Primary B' provides the basic framework from which to evaluate the demand for different qualities of wheat. It is a simplified version and will be adapted to include other constraints to account for regional and/or national peculiarities in a later section.

The dual of 'Primary B' can be constructed by following the normal procedures as set out by Baumol (1977: 107) and simplified as done in Appendix A.3:

Dual B

(17) $$\max \sum_{j=1}^{m} a_{j0} . y_j$$

subject to

(18) $$\sum_{j=1}^{m} \left[\{ \bar{x}_{ji} \pm \Omega(\alpha) . \sigma(\bar{x}_{ji}) \} . y_j \right] \begin{matrix} \geq \\ \leq \end{matrix} r_i : \quad i = 1, ... n,$$ [34]

(19) $$y_j \geq 0 : \quad j = 1, ... n$$

'Dual B' differs from 'Dual A' as it includes the effect on imputed value of characteristic variance. The aim of the objective function is to impute the maximum possible values into the constraining characteristic levels. In 'Dual A' the constraint to the size of the imputed value was that the total value of all the characteristics within an input could not exceed the market price of that input. In 'Dual B' an additional consideration in the determination of imputed values, variance, is added to the constraint. The imputed value y_j is not only assigned to the mean level of the characteristic, but the variance weighted by $\Omega(\alpha_j)$ as well. Thus, variance

[34] Note, if the primal contains ≥ sign then the dual contains ≤.

entails a cost to the value of a characteristic as some of the imputed value will have to be distributed to the variance component in order for the constraints in equation (18) to be satisfied.

2.4 Existence of optimum

Although the objective of 'Primary B' is to find the minimum cost, it needs to be shown that this minimum actually exists and that this minimum can be found using computational procedures.

The primary problem consists of two components, the objective function and the constraints. The set of constraints map out a *feasible region* - an area that contains all the vectors satisfying the constraints. The optimal blend of flour has to contain levels of characteristics that fall within this region with a $(1-\alpha_j)$ % probability. The aim of the objective function is to find those input values v_i that satisfy this constraint and minimise the total cost. The solution is found using computational procedures that follow a myopic iterative process whereby small adjustments are made to a given position within the feasible region. If the new position raises costs then we can be sure that a continuation in that direction will increase costs further. By iteration only that path that reduces costs is chosen (Baumol, 1977: 145).

This process is greatly influenced by the shape of the objective function and the feasible region which will determine whether the optimum is local or global and whether the dual exists. To find a global minimum Baumol (1977: 148) notes that "..... *nearsighted computational techniques can be used ..... if the objective function and the feasibility region are both convex*". The requirement concerning the objective function merely states that - assuming a two dimensional frame - the function must have a valley shape.[35] The second requirement ensures that there are no discontinuities and holes in the feasible region. If these conditions hold then the iterative computational procedure leads to the global minimum. At this point any small adjustments to the position will increase the cost of the objective function. This is analogous to the second order condition of a minimisation problem (Baumol, 1961: 146).[36]

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[35] This is not entirely correct as the function need not be strictly convex. The function may also have a linear component to it.

[36] This statement requires slight clarification. Heterogeneous inputs are composed of distinct and fixed bundles of characteristics. The ability to substitute characteristics in the production process is constrained by these fixed relationships. Substitution due to input price changes or characteristic requirement level changes may be a discontinuous

In the case of 'Primary B' these two conditions are satisfied. The objective function is linear which is concave *and* convex. This leaves the feasible region. The linear constraints (16) of 'Primary B' *always* result in a convex feasible region (Baumol, 1977: 146) and it can be shown that the vectors satisfying the non-linear constraints (15) are contained in a convex set (see Panne and Popp, 1963: 421). Because "*the intersection of a finite number of convex sets is a convex set*" (Chiang, 1984: 667), the linear and non linear constraints together form a convex feasible region. The model is thus well behaved permitting the derivation of a global optimum. The existence of an optimum also ensures the existence of the dual enabling the derivation of the implicit characteristic prices.

2.5 Discussion

The ICM as summarised in 'Primary B' supplies a theoretically appealing approach to evaluating the effect of deregulation and trade liberalisation on the domestic wheat sector.

- Firstly, its emphasis on price and demand for wheat as functions of its characteristics captures the demand orientation of the new marketing system.
- Secondly, by setting constraints on those characteristics (end-use performance characteristics) essential for the production of a high quality bread, the consumer defined notion of quality is incorporated in the model.
- Thirdly, the effects of trade liberalisation can be incorporated by including international sources of wheat as alternatives to domestic wheat.
- Fourthly, the consistency requirements of bakers are captured by the inclusion of characteristic uncertainty in the constraints.
- Fifthly, by solving the 'Primary' problem, a price reflecting the wheat's quality characteristic composition can be determined. The inclusion of international sources of wheat ensures that this price reflects international valuations of the quality characteristics. The model also supplies a myriad of opportunities to analyse the effects of various scenarios on the domestic wheat industry.

The following chapter builds and applies an ICM to the domestic wheat industry.

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process as opposed to the smooth marginal process predicted by orthodox theory. This is extrapolated from the similar response the Lancaster model predicts will occur when relative prices of heterogeneous consumer goods change.

Chapter 4

APPLICATION OF THE ICM TO THE DOMESTIC WHEAT INDUSTRY

1. INTRODUCTION

This chapter develops an Input Characteristic Model to evaluate the effect of trade liberalisation and deregulation on the domestic wheat industry. In developing it, the model takes cognisance of the distinctive characteristics of the production and consumption sectors mentioned in chapter 2. Once developed the model is utilised to:

1. analyse the regional demand effects of deregulation and trade liberalisation under different tariff levels;
2. determine representative prices of regional wheat sources;
3. analyse the regional substitution effects of changes in domestic wheat prices;
4. analyse the demand responses to fluctuations in Free State wheat supply; and
5. analyse the demand effect of characteristic uncertainty.

2. BUILDING THE MODEL

2.1 Primary non-linear programming problem

The aim of the model is to evaluate the demand for domestic wheat relative to international wheat and the implications thereof. The model takes the general form of 'Primary B' - a cost minimisation problem subject to a set of 'chance' constraints - but includes a number of other constraints as well. These constraints determine the minimum and maximum levels of the end-use performance characteristics desired by the milling and baking sector in a unit of flour. The objective of the model is to determine the blend of different wheat sources that minimises the cost of producing flour fulfilling these requirements. A choice of six international and domestic wheat types - Canadian Western Red Spring, 13.5% protein (CWRS), Australian Hard, ordinary protein (AHW), US Dark Northern Spring, 13% protein (DNS), Free State, Western Cape, Northern Cape and Transvaal wheat - were made available. This selection covers a broad spectrum of international wheat and captures the regional quality variations of domestic wheat. It thus represents the options available to domestic millers in the deregulated and trade liberalised environment. As only wheat prices were available the cost minimising objective function (equation 14) was stated in terms of wheat and not flour. The results of the model are, however, stated in terms of flour. To enable this wheat quantities were converted into flour quantities using their respective extraction rates adjusted for variance.[37]

The 'chance constraints' (see equation 15) and 'certainty constraints' (see equation 6) for the selected 'end-use performance characteristics' are set out in Table 4:

TABLE 4

Characteristic requirement levels

Characteristics	Required level min	max
Chance constraints		
Wheat Data		
wheat falling no. (sec)	250	
hectolitre mass (kg/hl)	76	84
Flour data		
flour protein (%)	10	12.75
farinograph abs. (%) (@14%mb)	60	66
farinograph develop time (min)	4	7
mixogram peak (min)	2	3.4
alveogram strength (cm^2)	28	50
alveogram P/L ratio	0.6	1.2
100g bake test vol. (cm3)	850	
Certainty constraints		
flour ash (%)[a]	0.6	0.8
Additional constraints		
Free State flour (%)		40
Northern Cape flour (%)		10
Transvaal flour (%)		10
Sum of flour	= 1	

Source: SACB, Quality guidelines for South African flours and personal correspondence with domestic bakers.

Note: (a) A 'certainty constraint' was used for flour ash as no solutions were feasible otherwise.

The wheat and flour constraints capture the milling and baking requirements for flour and bread production. The 'sum of flour' constraint is to ensure that the optimal flour quantities are given in percentages. The Free State, Northern Cape and Transvaal constraints are crude supply constraints to ensure that demand in the interior for these sources of wheat does not

[37] Flour quantities for each input, F_i ,are calculated using $\bar{x}_{ei}.v_i - \Omega(\alpha).\sigma(\bar{x}_{ei}).v_i = 100F_i$, where $\bar{x}_{ei}$ is the extraction rate of input i and v_i is the quantity of input i . See Table 5 for the extraction rates and variances of each wheat source.

exceed their average production levels between 1985/86 and 1994/95.[38] Alterations of these constraints permits an analysis of the sensitivity of demand to supply shocks. These will be performed later.

Two primary regions were chosen in which to perform simulations: Gauteng and the Western Cape. Gauteng serves as a centre for interior demand comprising of Natal, Free State, Northern Cape and Transvaal. The inclusion of a Western Cape simulation was necessary as interior demand for wheat only reflects the demand for Western Cape's surplus production. The significantly lower domestic transport cost to Gauteng for international wheat than for Western Cape wheat also implies that the effective Western Cape price in Gauteng does not represent the 'true' cost competitiveness of Western Cape wheat within its home region. As the Western Cape constitutes approximately 14% of total wheat consumption it was necessary to model wheat demand within this region separately. The choice of wheat sources for the Western Cape simulations excluded the interior regions as Western Cape millers have historically relied solely on local wheat (Simondsen, 1996). Eastern Cape wheat consumption has not been included in any simulation as it is assumed that because of its coastal proximity its consumption requirements will largely be met through the international market.

2.2 Data requirements and data analysis

The data required for the model consists of: (1) characteristic requirement levels, (2) quality characteristic break-down of the various sources of wheat, and (3) wheat prices.

