FINANCIAL IMPACT OF WHEAT QUALITY STANDARDS ON SOUTH AFRICAN WHEAT PRODUCERS: A DLP APPROACH

Sub theme: Working With Global and Local Markets

Johannes Daniël van der Merwe

North West University (Potchefstroom Campus), South Africa

Abstract

The South African wheat industry has been under pressure in recent years from global economic instability and a fast-changing domestic policy environment. This has manifested in declining wheat production and profitability at farm level. Wheat quality plays a key role in wheat-buying decisions, with quality improvements correlating negatively with yield and, ultimately, productivity. However, any new wheat cultivar released for commercial production must still meet the standards of the country's wheat-classification system, which has led to wheat sometimes being imported in the face of a domestic shortfall. This has inevitably led to tension within the industry and affected both performance and pricing. Using a Dynamic Linear Programming model, this paper takes an in-depth look at the financial impact that resulted from this classification system that affected the performance and pricing of primary producers.

Keywords: Financial impact, South African wheat industry, wheat quality, dynamic linear programming

1. Introduction

Over the past couple of decades, the wheat industry in South Africa has been buffeted by strong headwinds both locally and internationally, and today is a virtual shadow of its former self. After the abolition of the single channel marketing system and import control in 1997, market forces determined the wheat price, while tariffs became the only protection against imports of wheat and wheat flour. This brought about the restructuring of both the primary and secondary industries. According to Vink and Kirsten (2000), these drastic changes in policy have induced structural changes in the industry, not only affecting the financial position of farmers but also changing land-usage patterns, farm sizes and the ecological footprint left by farmers as they face mounting pressure to improve their productivity. The global market also plays an increasingly important role in the growth trajectory of local wheat production. Set against this changing landscape, South African wheat production has declined significantly in recent years.

Fossati *et al.* (2010) believe that the declining productivity in the local industry can be ascribed to certain quality-related characteristics of wheat. In these authors' view, quality characteristics, such as protein content (regarded as one of the key factors influencing wheat-buying decisions in South Africa), are negatively correlated with yield and consequently have a negative effect on productivity. Karaman *et al.* (2008) hold a similar view, asserting that wheat has the defect of conversion (i.e. yield declines as quality improves) as a general characteristic. When yield suffers due to quality improvements, the demand for wheat in South Africa exceeds available supply. As a result, the necessary quantities of wheat for the local grain-milling industry have to be procured from foreign sources (Karaman *et al*., 2008).

Notwithstanding the above, wheat quality plays a critical role in the end-product – whether bread, biscuits or pasta – and must be closely monitored if consumers are to receive an acceptable product (Engelbrecht, 2008). Wheat quality in South Africa is regulated by a so-called wheat classification system, introduced in 1989. This system was designed to evaluate the primary and secondary characteristics of any new wheat cultivar released for commercial production in order to guide wheat quality. However, the process spawned many classification discrepancies, which have generated much controversy, notably between the primary wheat producers and the wheat processors. Primary producers see the 'system' preventing the release of new cultivars that do not comply with the set biological standards, yet it allows processors to import wheat that does not comply with said standards. Another factor contributing to the controversy is that the price of locally-produced wheat is determined by the import parity price. Therefore, the classification discrepancy between local and imported wheat influences not only the yields of producers, but also the prices farmers receive for their produce.

Van der Merwe (2015) conducted a study to establish whether or not declining wheat production in South Africa can be attributed to prescribed standards of wheat quality. The author concluded that prescribed quality for the release of new cultivars for commercial production can in fact be partially held responsible for declining yields in the South African wheat industry. The author further indicated that this wheat classification system has resulted in the yield to be lower by between 12.8 and 20%, depending on what factors you consider[1]. Although the extent to which the prescribed quality influences the productivity of the South African wheat industry, the actual financial impact has not been determined. To this end, a DLP farm model (Louw *et al.*, 2007) was used to simulate the financial impact of possible increased yields that would have been realised if the wheat quality requirements were relaxed.