Characteristic requirement levels

The first task is to discern those wheat characteristics that are regarded as essential for the production of bread and then to stipulate the parametric values of these characteristics. This is a complicated task as these levels are influenced by the technology used in the baking sector and dependent on whether white or brown bread is being produced and whether production occurs in the interior or the coast. In addition, adjustments to the baking process and/or additives can be used to accommodate lower or higher than desired characteristic levels. The production process and its characteristic requirements are not 'set in stone' making the choice

[38] These values represent regional production as a percent of total internal consumption which is comprised of Natal, Free State, Northern Cape and Transvaal. The values for Northern Cape and Transvaal should be slightly higher. The Free State supply condition has been adjusted to account for the enormous crops during 1987/88 and 1988/89.

of levels an odious task. Nevertheless, consistency of quality characteristics are desired to prevent losses arising from unexpected quality variances. To facilitate the production of consistent flour quality, the 'Joint Technical Liaison Committee' (JTLC) of the South African Chamber of Baking and National Chamber of Milling has drawn up a list of guidelines for various quality characteristics. Through discussions with various baking technical analysts and consultation with the JTLC guidelines the characteristics and levels identified in Table 4 were selected as constraints for the non-linear programming model. The minimum and maximum parameters reflect the characteristic requirement levels for the production of *white bread* flour for bakeries in the *interior*. An exception is the level of flour protein content which is an average for brown and white bread flour.

Quality characteristic data

The measurement of quality characteristics is also a complicated process as the values calculated are influenced by the technical methods used. This poses a problem when comparing characteristic values across countries. Foreign wheat quality data is supplied by wheat agencies and wheat boards, but inconsistencies in measurement methods limit their comparability with domestic characteristics values. The problem of inconsistency in measurement methods was solved by using samples of the Wheat Board's quality analyses of imported wheat between 1990 and 1995. The Wheat Board performs the same quality analysis on all imported wheat into the country as it does on domestic wheat. The use of this data has the added benefit of reflecting actual imports into the country and will capture the experienced variations in characteristic levels facing the miller.

The disadvantage of using this data is that it limits the range of feasible alternatives to domestic millers. Ideally the model requires a range of wheat types with protein contents between 11 and 15 percent. An analysis of Table 5 indicates a narrow spread of international wheat with protein contents falling within the 12.5 to 13.5 percent range. Although this suggests homogeneity of internationally available wheat, Larue (1991), Larue and Laplan (1990) and Veeman (1987) argue that country of origin plays an important differentiating role in price determination. Price differences reflect not only differences in quality levels, but the confidence and reliability of each countries grading system. Maintaining distinctions between international sources of wheat is thus a necessity.

Data on domestic quality characteristic was taken from the Wheat Board "Wheat Crop Quality" reports between 1991/92 and 1994/95. For parsimonious reasons the data was aggregated into 4 domestic production regions: (a) Western Cape consisting of the Swartland and Ruens areas; (b) Transvaal consisting of Mpumalanga, Northern Province, Eastern Transvaal and Gauteng; (c) Free State and (d) Northern Cape. Eastern Cape and Natal were not included as they each constitute less than 5% of total production. The mean values, standard deviations and coefficients of variation of the quality characteristics of each wheat type given in Table 5.

An analysis of the mean values reveals that only Free State wheat compares favourably with international wheat in terms of quality. The Western Cape, on the other hand, displays inferior quality characteristics and does not satisfy numerous of the constraints such as farinograph absorption, farinograph development time and baking volume. As emphasised the variance of quality characteristics is also an important consideration. An analysis of the standard deviations and coefficients of variation indicates that the international wheat is characterised by a higher degree of stability than domestic wheat. The favourability of Free State wheat in terms of mean values is considerably reduced by high climatically induced variations around these means. In the more stable regions of South Africa the variations in characteristic levels are lower. Of the international wheats, CWRS and DNS have higher mean values and lower variances than the Australian wheat.

TABLE 5

Characteristic levels and variances of wheat sources

Wheat source	CWRS	AHW	DNS	F State	W Cape	N Cape	TVaal
Observations	n=41	n=34	n=34	n=113	n=158	n=38	n=58
Wheat Data			*Expected value*				
wheat protein (12%mb)	13.37	12.79	13.01	13.43	10.95	11.54	12.24
wheat falling no. (sec)	351.85	487.52	279.44	369.81	384.92	382.87	369.78
hectolitremass kg/hl	80.15	80.82	78.91	78.81	80.00	81.01	80.55
Flour data							
flour protein (%)	12.75	12.11	12.22	12.59	10.21	10.66	11.24
extraction rate (%)	75.81	75.24	76.27	75.43	74.39	75.18	75.72
flour ash (%)	0.61	0.59	0.61	0.58	0.62	0.65	0.64
farinograph abs. % (14%mb)	63.04	62.97	62.58	61.88	59.13	62.02	61.18
farinograph develop time (min)	5.22	4.88	4.79	5.07	2.85	3.42	4.43
mixogram peak (min)	2.91	2.57	2.78	2.58	2.94	2.40	2.99
alveogram strength (cm2)	42.78	38.74	44.18	36.73	28.57	22.95	32.69
alveogram P/L ratio	0.83	1.11	0.67	0.53	0.69	0.95	0.62
100g bake test vol. (cm^3)	904.97	883.38	907.50	919.12	799.62	794.34	842.03
			standard variation (coefficient of variation)				
Wheat protein (12%mb)	0.41	0.65	0.22	1.17	1.00	0.78	0.93
	(3.07)	(5.07)	(1.68)	(8.74)	(9.11)	(6.75)	(7.58)
wheat falling no. (sec)	25.91	58.54	49.01	34.90	50.62	39.59	53.08
	(7.37)	(12.01)	(17.54)	(9.44)	(13.15)	(10.34)	(14.35)
hectolitremass kg/hl	0.81	1.34	0.88	1.28	1.78	1.42	1.46
	(1.01)	(1.65)	(1.12)	(1.63)	(2.23)	(1.75)	(1.81)
flour protein (%)	0.41	0.70	0.20	1.25	1.00	0.83	1.59
	(3.21)	(5.75)	(1.60)	(9.92)	(9.82)	(7.79)	(14.17)
extraction rate (%)	1.79	1.06	0.87	1.02	0.92	1.71	0.93
	(2.36)	(1.41)	(1.14)	(1.35)	(1.24)	(2.28)	(1.23)
flour ash (%)	0.05	0.03	0.03	0.05	0.10	0.04	0.04
farinograph abs. % (14%mb)	1.49	2.42	1.35	1.79	1.94	2.07	1.37
	(2.36)	(3.84)	(2.15)	(2.89)	(3.28)	(3.33)	(2.24)
farinograph develop time (min)	0.81	0.66	0.87	1.61	1.46	0.81	1.61
	(15.52)	(13.53)	(18.07)	(31.74)	(51.19)	(23.64)	(36.45)
mixogram peak (min)	0.27	0.33	0.34	0.59	0.44	0.55	0.54
	(9.18)	(12.73)	(12.20)	(23.08)	(15.08)	(22.80)	(18.22)
alveogram strength (cm2)	6.33	8.16	5.60	10.06	6.36	4.08	6.83
	(14.79)	(21.07)	(12.69)	(27.39)	(22.27)	(17.78)	(20.89)
alveogram P/L	0.25	0.53	0.14	0.19	0.22	0.41	0.20
	(29.60)	(47.78)	(21.13)	(36.06)	(32.31)	(43.36)	(32.84)
100g bake test vol. (cm^3)	71.23	70.54	36.46	87.65	79.46	51.41	116.29
	(7.87)	(7.98)	(4.02)	(9.54)	(9.94)	(6.47)	(13.81)

Source: **Domestic**: Wheat Board, Wheat Crop Quality reports, 1991/92 to 1994/95 ; **International**: Wheat Board.

Notes: Coefficient of variation is calculated using the following equation: s.d/mean * 100

Price levels

Prices play an integral role in the model as they reflect the value attributed to characteristics contained within each wheat source. As the competition between wheat sources will take place at the mill-gate, international free on board and domestic producer prices must be adjusted to include transport and other marketing costs. The 1993/94 season was chosen as the base year because (a) it is the year in which the Wheat Forum (1994) tariff proposal is based, and (b) the prices reflect the average prices prior to the surge in international prices arising from low world stocks. Table 6 compares the Gauteng and Western Cape mill-gate prices of the various sources of wheat. The derivation of these prices is done in Appendix B.1.

TABLE 6

Gauteng and Western Cape mill-gate prices, 1993/94

Wheat source	CWRS	AHW	DNS	F State	W Cape	N Cape	Transvaal
			Mill-gate price (R/t)				
GAUTENG	934.55	750.82	874.27	834.38	896.38	841.38	841.38
WESTERN CAPE	849.55	665.82	789.27	n/a	766.38	n/a	n/a

From Table 6 it is clear that Free State, Northern Cape and Transvaal wheat were price competitive in Gauteng with respect to CWRS and DNS wheat, but not with respect to AHW. Western Cape wheat, because of its significant transport costs (R130/t) could not price compete in Gauteng, but could compete against CWRS and DNS in its home region.[39] Whether these regions can compete in terms of demand is dependent not only on price but on quality as well. The following section deals with this.

3. RESULTS

To realise the objectives set out in the introduction, the modeling results are grouped into three distinct sections: (a) analysis of trade liberalisation, (b) calculation of 'derived demand prices' and (c) sensitivity analyses of results. The results from the three sections are interdependent as the sensitivity analyses in section (c) are based on the derived demand prices determined in section (b). These prices in turn are calculated from the analysis done in section (a). Care must be taken in interpreting the results as they are dependent on the model structure

[39] The considerably higher CRWS wheat may be due to a premium beyond what can be accounted for by differences in levels of quality characteristics. Larue (1991: 114) argues that the premium is the value attributed to Canada's reputation of consistent wheat quality and reliable grading systems.

and the assumptions made. Problems associated with the model are discussed at the end of this section.

3.1 Analysis of trade liberalisation

To evaluate the effect of trade liberalisation on the demand for domestic wheat, the following trade scenarios were simulated: (1) pre-trade liberalisation, (2) trade liberalisation with zero tariff and (3) trade liberalisation with a 66% tariff. A discussion and an analysis of the results for each simulation follows.

Pre- trade liberalisation

Since the imposition of the Winter Cereal Scheme, the international market has primarily served as a source for domestic shortfalls or as the occasional outlet for domestic surpluses. To model this purchasing constraint on millers, a maximum import content of 20%, which approximates the average domestic production shortfall over the past ten years, was imposed. Effective import parity prices of international wheats assuming zero tariffs were used for each regional simulation. The results of the simulation are given in Table 7

The assumption of a 20% import content for the Western Cape proved too strong an assumption and it was necessary to raise this value to 60%. It was also necessary to assume relatively low confidence intervals of 69.15% and 59.87% for the Gauteng and Western Cape simulations, respectively. These necessary steps lend weight to the contention that the burden of domestic quality volatility was passed onto the miller and baker. As millers and bakers were 'locked' into purchasing domestic wheat, adjustments in their milling and baking processes had to be made to accommodate for quality variances. The results for Gauteng suggest that Western Cape wheat was used primarily as a shortfall once all remaining wheat in the country had been used up. This is substantiated by the values for the remaining domestic regions in the 'reduced cost' column.[40] The reduced cost measures the increase in the value of the optimum objective function per unit increase of the wheat source.[41] The value thus measures the extent

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[40] A result not included that confirms this contention is the price insensitivity of demand for Western Cape wheat. There was no change in quantity of Western Cape wheat demanded when using gross producer prices (R803) for all regions.

[41] For example: if the constraint for the maximum level of Free State wheat was raised to 0.5, the objective function value would decline by R132.23. The reduced cost value is endogenously determined and is dependent on the assumptions and constraints used in the simulation. The value reflects the implicit price of the wheat source as it is the changes in the effective constraints caused by a change in the quantity of the input that cause the value of the objective function to alter.

to which the input is over or under valued *relative* to the prices of the other inputs. Under the controlled system Free State, Northern Cape and Transvaal wheat were underpriced relative to Western Cape wheat. This reflects the extent of cross subsidisation that was taking place.

TABLE 7.

Flour demand: Pre-trade liberalisation

	Flour blend[c]	Reduced cost	Price (R/t)[d]
GAUTENG[a]	$\Omega(\alpha)=0.5$		
CWRS	0.053	0	934.55
AHW	0.024	0	750.82
DNS	0.123	0	874.27
F State	0.4	-1323.07	834.38
W Cape	0.2	0	896.38
N Cape	0.1	-353.17	841.38
T Vaal	0.1	-869.17	841.38
Total cost (R/t)	1144.81		
W CAPE[b]		$\Omega(\alpha)=0.25$	
CWRS	0.316	0	849.55
AHW	0.142	0	665.82
DNS	0.142	0	789.27
W Cape	0.4	1827.46	766
Total cost (R/t)	1042.74		

Notes: (a) The Gauteng results assume a maximum import content of 20 % and a confidence interval of 69.15% ($\Omega(\alpha)$=0.5). The effective constraints were farinograph development time, 100g baking test and 20% maximum international flour content.
(b) A feasible result for the Western Cape was only possible with a permissible import content of 60% and a lower confidence level of 59.87% ($\Omega(\alpha)$=0.25). The effective constraints were farinograph development time, 100g baking volume and 40% minimum quantity Western Cape flour.
(c) To obtain the *wheat* blend the flour blend values must be converted to wheat equivalents using the relevant extraction rate. Because the extraction rates for each wheat source are similar, the flour blend values approximate the wheat blend values.
(d) International and domestic prices for the Western Cape simulation do not include internal transport costs. Their inclusion is unnecessary as they are equivalent.

The results of both regional simulations are also supportive of the Western Cape miller's concerns that they faced cost disadvantages relative to the interior millers because of the higher percentage of the poorer quality wheat distributed to them. To accommodate for having to use lower quality wheat, the Western Cape millers had to make more extensive use of the relatively expensive high protein CWRS wheat. According to the reduced cost values a reduction of the minimum Western Cape flour content from 40% to 30% would lower the objective function value by R182.75.

Post trade liberalisation

Under tariffication and deregulation the miller is not 'locked' into domestic purchases, but will attempt to meet the quality requirements through blending wheat sources in the most cost competitive manner. Because consistency is a priority the miller will place greater emphasis on the stability of the flour quality characteristics. Two scenarios regarding trade liberalisation were simulated for each region. The first assumed a zero tariff and a confidence level of 80% ($\Omega(\alpha) = 0.84$) for the Gauteng simulation and a 64.8% ($\Omega(\alpha) = 0.38$) confidence level for the Western Cape simulation. The pre-trade liberalisation mill-gate prices were used. In the second scenario a 66% tariff was applied to the first scenario. A 66% tariff was chosen as this was the value the Wheat Forum proposed to the BTT during the tariff negotiations in 1994. It has subsequently been used in studies such as Troskie *et al* (1995) enabling a comparative analysis. The results of each scenario are given in Table 8.

TABLE 8

Flour demand: Post trade liberalisation

	Flour blend	Reduce d cost	Price [b] (R/t)	Flour blend	Reduce d cost	Price [b] (R/t)
	tariff = 0%			***tariff = 66%***		
GAUTENG[a]	$\Omega(\alpha) = 0.84$			$\Omega(\alpha) = 0.84$		
CWRS	0	87.65	934.55	0	152.60	1419.94
AHW	0.572	0	750.82	0.225	0	1121.92
DNS	0.323	0	874.27	0.149	0	1320.82
F State	0	19.13	834.38	0.4	-336.10	834.38
W Cape	0	151.58	896.38	0.026	0	896.38
N Cape	0.005	0	841.38	0.1	-71.47	841.38
T Vaal	0.1	-4.94	841.38	0.1	-203.62	841.38
Total cost (R/t)	1069.51			1305.44		
W CAPE[a]	$\Omega(\alpha) = 0.38$			$\Omega(\alpha) = 0.38$		
CWRS	0		849.55	0		1334.94
AHW	0.584		665.82	0.584		1036.92
DNS	0.175		789.27	0.175		1235.82
W Cape	0.241		766	0.241		766
Total cost (R/t)	950.80			1355.46		

Notes: (a) The effective constraints were flour ash and 100g baking volume.
(b) Prices for Western Cape do not include transport costs.

The results given in the table are supportive of the contention by Van Zyl (1995) that full trade liberalisation drastically effects the domestic wheat industry. However, the underlying cause of the decimation of production is a fall in demand for domestic wheat which differs from a fall in supply identified by Van Zyl (1995). In the Gauteng simulation demand for Free State and Western Cape wheat falls to zero. Demand for Transvaal wheat remains strong with the upper production limit effectively constraining demand. This strong demand arises from the relatively high flour ash level and 100g baking test volume of Transvaal wheat, both of which were effectively constrained in the optimal solutions. Within the Western Cape it is interesting to note that demand for the region's wheat is relatively strong at 24.1% of total regional consumption. The high demand arises from the relatively low price of Western Cape wheat within the home region and the need to compensate for the low flour ash of AHW.

The values of these simulations cannot be interpreted as the actual results of trade liberalisation because domestic prices are assumed fixed. The results are more useful as indicators of the direction of the market forces on demand and prices initiated by trade liberalisation. An analysis of the reduced costs reveals that Transvaal wheat is relatively under-priced, while Free State wheat and Western Cape wheat is overpriced. Free State wheat is only slightly over-priced implying that a small reduction in its price will lead to an increase in demand. Western Cape wheat, in contrast, is heavily overpriced implying significantly adverse effects in the Western Cape arising from complete trade liberalisation.

In the second scenario, the 66% rise in international wheat price through either tariffication or rising prices (as in 1996), should increase the opportunity cost of international wheat and cause a substitution towards domestic wheat. However, because the substitutability of wheat is dependent both on its price and quality a rise in the import price of international wheat is not a guarantee that more domestic wheat will be demanded.

Nonetheless, the results of the second scenario reveal a considerable substitution of demand towards domestic wheat. Demand for wheat from the Free State, Northern Cape and Transvaal increases dramatically and is constrained by the supply conditions (Table 8). Demand for Western Cape wheat increases to 2.6% in Gauteng, but not noticeably in the Western Cape. This suggests that it is primarily quality and not price that influences Western Cape wheat demand. Studies that do not take quality characteristics into consideration may thus underestimate the 'true' magnitude of the effect of trade liberalisation. The adverse effects of tariffication for the consumer is reflected in the increase in the total cost of the flour blend. The rise in cost is worse in the Western Cape which uses a higher percentage share of foreign wheat.

3.2 'Derived demand' prices

As stated the above results do not encompass the changes that trade liberalisation and deregulation will have on domestic prices. It was argued that deregulation would end the system of cross subsidisation and lead to differential prices according to transport and quality differences. To determine the 'derived demand' prices the reduced costs values of the trade liberalised scenario with a 66% tariff were used to alter the existing domestic prices. Minimum supply conditions were added to the 'additional constraints' in Table 4 to induce market equilibrium forces. Free State wheat was regulated to supply between 35% and 40% of interior consumption demand; and the Northern Cape and Transvaal to supply between 6% and 10% of interior consumption. No supply conditions were applied to Western Cape wheat as the previous results suggest that this wheat serves as a shortfall once surplus wheat from the other regions has been consumed.

Numerous simulations using different domestic price levels were performed to determine relative prices that equaled the value of the characteristic composition of each wheat. The inclusion of parametric international prices ensured that the value assigned to domestic wheat was consistent with miller's valuation of international wheat. Domestic prices including the Western Cape wheat price were determined solely on the basis of the Gauteng simulations. I have thus assumed that excess supply in the Western Cape will ensure a convergence of prices within the home region and the interior.