2. Methodology

Mathematical programming has become an important and widely-used tool to analyse similar impact studies in the agricultural economics environment (Mills, 1984, as cited by Buysse *et al*., 2007). The use of mathematical programming optimisation models, such as linear programming, can be seen as a communication-facilitating instrument for the various stakeholders in a changing policy environment – in particular, the farmer and the policymaker (Fernagut *et al*., 2004, as cited by Buysse *et al*., 2007). Linear programming is a method of determining a profit-maximising combination of enterprises that is feasible with regard to a set of fixed constraints (Hazell & Norton, 1986).

Applying this approach on the farm level gives a good indication of the impact of the change in production. Furthermore, it is necessary to make explicit allowance for the peculiar influence of time on the structure of the system under study. Of the many ways in which this

[1] For a detailed description of factors and methods used to quantify these statistics, see Van der Merwe (2015).

can be achieved, dynamic linear programming (DLP) provides a more complete analytical description of whole farm situations over time than most other tools (Throsby, 1962). Louw *et al.* (2007) hold a similar view, stating that DLP is an extremely useful tool to simulate the farm system and addressing 'what if' questions. As a result, Louw *et al*. (2007) developed a DLP farm-level model. The model's accuracy and complexity result in a more accurate representation of the real world than a new model with limited resources. With the assistance of Louw, the model was adjusted for the purposes of this study.

Louw and Van Schalkwyk (1998) developed a farm linear-planning model in South Africa called OPTIMA, the objective of which is to establish a holistic, user-friendly farm-planning model to aid farm planning and extension and the formulation of agricultural policy. During 2000, this basic model was converted from spreadsheet to algebraic formulation. Louw *et al.* (2007) stated that in regional spatial modelling, the use of DLP models was previously limited by computer capacity and that only in recent years has it become both possible and practical to embed several DLP whole farm models into a spatial framework and solve these models within a reasonable time. The value of this model lies in its ability to calculate the net farm income (NFI) that is generated by a specific set of activities and objectives through cashflow statements. The impact of higher yield on the NFI of farmers can therefore be accurately estimated.

2.1 Theoretical model specification

In an effort to analyse the conversion from a conventional to an organic farming system over time, Acs *et al*. (2006) developed – similar to Louw *et al*. (2007) – a DLP model for a typical farm in the central clay region of The Netherlands. The general structure of the DLP model is summarised as follows (Hazell & Norton, 1986, as cited by Acs *et al*., 2006):

$$\text{Maximise } Z = \sum_t 8_t[(c_t x_t) - f_t] \quad (1)$$

Where:

$8_t = (1/(1 + i))^{t-1}$

$A_t x_t$ � b_t x_t

2:

Where:

Z is the discounted labour income;

t is the year;

i is the discounted rate;

x stands for the vector of activities;

c is the vector of gross margin or costs per unit of activity;

f is the vector of fixed costs per year;

A is the matrix of technical coefficients;

b is the vector of the right-hand side value.

Activities and constraints are included in each period for all the relevant decisions, and many of them are duplicated from one year to the next (e.g. annual crop activities). The link between the years is provided by the conversion of the land area and the objective function (Acs *et al*., 2006).

Although a basic knowledge of the model's theoretical background is necessary, Louw *et al.* (2007) stated that the first step in the development of a decision-making framework is to describe the system. As mentioned, this study focuses on the South African Wheat Industry (SAWI) and the possible impact that concentration in the market may have on the release criteria and subsequently on the productivity and competitiveness of primary wheat producers. The model developed by Louw and Van Schalkwyk (1998) was utilised to determine the exact impact that a decline in productivity of primary wheat producers in South Africa has on the entire industry. The model was therefore developed based on a typical wheat farm in South Africa, with special reference to dry-land and irrigated production practices.

Louw *et al*. (2007) stated that the second step in developing a decision-making framework is to create a modelling framework based on the identified 'system'. This enables decision-makers to acquire a better understanding of how the system reacts to impulses from the outside. As this model was developed by Louw in 1998 and improved since then, the following section provides a brief description of the model and the methods implemented by Louw *et al*. (2007) to accomplish the above.