Results

The 'derived demand' prices and quantities demanded are given in Table 9. A table of the slack amounts and dual prices for each constraint is given in Appendix B.

TABLE 9

Derived demand prices

Wheat source	Flour blend	Reduced cost	Prices (R/t)
CWRS	0	152.18	1419.94
AHW	0.252	0	1121.92
DNS	0.154	0	1320.82
F State	0.362	0	1115
W Cape	0.058	0	880
N Cape	0.082	0	885
T Vaal	0.092	0	971
Total cost (R/t)	1477.24		

Notes: Results assume a 79.95% confidence level. The following supply constraints pertain: 0.35 ≤ Free State ≤ 0.4 ; 0.6 ≤ N Cape and Transvaal ≤ 0.1. The minimum flour ash and 100g baking volume were effective characteristic constraints.

As indicated in the table domestic prices were adjusted until the reduced cost of each equaled zero. This signified that the value attributed to each wheat source as a collection of characteristics was equal to its price. A comparison with Table 8 reveals that deregulation and trade liberalisation with a 66% tariff raise the mill-gate price per ton of Free State wheat to R1115, Transvaal wheat to R971 and Northern Cape wheat to R885. The price of Western Cape wheat, because of its inferior quality, will be driven down to R880. Subtracting the internal transport costs to obtain the free on rail (f.o.r) price yields a Free State price per ton of R1047 (36.7% increase from the 1994 price), a Transvaal price of R895 (16.8% increase), a Northern Cape price of R810 (5.7% increase) and a Western Cape price of R750 (2.1% fall). It is apparent that a 66% tariff not only protects the interior domestic producers in terms of demand, but raises the prices obtainable for their crops. A consequence is a rise in the cost of the optimal flour blend from R1305.43 to R1477.24 (a 13.2% rise).

The Western Cape is the only region that suffers from a decline in producer price, although the decline is low. The response in demand to the lower price is negligible and remains at 24.1% of Western Cape consumption. However, the cost of the optimal flour blend falls to R1338.28 in response to the lower Western Cape wheat price. The lower flour blend cost in the Western

Cape than in Gauteng suggests that the negative effect from having to use an increased portion of imported wheat to accommodate for the low quality Western Cape wheat is more than compensated for by the lower transport costs. The results also suggest that the Western Cape because of its low wheat quality is demand constrained and methods other than tariffication (or international price rises) are required to protect the region from trade liberalisation.

3.3 Sensitivity analysis

Although the level of 'derived demand' prices is informative, the real importance lies in the sensitivity of these prices and the related quantities demanded to the changes in the domestic wheat industry discussed in Chapter 2. Although the ICM captures the quality factor, the effect of production volatility and characteristic uncertainty have not been adequately dealt with. Within this section scenarios were developed and tested to evaluate: (a) the effect of price changes in the Free State and Western Cape, (b) the effect of the volatility of Free State production, and (c) the impact of characteristic uncertainty on demand.

Price sensitivity

It was argued that an impact of deregulation of the domestic wheat industry would be increased inter-regional competition for market share. The results of the trade liberalisation scenario depicted earlier suggest that this competition may be fierce given the substantial inroads by the international market (over 40% of total domestic consumption) into the domestic market. It is further evident that the low demand for Western Cape wheat may lead to severe price reductions in an attempt to increase their market share. Given their relatively superior quality within the domestic market the Free State may also test their market power by raising prices. To test the effects of increased price competition between the regions, separate runs of the model were done assuming 10% and 20% price changes above and below the base values ('derived demand' prices) for Free State and Western Cape wheat. The results are more informative of the direction and extent of market pressures induced by the changes than of the *level* of change, because they assume all other variables and prices to be fixed,. The resulting flour blend compositions and the percentage changes from base value are given in Table 10.

TABLE 10

Price sensitivity of demand for Western Cape and Free State wheat

% Price change	-20%		-10%			+10%		+20%	
	Flour blend	% Δ	Flour blend	% Δ	Flour blend	Flour blend	% Δ	Flour blend	% Δ
GAUTENG[a]	$\Omega(\alpha) = 0.84$		*P change in Western Cape*						
Price (R/t)	R 704		R 792		R 880	R 968		R 1056	
CWRS	0	0 %	0	0 %	0	0	0 %	0	0 %
AHW	0.215	-14.68 %	0.211	-16.35 %	0.252	0.269	7.02 %	0.27	7.30 %
DNS	0.229	48.69 %	0.201	30.76 %	0.154	0.14	-8.91 %	0.14	-8.98 %
F State	0.302	-16.60 %	0.328	-9.41 %	0.362	0.367	1.50 %	0.367	1.35 %
W Cape	0.186	218.44 %	0.152	159.63 %	0.058	0.023	-59.98 %	0.023	-60.12 %
N Cape	0	-100 %	0	-100 %	0.082	0.1	21.57 %	0.1	21.57 %
T Vaal	0.067	-25.38 %	0.109	18.22 %	0.092	0.1	8.64 %	0.1	8.64 %
Total cost	1441.85	(e)	1463.47	(c)	1477.24	1480.51	(c)	1483.29	(c)
			P change in Free State						
Price (R/t)	R 892		R 1003.5		R 1115	R 1226.5		R 1338	
CWRS	0	0 %	0	0 %	0	0	0 %	0	0 %
AHW	0.216	-14.45 %	0.21	-14.71 %	0.252	0.361	43.33 %	0.297	18.21 %
DNS	0.153	-0.18 %	0.15	0.06 %	0.154	0.166	7.79 %	0.344	123.47 %
F State	0.4	10.57 %	0.40	10.57 %	0.362	0.251	-30.67 %	0.082	-77.42 %
W Cape	0.04	-31.88 %	0.04	-30.41 %	0.058	0.073	24.89 %	0.131	123.52 %
N Cape	0.091	11.06 %	0.091	10.36 %	0.082	0.05	-39.59 %	0.046	-43.52 %
T Vaal	0.1	8.64 %	0.1	8.64 %	0.092	0.1	8.64 %	0.1	8.64 %
Total cost	1358.40	(c)	1418.18	(c)	1477.24	1523.01	(c)	1537.90	(d)

WESTERN CAPE[b]	$\Omega(\alpha) = 0.38$		*P change in Western Cape*						
Price (R/t)	R 574		R 662		R 750	R 838		R 926	
CWRS	0	0 %	0	0 %	0	0	0 %	0	0 %
AHW	0.387	-33.69 %	0.415	-29.03 %	0.584	0.584	0 %	0.584	0 %
DNS	0.301	72.10 %	0.282	61.42 %	0.175	0.175	0 %	0.175	0 %
W Cape	0.311	29.39 %	0.302	25.83 %	0.241	0.241	0 %	0.241	0 %
Total cost	1268.41	(f)	1305.10	(d)	1338.28	1366.88	(c)	1395.48	(c)

Notes: (a) Results assume a 79.95% confidence level.
(b) Results assume a 64.8% confidence level.
(c) Constrained by 100g bake test volume and flour ash.
(d) Constrained by 100g bake test volume
(e) Constrained by 100g bake test, flour ash and farinograph development
(f) Constrained by 100g bake test and farinograph development
The percentage changes are calculated using flour values of a higher decimal place than indicated in graph. Different % changes are associated with the same flour blend in some cases

The Gauteng results of price changes of Western Cape wheat will be discussed first. The discussion on price changes of Free State wheat and the Western Cape regional simulation will follow.

Reductions in Western Cape wheat prices indicate a high price elasticity of demand for Western Cape wheat within Gauteng. A 10% reduction in price results in a 159.6% rise in quantity demanded from 5.8% to 15% of interior flour consumption.[42] A further 10% reduction in price continues the upward trend in demand (to 18.6%), although at a lower rate. The rise in demand for Western Cape wheat is primarily at the cost of Northern Cape wheat which drops to zero. Once this substitute has been depleted inroads are made into Free State and Transvaal wheat. The strong negative relationship between Western Cape and Northern Cape wheat indicates a high degree of substitutability between the two sources. The increased usage of low quality Western Cape wheat is compensated by an increased demand for the expensive high quality DNS wheat whose share of the flour blend increases from 15.3% to 23% in response to a 20% fall in the Western Cape wheat price. This positive relationship indicates a complementary relationship between the two sources; a fact substantiated in the analysis of a price rise.

The noticeable feature of a rise in Western Cape wheat prices is the price insensitivity of demand for all wheats beyond a 10% rise in Western Cape wheat prices. This arises because the supply of the closest two substitutes, the Northern Cape and Transvaal, become effective constraints with even low price increases of Western Cape wheat. The remaining wheat sources, especially Free State wheat, are poor substitutes for Western Cape wheat. The high degree of substitutability between Western Cape wheat and Northern Cape wheat may give rise to severe price competition as each competes for market share.[43] However, the poor substitutability between these wheats and the remaining wheats suggest that they will be competing for a limited and fixed market share.

The demand for Free State wheat is highly price elastic as indicated by the large fluctuations in demand in response to price changes. The results for price rises are more illustrative of the

[42] Because of similar extraction rates, the percentage flour use closely approximates percentage wheat consumption.

[43] The price inelasticity of demand for Western Cape wheat identified in Table 10 and the positive revenue implications from lowering prices suggests that the Western Cape 'derived demand' prices used in this analysis are excessively high.

price responsiveness of quantity demanded as the 40% maximum supply condition becomes a restriction once the Free State price falls. The results from the rise in Free State price indicate its high degree of substitutability with international wheat sources. The large fall in demand for Free State wheat from 36% to 25% of interior flour consumption in response to a 10% price rise, is largely due to a 13 percentage rise in the demand for international wheat. Although the substitutability of Western Cape wheat is fair for a 10% price rise of Free State wheat (demand rises to 7.3% of interior flour consumption), the substitutability increases with any further price rises. A 20% price rise causes demand for Free State wheat to fall to 8.2% and demand for Western Cape wheat to increase to 13.1% of interior flour consumption requirements. The composition and level of international wheat demand is affected by the increased share of Western Cape wheat and rises to 64% of the flour blend. In particular the share held by DNS rises from 15.3% to 34.4% to compensate for the lower baking volume of Western Cape wheat. A further noticeable feature is the complementarity of demand between Free State wheat and Northern Cape wheat. This relationship, however, may be due to the high substitutability between Western Cape wheat and Northern Cape wheat identified in the earlier analysis.