3. Application of the model to different farm-model scenarios

The importance of analysing and applying the information recorded in cashflow statements to make sound farm-related business management decisions cannot be over-emphasised. A lack of cashflow is the stumbling block to many plans being realised. Identifying periods in which there is a potential cashflow surplus or cashflow deficit allows the manager to take advantage of opportunities as they arise or to plan for periods when cash is limited (SMA, 2014). As a result, the model places specific emphasis on the effects of externalities on the cashflow statements on farm level.

In the process of adjusting the model for the purposes of this study, it became evident that differences in input structures between dry-land and irrigated wheat production practices resulted in the model behaving differently under these two conditions. The model therefore had to make special reference to each of these conditions. To accomplish this, a dry-land wheat-farm model and an irrigated wheat-farm model were used to simulate increased yields. Although different input structures are required for different dry-land regions in South Africa, the effect on results obtained by the model proved to be minor. As a result, a dry-land wheat-producing farm in the Moorreesburg area (Western Cape) was used as an example to determine the effects of increased yields on dry-land wheat-production regions in South Africa. In an effort to determine the effects of increased yields on irrigated wheat-production regions, an example of an irrigated wheat-producing farm in the Douglas region was used.

A typical dry-land wheat farm of 1 000 hectares in the Moorreesburg region was used to simulate the possible effects of increased yields, while a 256-hectare farm unit was used to simulate the effects of increased yields in the irrigated regions of Douglas. On these typical farm units, alternative commodities were also produced and the effect thereof was considered. In each case, a base scenario with an unchanged yield, representing the current situation in the specific area, was compared to four additional scenarios, each representing a different yield increase. Table 1 provides a description of the wheat farm scenarios. As can be seen, the base scenario produced no change to existing cultivar yields, but allowed 50% upwards and downwards variation on areas cultivated.

The first scenario, which is also the most likely scenario to occur if wheat quality standards were to be adjusted (Van der Merwe, 2015), assumes that wheat yields were increased by 12.80% in all wheat-production regions in South Africa. The second most likely scenario was the 19.03% increase in yields represented by Scenario 3, this is represented by a 20% increase in wheat yields in the model. Two additional scenarios, representing an increase in yield of 15% (Scenario 2) and 25% (Scenario 4), are included for comparison purposes[2].

Table 1: Description of wheat farm scenarios

Base scenario	**No change to existing cultivar yields – 50% up and down variation allowed on base areas cultivated**
Scenario 1	**Similar to base with a 12.80% increase in yield**
Scenario 2	**Similar to base with a 15% increase in yield**
Scenario 3	**Similar to base with a 20% increase in yield**
Scenario 4	**Similar to base with a 25% increase in yield**

4. Effects of increased yields on the performance of the wheat industry

The performance of an industry can be successfully determined from the profitability of the role-players. Smith (2000) stated that agricultural producers are generally concerned about maximising the profitability of their operations while avoiding excessive financial risks.

According to Hofstrand (2009) and Van Zyl *et al*. (1993), profit is the difference between revenues and costs, and an industry or business can generate a profit through productivity growth and/or price over-recovery. The particular approach taken has important implications for long-term competitiveness (Van Zyl *et al*., 1993). A constraint to either productivity growth or prices can consequently severely affect the performance and competitiveness of an industry. As has been proven, quality standards have negatively affected the productivity of wheat producers in South Africa. However, the impact of low productivity on the economy has not yet been quantified.

According to Louw *et al*. (2014), calculating the effect of decreased productivity on the NFI can directly measure the effect on the performance of the industry.

4.1 Changes in NFI

NFI accounts are designed to provide an annual measure of income returned to the operators of agricultural businesses from the production of agricultural commodities. The numbers are used to assess the state of the agricultural industry and to form the basis of various policy measures (Statistics Canada, 2013).