The Western Cape regional analysis confirms the elastic response in demand to a fall in Western Cape wheat price identified in the Gauteng simulation. A 10% fall in price increases demand for Western Cape wheat by 25.8% to 30.2% of regional consumption. The complementary relationship between Western Cape wheat and DNS is again visible in the substantial rise in demand for DNS. Subsequent lowering of price has a minimal effect with demand only increasing by one percentage point with a further 10% reduction in price.

The insensitivity of Western Cape wheat demand to rises in price suggests a technical dependency of the baking industry on domestic wheat production. Baking parameters have been structured around the particular characteristics of domestic wheat necessitating a minimal quantity of domestic wheat. The insensitivity of demand also suggests that the 'demand derived' prices are excessively high.

Production sensitivity

A characteristic of domestic wheat production is the high volatility of Free State wheat production. This poses a problem to the domestic milling industry given the importance of Free State wheat as suggested in the earlier results. As the Free State is the largest producer, changes in its production will have important spill-over effects on the demand for the remaining region's wheat. In the past this spillover had a direct demand effect for Western Cape wheat. With deregulation the strength of this relationship may change. To test the sensitivity of domestic purchases to a failure in the Free State crop, the Free State supply constraint was altered to a maximum of 15%, 20%, 25% and 30% of interior demand. Production in excess of 40% was not measured because the 40% supply constraint used to determine the 'derived demand' prices is already biased upwards by the surplus years in the late eighties.

Supply changes will elicit equilibrium forces which will alter the relative prices and demand for each wheat source. Although Table 11 does not give a new set of derived prices for each change in Free State production, in cases where a supply condition effectively constrains demand one can expect the price of that wheat source to be forced upwards.

TABLE 11

Sensitivity of domestic demand to changes in Free State production

Max % FS flour	40%	30%		25%		20%		15%	
GAUTE NG	Flour blend	Flour blend	% Δ	Flour blend	% Δ	Flour blend	% Δ	Flour blend	% Δ
CWRS	0	0		0		0		0	
AHW	0.25	0.26	4.5 %	0.27	7 %	0.27	5.5 %	0.255	1.42 %
DNS	0.15	0.18	18.7 %	0.21	37.6 %	0.25	63.1 %	0.298	93.7 %
F State	0.36	0.3		0.25		0.2		0.15	58.5 %
W Cape	0.06	0.07	13.7 5	0.07	18.6 %	0.08	42.8 %	0.097	65.8 %
N Cape	0.08	0.09	7.2 %	0.1	21.6 %	0.1	21.6 %	0.1	21.6 %
T Vaal	0.09	0.1	8.6 %	0.1	8.6 %	0.1	8.6 %	0.1	8.6 %
Total cost	1477.24	1479.01		1482.27		1487.81		1495.55	

Notes: Results assume a confidence level of 79.95%. 'Derived demand' prices are assumed constant. 100g baking volume and the Free State supply constraint were effective constraints for all simulations.

The results in Table 11 indicate a relatively low substitutability between Free State and Western Cape wheat. A fall in Free State production increases demand for Western Cape wheat to a maximum of 9.7% of interior consumption. Demand rises for Northern Cape and Transvaal wheat, but both supply conditions for these regions become effective constraints after a fall of Free State production to 25%. The primary substitute for a failure in the Free State crop is the international market, in particular DNS. Total share of imported wheat rises from 40.5% with a 40% Free State supply condition to 55.3% with a 15% Free State supply condition. The proportionately greater rise in DNS is due to the need to compensate for the fall in baking volume implied by a fall in Free State wheat and the increased use of Western Cape wheat.

Changes in Free State production will initiate certain changes in the domestic wheat industry. Firstly, because of excess demand for Free State, Northern Cape and Transvaal wheat when Free State wheat production falls, upward pressure will be placed on their prices. Secondly, the volatility of Free State wheat production causes the cost of the flour blend to fluctuate as more or less imported wheat is used. Price rises in response to a fall in Free State wheat production will be transferred to the baking sector and then to the consumer. Thirdly, because of the close substitutability of international wheat with Free State wheat, the balance of payment effect of a fall in Free State wheat production will be greater than in the past where millers were forced to purchase domestic wheat.

Characteristic uncertainty

Characteristic uncertainty has been emphasised as a crucial determinant of wheat demand. Increased characteristic variance adversely affects bread production and consumer demand and can be interpreted as a cost. To test the importance of characteristic uncertainty the model was solved using a selection of confidence levels. By increasing the confidence level (which increases $\Omega(\alpha)$ in equation 15), a greater weighting is placed on the variance of characteristics. Six confidence levels were chosen, 50% (equivalent to a linear programming model ('Primary A')), 60%, 70%, 80%, 90% and 95%, where each successive increase reflects a more stringent quality requirement and a greater inability to adjust the baking process in response to characteristic variations. The solution results are given in Table 12.

TABLE 12

Sensitivity of demand to characteristic uncertainty

probability	Percentage flour blend 50 %	60 %	70 %	80 %	90 %	95 %
$\Omega(\alpha)^a$	0	0.25	0.52	0.84	1.28	1.64
CWRS	0	0	0	0	0	0.061
AHW	0.031	0.135	0.272	0.252	0.223	0.224
DNS	0	0	0	0.154	0.369	0.453
F State	0.4	0.4	0.4	0.362	0.261	0.196
W Cape	0.369	0.265	0.128	0.058	0.047	0
N Cape	0.1	0.1	0.1	0.082	0	0
T Vaal	0.1	0.1	0.1	0.092	0.1	0.066
Total cost (R/t)	1319.85	1356.41	1404.53	1477.24	1566.23	1642.67

Notes: (a) $\Omega(\alpha)$ is the standard normal distribution coefficient for α level of significance. Its value reflects the weighting given to the characteristic variance of the non-linear constraint (equation 15). The results are calculated for Gauteng using the 'derived demand' prices. The following characteristics were effective constraints in the optimal solutions: **50%**: farinograph absorption, **60%**, **70%** and **90%**: 100g baking volume, **80%**: flour ash and 100g baking volume, **95%**: farinograph absorption and 100g baking volume.

The results confirm the importance of characteristic uncertainty as a determinant of demand. Using the 50% confidence level as the base result, one notes that as the confidence level increases millers substitute the higher priced, lower variance international wheats for domestic wheats. At the 50% confidence level, domestic wheat demand accounted for 97% of the total flour blend. At a 95% confidence level domestic wheat constitutes a mere 27% of the flour blend. The substitution occurs because as the confidence level rises demand shifts to wheats with a higher (or lower) mean and a lower variance. In this model this entails a shift in demand towards DNS and CWRS. The region most severely affected by an increase in confidence level is the Western Cape whose wheat demand falls from 37% to 0% over the tested range. This implies that it is the combination of *both* the low mean value and the variance of Western Cape wheat that negatively affect its demand. Demand for Free State and Northern Cape wheat is constrained by supply over the 50% to 70% confidence level range, but rapidly falls over the remaining range. Demand for Transvaal wheat remains high and stable over the entire range reflecting the importance associated with its high flour ash content and 100g baking test volume.

Characteristic uncertainty has implications for the price of wheat and for the cost of the optimal flour blend. A change in the confidence level alters the importance attributed to the characteristic level and variance of each wheat source and thus their 'derived demand' values. Under the low confidence level solutions, the effective supply constraints for Free State, Northern Cape and Transvaal wheats imply that they are undervalued relative to international wheats. One would expect their prices to rise from the 'derived demand' levels used in the solutions (those reflecting the 80% confidence level). As the confidence level increases more value is placed on the variance of the characteristics reflected by the move to the more expensive low variance wheats. Domestic wheats, apart from Transvaal, are relatively over-priced and downward pressure on prices will be exerted. The cost associated with variance is reflected in the increased cost of the optimal flour blend from R 1319.85 (50%) to R1642.67 (95%). High variance entails a cost, as millers are required to use an increased proportion of higher priced low variance wheats to ensure compliance with the baking requirements.

This section highlights the importance attributed to variance of wheat characteristics. This is most notably apparent when comparing the demand for Free State, CWRS and DNS wheat. All have similar mean values of the crucial characteristics which in the absence of variance would imply similar prices. Yet if one includes variance, one notes the value attributed to the higher variance Free State wheat is substantially below that of the other wheats. A premium is thus paid to low variance wheats and may explain why the CWRS and DNS wheats are so highly priced. These results substantiate Larue's (1991) and Larue and Laplan's (1990) contention on the importance of a rigid and consistent grading and inspection system as practiced in Canada.

3.4 Clarification of certain problems

The dissertation utilises the ICM to evaluate the demand for domestic wheat relative to international wheat and determine representative prices for domestic wheat. As with most models, there are numerous faults making the results highly conditional on the assumptions made. For the interpretation of the results to have validity it is necessary to clarify some of the assumptions made.

The first set of problems relate to the fixed demand and supply relationships assumed. The model assumes that demand over subperiods is stable, and that "*variations in prices and associated quantities of characteristics within these subperiods are generated by variations in* *the supply of characteristics rather than shifts in the demand for characteristics*" (Veeman, 1987: 539). In reality the implicit prices are a function of both demand and supply. If demand for a certain characteristic increases, the implicit price of that characteristic will increase, forcing the wheat price upwards. Similarly, if the supply of a wheat embodying a constraining characteristic falls, the price will rise. The model used assumes that the demand conditions as reflected in the characteristic constraints are fixed and do not change in response to wheat price changes. This yields the insensitivity of demand to price changes, especially seen in connection with Western Cape wheat. In reality the baking constraints are not 'fixed', enabling adjustments with the aid of additives in response to excessively high prices. The results thus may underestimate the sensitivity of quantity demand to price changes.