The NFI of farm businesses is derived by subtracting operating expenses from farm cash receipts. It represents the amount of cash generated by the farm business that is available for debt repayment, investment or withdrawal by the operators (Statistics Canada, 2013). Table 2 depicts the expected increase in NFI on a dry-land wheat-farm unit of 1 000 hectares. Under current conditions (base scenario), it is estimated that this specific farm unit will generate an NFI of approximately R17.8 million over a 20-year period, amounting to R17 807 per hectare over the period or R890 per annum.

As can be seen, the 12.80% increase in yield (Scenario 1) on dry land in South Africa resulted in NFI increasing from R17 807 per hectare to R25 911 per hectare over a 20-year period. This amounts to R1 296 per hectare per annum, representing an increase of 46%. Table 2 indicates that NFI per hectare increased from R17 807 to R30 333 with a 20% increase in yields, which represents an increase of 70% compared to the base scenario. Two additional scenarios (Scenarios 2 and 4) are also included in the analysis for reference purposes. If yields were to increase by as much as 25%, NFI would increase from R890 per hectare per annum to an estimated R1 668 per hectare, representing an 87% increase in NFI[3].

Table 2: Expected increase in NFI under dry-land conditions

	Base	**Scen1**	**Scen2**	**Scen3**	**Scen4**
	0% increase	**12.8% increase**	**15% increase**	**20% increase**	**25% increase**
Objective per farm unit (1000 ha) over a 20-year period	R17 810 000	R25 910 000	R27 270 000	R30 330 000	R33 360 000
Objective per ha over a 20-year period	R17 807	R25 911	R27 265	R30 333	R33 361
Objective per ha per annum	**R890**	**R1 296**	**R1 363**	**R1 517**	**R1 668**
Percentage deviation per ha		**46%**	**53%**	**70%**	**87%**

Table 3 shows the expected increase in NFI on an irrigated wheat farm of approximately 256 hectares due to increased yields. Similar to dry-land regions, a base scenario was compared to four different scenarios, each representing different levels of increased yields (see Table 3). As mentioned, Scenario 1, with a 12.80% increase in yield, is the most likely scenario to occur if the wheat quality standards are adjusted. As can be seen, the NFI per hectare over a 20-year period will increase from R21 516 to R28 106 under the assumption of Scenario 1. This amounts to R1 405 per hectare per annum, representing an increase in NFI of 31%. The NFI in Scenario 3 (second most likely scenario), representing an increase in yield of 20%, will increase from R21 516 to R30 555 per hectare over a 20-year period. This amounts to R1 528 per hectare per annum, representing an increase in NFI of 42%.

Table 3: Expected increase in NFI on irrigated land

	Base	**Scen1**	**Scen2**	**Scen3**	**Scen4**
	0% increase	**12.8% increase**	**15% increase**	**20% increase**	**25% increase**
Objective per farm unit (200 ha) over a 20-year period	R5 510 247	R7 255 125	R7 604 658	R8 454 686	R9 559 702
Objective per ha over a 20-year period	R21 516	R28 106	R29 357	R30 555	R30 406
Objective per ha per annum	**R1 076**	**R1 405**	**R1 468**	**R1 528**	**R1 520**
Percentage deviation per ha		**31%**	**36%**	**42%**	**41%**

4.2 National effects of increased wheat yields on the performance of the wheat industry

To gain a clear understanding of the extent of the impact of the wheat classification system on wheat producers, the total effect in South Africa must be determined. As depicted in Tables 2 and 3, the farm-level effects of decreased productivity were determined on a per hectare basis. Multiplying this effect by the total hectares in each region therefore determines the national effect. As can be seen in Table 4, the potential increase in NFI in the Free State, generated by a 12.80% increase in yield, amounts to R152 million per annum, while the effect is much greater in the Western Cape at R358 million per annum. The increase in NFI in the Northern Cape irrigation region amounts to R95 million per annum. The combined effect in all these regions due to a 12.80% increase in yield is estimated to be R606 million per annum or just over R12 billion over a 20-year period. To put this into context, the NFI generated by the entire agricultural industry in 2012/2013 was R58.9 billion. This means that the strict criteria enforced by the wheat industry resulted in the NFI generated by the entire agricultural industry shrinking by an estimated 1.03%.

As mentioned earlier, Scenario 3, which represents a 20% increase in yield, is regarded as the second most likely scenario to occur. The effect of the 20% percent increase in NFI amounts to R236 million in the Free State, R553 million in the Western Cape and R130 million in the Northern Cape irrigation region per annum. The total effect therefore amounts to an estimated R920 million per annum or approximately R18.4 billion over a 20-year period. If this increase in yield had, in fact, occurred, the NFI generated by the entire agricultural industry could have been 1.56% higher.

Table 4: Effect of increased yields on NFI on a national scale

		Base scenario	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Region	**Hectares**	**0% increase**	**12.80% increase**	**15% increase**	**20% increase**	**25% increase**
Free State	377 000	R335 653 998	R488 422 399	R513 952 326	R571 785 782	R628 850 228
Potential increase in NFI in the Free State			R152 768 401	R178 298 328	R236 131 784	R293 196 230
Western Cape	884 000	R787 050 753	R1 145 266 314	R1 205 129 592	R1 340 739 075	R1 474 545 362
Potential increase in NFI in the Western Cape			R358 215 561	R418 078 839	R553 688 322	R687 494 609
Northern Cape irrigation region	289 800	R311 771 067	R407 257 335	R425 382 447	R442 735 303	R440 578 496
Potential increase in NFI in the Northern Cape irrigation region			R95 486 268	R113 611 380	R130 964 236	R128 807 429
Total	1 550 800	R1 434 475 818	R2 040 946 047	R2 144 464 365	R2 355 260 160	R2 543 974 086
Total potential increase in NFI in South Africa			**R606 470 229**	**R709 988 547**	**R920 784 343**	**R1 109 498 268**
Total potential increase in NFI in South Africa over a 20-year period			**R12 129 404 586**	**R14 199 770 942**	**R18 415 686 850**	**R22 189 965 364**

5. Conclusion

It was concluded that the DLP method provides a more satisfactory analytical description of whole farm situations over time than most other tools. A DLP farm model, as developed by Louw *et al*. (2007), was used to simulate the possible increases in yields that would most likely occur if the wheat quality requirements were relaxed. Because this study mainly focused on determining the effect on the performance (profitability) of the wheat industry in South Africa, results from the DLP farm model pertaining to NFI were analysed and discussed.

When comparing the application of the model to a dry-land situation and to an irrigated situation, respectively, significant differences were seen. As a result, two different analyses had to be performed to improve the accuracy of the model. In both cases, a base scenario – representing the *status quo* – was compared to four different scenarios, each representing different increases in yield. The results showed that a 12.80% increase in yield generated a 46% and 31% increase in NFI on dry land and irrigated land, respectively. A 20% increase in yield generated a 70% and 42% increase in NFI on dry land and irrigated land, respectively.

The country-wide effect on NFI was estimated at R606 million per annum due to a 12.80% increase in yield or approximately R18.4 billion over a 20-year period. An estimated R920 million per annum or just over R12 billion over a 20-year period was estimated when yield was increased by 20%.

Knowing that these NFIs could have been realised by wheat producers and that the benefits could have found their way to a struggling wheat industry certainly amplifies the need to pay urgent attention to these factors. Moreover, considering the knock-on effects on factors such as job creation, the balance of payments and exchange rates, it prompts the question why government has not yet intervened. Increasing the competitiveness of the South African wheat industry is a particular priority, since many government policies focus on welfare issues, including the problems of unemployment and food insecurity, through the agricultural sector.

References

Acs, S., Berentsen, P.B.M. and Huirne, R.B.M. 2006. Conversion to organic arable farming in The Netherlands: A dynamic linear programming analysis. Agricultural Systems, 94: pg 405–15.