The assumption of fixed constraints is also applicable to the supply side. The minimum and maximum supply conditions used to induce market clearing forces are crude as they ignore the price effect on quantity supplied. They are not used to evaluate the supply effect of price changes, but are used to determine 'derived prices' required for wheat demand to fall within each (except Western Cape) region's historical production levels. This poses problems because in reality if supply at the 'derived prices' exceeds or is exceeded by demand, adjustments in both price and production will occur. In determining the 'derived demand' prices the full adjustment occurs through price changes. The supply conditions also ignore the inverse relationship between wheat quality and production. Wheat quality is influenced by climatic variations; falling during moist seasons and rising during dry seasons. In the production sensitivity analysis a quality premium should be included to the Free State price level for each successive fall in production.

The assumption of stable supply and demand conditions also extends to the international market via the choice of constant international prices. As discussed in chapter 2 the international wheat market is characterised by volatile prices arising from climatic variations and political involvement in trade decisions. However, volatility of *absolute* prices does not pose a problem on the demand side if *relative* prices remain constant. The allocation of wheat sources is dependent on relative prices and if they remain constant the proportion of each wheat used in the optimal blend will remain the same. All that will change is the cost per unit output (minimum cost).[44] The assumption of relative price consistency is not too strong as there is evidence that world wheat prices fluctuate together (Atkin, 1992: 88).

A second major problem lies with the choice of the optimal implicit prices. Wheat sources are comprised of distinct and fixed bundles of characteristics. These fixed relationships constrain the marginal substitutability of characteristics resulting in a discontinuous process of substitution in response to price changes. As result a range of feasible price-quality combinations are possible making the choice of a single set of representative prices for domestic wheat somewhat arbitrary. Nevertheless, it is not the level of prices that is most important, but the sensitivity of demand for each wheat source in response to changes in price, production and consistency that is most important.

Thirdly, the model assumes that domestic producers do not substitute production between different wheat qualities as a new grading system emerges from tariffication. The Western Cape farmers are likely to substitute their lower quality crop for a higher quality crop in response to low price and demand forecasts. The result will be higher domestic purchases and 'derived demand' prices than estimated. Nevertheless, the possibility for quick supply responses is constrained by existing agro-climatic conditions and the availability of suitable wheat cultivars. In the long run a re-running of the blending program is required.

Finally, the results are not only dependent on the parameters of the model, but the structure of the price-characteristic relationship of equation (3). Equation (3) assumes that wheat prices are a *linear* function of the sum of the values of their characteristics. This assumption is crucial to the optimisation problem as it is implicitly assumed by the dual. It is possible that the relationship is logarithmic or semilogarithmic (loglinear) which is not consistent with the optimisation model used.[45] However, tests on the linearity of the functional form of the wheat price-characteristic relationship by Uri *et al* (1994) could not reject the null hypothesis of linearity. Studies by Hyslop (in Ladd and Martin, 1976: 24) also found that a large proportion of the variance in prices of hard red spring wheat could be explained by a linear combination of characteristics. Thus the assumption can be accepted with reasonable confidence.

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[44] Note the further assumption that price fluctuations do not affect demand for wheat.

[45] Equation (3) also assumes perfectly competitive markets. A discussion and adaptation of equation (3) to incorporate imperfectly competitive markets is given in Appendix A.2.

In conclusion, because the results are influenced by the use of simplifying assumptions, care must be taken in their interpretation. Nevertheless, they are useful in discerning the nature of demand for domestic wheat in a trade liberalised and deregulated wheat market. The results give an indication of the direction and extent of change in wheat demand and price. From this, useful conclusions and suggestions can be made. The following section concludes the chapter.

4. POLICY IMPLICATIONS AND SUGGESTIONS

The previous section gives insight into the market dynamics that will be unleashed in response to trade liberalisation and deregulation. Numerous policy implications and suggestions arise; some of which are dealt with in the discussion that follows.

A primary concern for the wheat industry as it prepares itself for the implementation of the new Marketing of Agricultural Products Bill, 1996, has been the setting of tariff levels that adequately protect the domestic wheat industry. The excessively high GATT negotiated tariff levels places the responsibility of tariff levels squarely in the hands of the domestic authorities.[46] The Wheat Forum, comprised of agents from each sector of the wheat industry (except retailers), agreed upon a 66% tariff level based on 1994 prices. This, they argued, would serve the interests of both the industry as a whole and consumers. The results of this study suggest that a 66% tariff overprotects domestic wheat production and will lead to a substantial rise in price of interior wheat sources. This rise in price together with the high tariff payments has a negative impact on the cost of flour and will raise the price of the final good, bread. This has serious repercussions for the emerging orientation towards *food security* of agricultural trade policy. Lower tariff levels will place downward pressure on domestic prices and will have significant benefits for the consumer in the form of lower bread prices. This conclusion is especially pertinent at the moment with the substantial rise in international wheat prices since 1994 already giving domestic producers a cushion of protection. The effect on supply of the various wheat prices cannot be determined with this model and will require further analysis of the supply side.

[46] Owing to the agreed upon method of calculating tariff equivalents, the tariff ceiling for wheat in 1995 is 120%. This has to be reduced linearly to at most 72% in 2000. Neither of these are likely to pose an effective constraint on domestic tariff levels.

A second implication of deregulation and trade liberalisation is that Western Cape wheat production is constrained by demand. Scope exists to increase interior demand for surplus Western Cape wheat through lowering prices, but only to a limited extent. Even at the lowest price tested for Western Cape wheat (see Table 10) total demand for Western Cape wheat within its home region and the interior translates into between 65% and 73% of the region's production levels. It is not price that constrains demand for Western Cape wheat, but the poor quality that hampers its substitutability with other wheat sources. Tariffs may be a misplaced attempt at increasing the cost competitiveness of Western Cape wheat.

Two trends may emerge as Western Cape wheat farmers attempt to compete in terms of demand. Firstly, Western Cape farmers may start producing low protein high yielding feed wheat or move out of wheat production and into mixed farming or barley and oats production. Secondly, farmers may substitute high quality wheats for the low quality wheat presently produced. Although this is a long term process it is only through this channel that Western Cape wheat farmers can make substantial inroads into the domestic market.

A further implication is the negative impact that trade liberalisation can have on the Balance of Payments. The results suggest that shortages arising from a decline in Free State wheat production will be sourced from the international market and not from the Western Cape as in the past. Given the volatility of Free State wheat production this may result in undesirable usage of the foreign reserves of the Reserve Bank. A solution to this problem is the maintenance of buffer stocks to smooth out the volatility of domestic production. These stocks can also serve to reduce the importation of international price fluctuations arising from trade liberalisation.

A final implication is the sensitivity of demand to characteristic uncertainty. As noted in Table 12 domestic wheat is disadvantaged by its relatively higher characteristic variance. Characteristic variance plays a strong role in determining the competitiveness of domestic producers *vis-à-vis* the international market in securing a demand outlet. A role exists for an institution such as the Wheat Board to perform and distribute technical analyses of domestic wheat quality. Increased information on domestic wheat quality will lower the risks associated with purchasing from the domestic market and will positively affect domestic wheat demand. The Wheat Board can also play a role in developing a consistent and reliable grading system that reflects the commercial value of wheat in terms of consumer defined quality characteristics. Increased reliability of the grading system enables millers to purchase and blend different wheat sources at a minimum risk of not complying with their quality parameters. A further role of the Wheat Board may be the development of a comprehensive information network estimating future production and quality levels within the various production areas. This will facilitate market transactions, lower transaction costs and enable millers and producers to respond quickly and efficiently to changing expectations. On the production side research can be performed and advice given (by institutions such as the Wheat Board) on improving managerial skills. As Van Lill (1992: 15) notes, environmental factors, of which managerial practices is a component, are responsible for a large percentage of quality variations. There is also scope for research into developing wheat cultivars that are able to withstand domestic climatic variations and produce consistent quality levels.

Chapter 5

CONCLUSION

The imminent implementation of the Marketing of Agricultural Products Bill, 1996 necessitates in-depth case studies of the various food commodity chains. Through these case studies the consequences of trade liberalisation and deregulation can be analysed along all levels of the food commodity chain. This dissertation is a study of the transformations that these policies will induce in the wheat marketing system. The dissertation is comprised of two components, the first of which is an analysis of the process whereby wheat will be marketed in future. The implications drawn from this analysis are then used to develop a model with which the impact on the demand for domestic wheat of these policies is estimated.

A food marketing system facilitates the interconnection between raw material production and consumer food purchases and is therefore influenced by the nature of the production and consumption sectors. In the domestic wheat industry this implies that the organisational structure of the marketing system has to:

a. facilitate the transportation of wheat from the surplus producing Western Cape and Free State regions to the consumption centres of Gauteng and Natal.
b. meet the miller's demands for good quality wheat at prices reflective of their commercial value.
c. limit the disturbances arising from volatile wheat production and wheat quality.

The *Winter Cereal Scheme* dealt with these issues by ossifying the linkages between all stages of the food commodity chain. All pricing, storage, distribution and purchasing decisions were administered by the Wheat Board or its agents in a manner orientated towards the producer. While protecting domestic wheat producers from imports, the Wheat Board used the international market as a source (outlet) for domestic shortages (surpluses). This enabled the Wheat Board to overcome destabilising market forces (such as price fluctuations) arising from domestic production and quality variations. The isolation from international wheat sources and the allocation procedures followed by the Wheat Board implied that millers lacked the freedom to purchase wheat in accordance with their desired quality requirements. This was especially disadvantageous to millers who were allocated the inferior quality Western Cape wheat. The net effect was an inferior bread as bakers tried to adjust to fluctuating and low wheat qualities. The pricing system was also disadvantageous to millers who were liable for the railage costs from the co-operative to the mill and had to purchase wheat at prices inflated above comparative international levels.

The implementation of the Marketing of Agricultural Products Bill, 1996 challenges these ossified marketing relationships and severs the power of the producer over the processor.

Firstly, prices are no longer determined by a producer representative Wheat Board, but are dependent on the international wheat market. This implies greater price volatility and uncertainty than in the past and the possibility of a price reduction in the future.

Secondly, producers are no longer secured an outlet at a fixed price for their wheat. The ability to sell their wheat will depend on its competitiveness relative to alternative domestic and international wheat. The effect will be an emergence of internal competition between wheat producers, differential prices among regions and a greater emphasis on wheat quality. Competition between millers for a share of the bread market will ensure that consumer demands for a high quality consistent bread will filter down to wheat demand. Premiums will be paid for wheats with a high quality and a low variation of the essential characteristics which make the production of good bread possible.

These changes will have substantial effects on the domestic wheat industry. Producers from the Western Cape will struggle to compete against the higher quality Free State wheat. They will also face the full brunt of international competition given their close proximity to the coastal ports and their relatively greater distance to the interior market. The adverse effects of trade liberalisation and deregulation in terms of price and demand will thus be greater in the Western Cape than the Free State.

The prioritisation of quality and the lack of a secure wheat market for producers signals a change from the supply orientated market of the past to a demand orientated market in the future. This has significant implications for estimating the pricing and production decisions of producers as they respond to trade liberalisation and deregulation. Most models prioritise the supply response of farmers without analysing the demand for this wheat as a function of quality. They also tend to treat wheat as a homogenous input into the baking industry when it is heterogenous in terms of the characteristics essential for the production of bread. This inadequacy of the past modeling attempts necessitates an analysis of the desirability of domestic wheat relative to international wheat in terms of its characteristic composition. To evaluate the pricing and production effects of deregulation and trade liberalisation on the domestic wheat industry, more information on the demand curve facing each wheat source is required.

In pursuit of this objective the dissertation used an Input Characteristic Model to evaluate the demand effects of trade liberalisation and deregulation. Special attention was placed on incorporating the regional dynamics such as quality and transport differentials. From the model demand and prices on a regional basis could be determined; a priority many of the other trade models have not emphasised.

The results use 1994 as a base year as it was during this time that pressure was being placed on the government to impose tariff protection to prevent the 'decimation' of domestic production. Under trade liberalisation with existing prices and a zero tariff level, demand for domestic wheat plummets. However, simulations of the model using the recommended 66% tariff with the respective 'derived demand' prices suggest that the domestic industry would be overprotected. Prices for Free State, Transvaal and Northern Cape wheat are driven upwards by strong demand pressures. The end result of tariffication is a higher bread price which conflicts with the government focus on food security. A lower tariff is called for that grants wheat producers some protection, but ensures a supply of bread at affordable prices. This conclusion is especially pertinent at the moment with high international prices and a depreciated exchange rate affording domestic farmers extra protection.

In contrast to the strong demand for interior wheat, demand and prices for Western Cape wheat falls dramatically when simulating a 66% tariff. The undesirability of Western Cape wheat is confirmed in the sensitivity analyses that followed. Although characterised by an elastic response in demand to a fall in its price, total demand for Western Cape wheat in all the price simulations did not meet its production levels. When simulating the demand responses to a fall in Free State wheat production it was noted that millers prefer to import wheat than to purchase Western Cape wheat. In the past these demand shortages were sourced from the Western Cape. The results suggests that it is primarily inferior quality factors and *not* price that constrain demand for Western Cape wheat. To focus solely on tariff measures as a means of protecting the Western Cape wheat farmer ignores the structural problems in terms of quality factors that these farmers face as they prepare to integrate into the international market.

Domestic wheat faces a further disadvantage in relation to international wheat: characteristic uncertainty. Pressure for consistent bread by the consumer translates into rigid wheat characteristic requirements by millers. Demand for domestic wheat accounts for 97% of total internal consumption when the baking parameters are flexible, but falls rapidly to 27% of internal consumption as they become more stringent. This suggests that, to remain competitive, farmers need to improve farming practices to reduce the variations in wheat quality. Millers may also engage in contractual agreements with farmers from the more stable producing areas to limit the uncertainty associated with domestic purchases.

As government and the domestic wheat industry prepare to adapt to the Marketing of Agricultural Products Bill, 1996, they must take cognisance of both the price implications and the prioritisation of wheat quality. Years of protection under the *Winter Cereal Scheme* has facilitated the development of a domestic wheat industry structured around producer needs. This has left many farmers unprepared for the demand induced changes that will be brought about by the new Marketing Bill. Solely focusing on protection through tariff measures (as is presently done) ignores the importance of quality. To ensure the protection of domestic production in the long run, other means than price protection are required.

Firstly, the Wheat Board should not be completely disbanded as it can play a major role in the provision of technical analyses of domestic wheat quality, the development of a consumer orientated wheat grading system, the provision of information and estimations regarding domestic wheat quality and production, and research into the development of high quality consistent wheat cultivars suited to the domestic climate. Further, to offset the negative consumer effects of volatile domestic production and international prices, the Wheat Board can administer the maintenance of buffer wheat stocks. Increased information will limit the risks associated with the purchase of domestic wheat and will positively affect domestic wheat demand.

Secondly, the Western Cape is likely to be the most severely effected by trade liberalisation and deregulation. The results of the model suggest that, if the Western Cape is to remain competitive in the long run, either it has to improve its wheat quality or move into alternative products such as feed wheat, barley production, pastures or mixed farming. Price protection in the form of tariffs will only be a short run solution.

In conclusion, the dissertation is a tentative step towards developing a deeper understanding of the demand for domestic wheat. From this it is hoped that a more accurate estimation of the effects of trade liberalisation and deregulation on the wheat industry will be made possible. However, the dissertation does not deal adequately with the supply side. Further research is required to estimate how farmers will respond to changing 'derived demand' prices. It is possible that the decline in Western Cape wheat production will be offset by a rise in Free State production. To determine this, normal supply side models are required.

APPENDIX A

A.1 Derivation of a perfectly competitive hedonic function

This appendix derives the hedonic function identified in equation (3). The derivation of the price-input relationship unique to this approach is taken from Ladd and Wilson (1976).

The input characteristic model differs from the standard neoclassical approach as the basic element is not the input v_i, but the characteristics that make up the inputs. Assume v_i = the quantity of the i th input used in the production of q, r_i = price of i th input, x_{ji} = amount of characteristic j found in a single unit of the i th input, and $x_{j.q}$ = the total quantity of characteristic j used in the production of q, The production function of the ICM can be represented as

(a) $q = F(x_{j.q})$: $j = 1,......m$.

This equation states that the production of q is a function of the total characteristics used in its production.

The total quantity of each characteristic ($x_{j.q}$) in turn is a function of the inputs used in the production of q that contain the characteristic j. Thus, $x_{j.q}$ can be written as

$$x_{j.q} = X_j(v_i): \quad j = 1,......m; i = 1,......n$$

The objective of the firm is to allocate inputs in order to maximise profits. The firm's profit function can be written as

(b) $\Pi = p.F(x_{1.q}, x_{2.q}, ..., x_{m.q}) - \sum_{i=1}^{n} r_i.v_i$.

As in the case of the standard neoclassical firm model, the profit maximising firm will differentiate equation (b) with respect to v_i. However, because F is a function of $x_{j.q}$, which in turn is a function of v_i, [47]

[47] This implies that $\frac{\partial F}{\partial v_i} = \sum_j (\partial F / \partial x_{j.q})(\partial x_{j.q} / \partial v_i)$ as result of the chain rule on a compound function.

$$\frac{\partial \Pi}{\partial v_i} = p.\partial F/\partial v_i - r_i$$

$$= p.\sum_{j=1}^{m}(\partial F/\partial x_{j.q}).(\partial x_{j.q}/\partial v_i) - r_i = 0$$

Solving for r_i,

(d) $r_i = p.\sum_{j=1}^{m}(\partial F/\partial x_{j.q}).(\partial x_{j.q}/\partial v_i)$;

where $(\partial x_{j.q}/\partial v_i)$ is the marginal yield of characteristic j to production from the i th input; $(\partial F/\partial x_{j.q})$ is the marginal physical product of one unit of characteristic j; and $p.(\partial F/\partial x_{j.q})$ is the value of the marginal product (implicit price) of the j th characteristic. This equation states that a profit maximising firm will utilise inputs till the implicit value of all the characteristics within the input equals its price. The derivation of the second order conditions has been ignored.

A.2 Derivation of an imperfectly competitive hedonic function

Equation (3) assumes perfectly competitive markets for wheat and for flour. The applicability of this assumption to the domestic and international market can be questioned. The international wheat market is characterised by high degrees of concentration on the export and import sides. The oligopolistic power arising from this concentration is evident in the ability of the former Soviet Union and China (who control a combined share of 33% of world wheat imports) to influence the world wheat price (Ahmadi-Esfahani and Jensen, 1994: 62). In addition, high levels of subsidies by the USA and the E.U, two major exporters, distort international wheat prices. Domestically, the wheat industry is characterised by a large number of predominantly small producers of less than 200 ha (a competitive supply side) and a few large purchasers (a concentrated demand side).

The concentrated nature of the milling sector signals potential oligopsonistic power in the wheat input market and oligopolistic power in the flour output market. Oligopolistic, monopolistic and monopsonistic power implies that firms have the ability to influence either the price (p) of the final output and/or the price (r_i) of the input. In the oligopolistic market the flour price becomes a function of quantity of flour produced, and in the oligopsonistic market the price of wheat becomes a function of the quantity of wheat purchased. This contrasts the perfectly competitive market represented by equation (3) where both the wheat price and the flour price are not influenced by individual buyer/firm's output decisions.

The following section adapts equation (d) of A.1 to incorporate monopolistic rents. A brief discussion of a monopsonistic wheat market follows.