Buysse, J., Van Huylenbroeck, G. and Lauwers, L. 2007. Normative, positive and econometric mathematical programming as tools for incorporation of multifunctionality in agricultural policy modelling. Agriculture, Ecosystem and Environment, 120: pg 70–81.

Engelbrecht, M. 2008. Assessment of variance in measurement of hectolitre mass of wheat and maize, using equipment from different grain producing and exporting countries. Presented in partial fulfilment of the requirements for the degree Master of Science in Food Science, Department of Food Science, Faculty of AgriSciences, University of Stellenbosch.

Fernagut, B., Nasse, L., Lauwers, L., Buysse, J., Van Huylenbroeck, G., Harmingie, O., Polomé, P. and De Frahan, B., 2004. Organisation of knowledge transfer in agricultural policy analysis. In: G. van Huylenbroeck, W. Verbeke, L. Lauwers, (eds.), Role of Institutions in Rural Policies and Agricultural Markets. Elsevier B.V., Amsterdam, pg 183–96.

Fossati, D., Brabant, C. and Kleijer, G. 2010. Yield, protein content, bread making quality and market requirements of wheat. Tagung der Vereinigung der Pflfl anzenzüchter und Saatgutkauflfl eute Österreichs, 61: pg 179–82.

Hazell, P.B.R. and Norton, R.D. 1986. Mathematical programming for economic analysis in agriculture. Macmillan Publishing Company.

Hofstrand, D. 2009. Understanding Profitability. Ag Decision Maker. Available online at: http://www.extension.iastate.edu/agdm. Accessed 1 December 2014.

Karaman, S., Cetin, B., Oguzlar, A. and Yagdi, K. 2008. Hedonic price estimation for the Turkish bread wheat characteristics. Qual Quant, 43: 895–902.

Louw, D.B. and Van Schalkwyk, H.D. 1998. The development of a methodology to determine the true value of water in the berg river basin. Unpublished background report. Water Research Commission.

Louw, D.B., Van Schalkwyk, H.D., Grovè, B. and Taljaard, P.R. 2014. Market risk, water management and the multiplier effects of irrigation agriculture with reference to the Northern Cape. Final report to the Water Research Commission — Adjusted for the purposes of this study. Department of Agricultural Economics, University of the Free State.

Louw, D.B., Van Schalkwyk, H.D., Grovè, B. and Taljaard, P.R. 2007. Market risk, water management and the multiplier effects of irrigation agriculture with reference to the Northern Cape. Final report to the Water Research Commission. Department of Agricultural Economics, University of the Free State.

Mills, G. 1984. Optimisation in Economic Analysis. London: George Allen and Unwin Ltd.

SMA, 2014. Comprehensive Guide to Farm Financial Management: Programs and Services. Module 7: Cash Flow Statement Analysis. Available online at: http://www.agriculture.gov.sk.ca/CGFFM_Cash_Flow_Statement_Analysis. Accessed 12 August 2014.

Smith, V.H. 2000. Wheat Quality and Wheat Yields: Trade-Offs among Price, Yields, Profit and Risk. U.S. Department of Agriculture, Special Report No.5.

Statistics Canada. 2013. Net Farm Income. Statistics Canada Catalogue no. 12-591-XWE. Available online at: http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=3473. Accessed 24 October 2013.

Throsby, C.D., 1962. “Some Notes on ‘Dynamic’ Linear Programming: A Reply,” Review of Marketing and Agricultural Economics, Australian Agricultural and Resource Economics Society, 30(04).

Van der Merwe, J.D. 2015. Quality, pricing and the performance of the wheat industry in South Africa. Submitted for the degree: Philosophiae Doctor. North-West University (Potchefstroom Campus).

Van Zyl, J., Van Schalkwyk, H.D. and Thirtle, C. 1993. Entrepreneurship and the bottom line: how much of agriculture's profits is due to changes in price, how much to productivity? Agrekon, 32(4): pg 223–29.

Vink, N. and Kirsten, J. 2000. Deregulation of agricultural marketing in South Africa: Lessons learned. Sandton: The Free Market Foundation, Monograph 25.

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