Monopolistic market

In a monopolistic market, price is a function of output

$$\text{(e)}\quad \begin{aligned} &p = p(q) \\ &\Rightarrow p = p(F(x_{j.q})): \quad j = 1,......m \end{aligned}$$

The profit maximising function is thus written as

$$\text{(f)}\quad \Pi = p(F(x_{j.q})).F(x_{j.q}) - \sum_{i=1}^{n} r_i.v_i: \quad j = 1,......m \ .$$

Because monopolists are also profit maximisers they will differentiate equation (f) with respect to v_i. However, because p is a function of F, and F is a function of $x_{j.q}$, which in turn is a function of v_i; the chain and product rules of differentiation give us the following profit maximising solution:

$$\begin{aligned} \frac{\partial \Pi}{\partial v_i} &= \{p.(\partial F/\partial v_i) + F.(\partial p/\partial v_i)\} - r_i \\ &= \sum_{j=1}^{m} \{p.(\partial F/\partial x_{j.q}).(\partial x_{j.q}/\partial v_i) + F.(\partial p/\partial F).(\partial F/\partial x_{j.q}).(\partial x_{j.q}/\partial v_i)\} - r_i \\ &= \sum_{j=1}^{m} \{\{F.(\partial p/\partial F) + p\}.(\partial F/\partial x_{j.q}).(\partial x_{j.q}/\partial v_i)\} - r_i = 0 \end{aligned}$$

The structure of the first order condition is similar to the perfectly competitive scenario, except that the monopolist has a more complex implicit price $\{F.(\partial p/\partial F) + p\}.(\partial F/\partial x_{j.q})$. The implicit price of the j th characteristic takes into consideration both the marginal physical product of that characteristic as well as the change in the final price caused by change in characteristic level. The implicit price reflects two revenue processes arising from a change in characteristic level. Firstly, it reflects the increase in revenue arising from a rise in output due to a rise in the characteristic. Secondly, it reflects the fact that the increase in output has a negative effect on the final price. As the lower price affects all previously sold output, this entails a fall in revenue associated with the rise in output. Together, they determine the change in revenue accruing to the firm associated with a change in characteristic level. This is analogous to the monopolist and perfect competition models using homogenous products. In the characteristic approach to perfect competition, the return in revenue from a unit change in output brought about by increasing a characteristic's level exactly equals the market price. In the characteristic approach to the monopoly, the change in revenue from a unit change in output brought about by a change in characteristic level is less than the market price. These are similar conclusions to the orthodox theory. In both the competitive and monopolistic models, profit maximisation ensures that characteristics are used till the point where the total revenue accrued from the purchase of an additional input equals the input price.

Monopsonistic markets

In a monopsonistic market input demand is concentrated among a few producers. The purchasers of inputs thus have market power over the determination of the price of the input. The input price becomes a function of the quantity of input demanded, i.e. r_i is a function v_i. Thus, in determining output the profit maximising firm will take into consideration the effect its purchase of inputs will have on the input price. The monopsonist faces two forces in purchasing additional characteristics. Firstly, total revenue will increase as an increase in characteristics will increase output sold on the market. Secondly, the increased demand for the inputs embodying the characteristic will drive the input price up, thereby increasing costs. The implicit price of each characteristic embodies both these forces.

Market power on the international front is not a concern to the model. Although it may worsen the competitiveness of domestic producers, these effects can be eradicated through compensatory tariffs. The problem of market power and distortions is also expected to wane as the lowering of trade restrictions and subsidisation according to the GATT agreement is expected to elicit greater competition as more countries participate in the international wheat market and (Goldin et al, 1993). A greater concern is the power relationship within the domestic market which will alter the 'derived demand' price of domestic wheat. This, however, can be combated through the 'fair' use of tariffs on both the wheat and the flour market. Tariffication takes price control out of the domestic market and eradicates the market power held by domestic agents.

A.3 Construction of the dual uncertainty constraint

The procedure set out by Baumol (1977: 107) constructs the following dual from equation (15):

$$\text{(g)} \qquad \sum_{j=1}^{m} \bar{x}_{ji}.y_j \pm \sum_{j=1}^{m} \Omega(\alpha_j).\left[\sigma^2(\bar{x}_{ji}).y_j^2\right]^{1/2} \begin{matrix}\geq\\ \leq\end{matrix} r_i : \quad i = 1,\ldots\ldots.n$$

The effect of variance on implicit prices is more clearly exemplified if we assume a constant confidence interval for all characteristics (i.e. $\Omega(\alpha_1) = \Omega(\alpha_2) = \ldots\ldots\ldots = \Omega(\alpha_m) = \Omega(\alpha)$) and simplify equation (g) to:

$$\text{(h)} \qquad \sum_{j=1}^{m} \bar{x}_{ji}.y_j \pm \Omega(\alpha).\sum_{j=1}^{m} \left[\sigma^2(\bar{x}_{ji}).y_j^2\right]^{1/2} \begin{matrix}\geq\\ \leq\end{matrix} r_i : \quad i = 1,\ldots\ldots.n.$$

Solving for the square root of the right hand component of the equation and simplifying further yields:

$$\text{(i)} \qquad \sum_{j=1}^{m} \left[\{\bar{x}_{ji} \pm \Omega(\alpha).\sigma(\bar{x}_{ji})\}.y_j\right] \begin{matrix}\geq\\ \leq\end{matrix} r_i : \quad i = 1,\ldots\ldots.n,$$

which is utilised in Dual B.

APPENDIX B

B.1 Derivation of Gauteng mill gate prices

In deriving these prices numerous sources had to be relied upon. Because of fluctuating transport costs, international prices and exchange rates, the calculation of a value valid for the entire year is impossible. Nevertheless the values do reflect the average mill-gate prices for the year.

International wheat

International free on board (f.o.b) prices were obtained from the Wheat Board and the USDA internet site. To obtain effective import prices for millers in the Gauteng region the f.o.b prices were adjusted according to the following table:

TABLE A

Calculation of effective import price in Gauteng

	CWRS	AHW	DNS
f.o.b ($/t)	207.75	158.83	191.13
Tariff (%)			
Freight ($/t)	19.71	16.72	19.31
Insurance (R/t)	1.35	1.35	1.35
e - rate (R/$)	3.54	3.54	3.54
C.I.F (R/t)	806.55	622.82	746.27
Offloading cost (R/t)	43.00	43.00	43.00
Landed cost (f.o.r)	849.55	665.82	789.27
Transport cost (R/t)	85	85	85
Mill-gate price (R/t)	934.55	750.82	874.27

Source: **International prices**: Wheat Board and USDA ; **Freight charges**: Wheat Board ; **Insurance**: Wheat Forum (1994) ; **Offloading costs**: De Jager, 1994.

Notes: Exchange rate is average for 1994. Domestic transport costs for international prices are from Durban harbour. F.o.b price for CWRS is from Saint Lawrence port. F.o.b price for DNS is from Gulf port.

Western Cape mill-gate prices were obtained by subtracting the R85/t domestic transport cost. A further R25/t, representing transport costs within the Western Cape region, should be included, but because the same transport costs apply to Western Cape wheat they have been omitted. These prices do not include the price increasing effect of tariffs, although the simulated results assume a 66% tariff in some cases. A further factor that will influence price is the exchange rate. A depreciation of the exchange rate, as occurred in 1996, drives the mill-gate price of international wheat upwards.

Domestic prices

The effective mill-gate price has to include all factors such as levies and transport costs that cause a divergence from the basic selling price. Price support has been included to determine the actual mill-gate prices paid during 1993/94. The use of single transport costs within each region is a necessary simplifying assumption and implies common transport costs within each region. The results of the simulations are therefore aggregations and must be treated with caution. The 1993/94 Gauteng mill-gate price for regional wheat sources is given in Table B

TABLE B

Mill-gate prices for domestic wheat in Gauteng

Wheat source	Free State	W Cape	N Cape	Transvaal
Basic selling price	802.48	802.48	802.48	802.48
Add: levies + payments	68.59	68.59	68.59	68.59
Less: price support	104.69	104.69	104.69	104.69
Net selling price (f.o.r)	766.38	766.38	766.38	766.38
Domestic transport	68	130	75	75
Mill-gate price (R/t)	834.38	896.38	841.38	841.38

Source: Wheat Forum (1994) ; **Domestic transport**: De Jager (1994)
Note: Wheat prices are for BS1

Western Cape wheat prices are determined by subtracting the R896.38/t transport cost. Western Cape prices for wheat from the other South African regions have not been given as this wheat is rarely delivered to the Western Cape.

B.2 Slack and dual prices of optimal solution

Table C below gives the slack variables and the dual prices of the optimal solution using the 'derived demand' prices.

TABLE C

Slack and dual prices of 'derived demand' solution

Characteristic	Slack min	Dual price	Slack max	Dual price
wheat falling no. (sec)	120.26	0	n/a	n/a
hectomass kg/hl	3.22	0	3.74	0
flour ash (%)	0	401.21	0.2	0
flour protein (%)	1.59	0	0.36	0
farinograph abs. % (14%mb)	1.28	0	3.13	0
farinograph development time (min)	0.13	0	1.85	0
mixogram peak (min)	0.45	0	0.54	0
alveogram strength (cm2)	4.75	0	9.96	0
alveogram P/L	0.14	0	0.32	0
100g bake test vol. (cm3)	0.08	5.00	n/a	n/a

Notes: The tolerance of the solution considers the slack of 100g bake test to be zero. A dual price of R5 is thus given.

The value of the slack variable represents the excess of the characteristic in the case of the minimum required level and the scope to increase the characteristic in the case of the maximum required level. As discussed in the theoretical discussion on dual prices, in only those characteristics that effectively constrain the optimal solution (i.e. have a zero slack value) will values be imputed. From the above table it is clear that values have only been imputed in the 100g baking volume and flour ash. The dual price values measure the increase in the objective function value per unit change of the 'characteristic requirement level'.

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