Facilitating decision-making in agriculture by using a system of models

PG Strauss, FH Meyer and JF Kirsten[1]

Abstract

This article presents a deterministic farm-level model developed to link to an existing partial equilibrium sector-level model of the grain and livestock sectors of South Africa. The objective is to create a linked system of models consisting of a sector- and farm-level model with the capability to analyse the likely effects of changes in policies and markets at both the sector and representative farm level in South Africa. A representative farm in the Free State Province is used to validate the farm-level model. The farm-level model is used to simulate a baseline as well as two scenarios of the representative farm for the period 2003 to 2010. Results indicate that the farm-level model simulates the representative farm rather accurately compared to historical data. The baseline and scenario results indicate that the linked system of models can be useful for policy and business decision-makers to analyse the impact of change in policies and markets at both the sector- and farm level.

Keywords: Farm-level modelling; representative farm; agricultural policy; strategic decision-making

1. Introduction

The survival and growth of the South African agricultural sector is of significant importance to the country's attainment of important economic and development goals. However, during the past years the sector has experienced significant and seemingly increasing variability in terms of economic, social, political, technological and environmental factors. The high and increasing level of variability creates uncertainty, which impedes decision-making in terms of designing and implementing policies as well as business strategies. Such obstacles in turn deter investment. In order to facilitate improved decision-making within this highly variable and uncertain environment, it is critical to understand the dynamics that drive the environment. One way of achieving this, is by utilising models that have the ability to capture the salient features of the environment within which decision-makers operate.

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Econometric modelling has proven to be effective in facilitating an understanding of change at the sector level. Examples of such models in relevant South African literature include Meyer (2002), Meyer, Westhoff, Binfield and Kirsten (2006), and Cutts, Reynolds, Vink and Meyer (2007). However, these models can only simulate the impact of changes in markets, policies and other factors at the sector level, not at the farm level. Internationally, positivistic models have been developed at the farm level that link to a sector-level model. The linkage of such models offers a "tool" for decision-makers which have the ability to simulate the impact of change both at the sector and farm level. An example of such a system is the linkage between the farm model, FLIPSIM (Richardson & Nixon, 1986) and the sector models of the Food and Agricultural Policy Research Institute (FAPRI).

There is an indication that several positivistic farm-level models exist in South Africa that certainly has the potential to be linked to sector-level models. However, it appears that at present no such model is linked and used on a frequent basis to facilitate policy and business decisions in South Africa's various agricultural industries. The objective of this article is therefore to present a positivistic farm-level model, developed and validated in South Africa, which links to an existing sector-level model, referred to as the BFAP sector model. The first version of the BFAP sector model was developed and operationalised by Meyer and Westhoff (Meyer & Westhoff, 2003). It can be classified as a large-scale multisector commodity-level simulation model and in total, six crops, five livestock and five dairy commodities are included in the current version of the model. The model is maintained within the Bureau for Food and Agricultural Policy (BFAP) at the University of Pretoria. The link with the BFAP sector model enables those who use the farm-level model to analyse the impact of changes in policies and markets on the financial position of a representative farm. The development of such an integrated system of a sector-level and farm-level model could assist South African policy- and business decision-makers in analysing alternative market and policy situations and the resulting impacts on both sector- and farm-level and thereby should assist them in making decisions.

2. Method

2.1 Farm-level models

The literature distinguishes between two basic approaches to farm-level modelling: a positivistic approach and a normative approach (Richardson, 2003). In addition to the two basic approaches, two basic types of models exist based on the type of system analysed in the research problem (France & Thornley, 1984; Johnson & Rausser, 1977; Richardson, 2003), namely deterministic models and stochastic models. The assumption underlying deterministic models is that all input values of the various input variables are fixed or certain, and that interrelationships between the different elements within the model are also fixed or certain. The assumption underlying stochastic models is variability in terms of the values of some of the input variables, as well as variability between the interrelationships of the various elements within the model (Richardson, 2003; Johnson & Rausser, 1977).

It is also clear from existing literature that a wide number of farm-level models have been developed during the past four decades both within South Africa and internationally. Examples of international models are the Farm Level Income and Policy Simulator (FLIPSIM, Richardson & Nixon, 1986), the Technology Impact and Policy Impact Calculations (TIPI-CAL, 2003) Model, the Financial Economic Simulation Model (FES, 2004), as well as the models by Patrick and Eisgruber (1968), Hardin (1978), and Held and Helmers (1981). Examples of farm-level models developed within South Africa include the models developed by Louw (1979) and Meiring (1994).[2]

Although all of the above-mentioned models have the ability to simulate farm-level output, very few of these models are in some way linked directly to an existing sector model. Since decision-makers in the South African agricultural sector need to understand the impact of changes in markets (domestic and international) and policies on both the sector and farm level on an ongoing basis, a modelling system with the ability to regularly simulate both sector and farm-level impacts would probably prove invaluable for both policy- and business decision-makers.

2.2 Representative farms

Researchers have over the years endeavoured to study the farming system in such a way that findings can be used to inform and improve decision-making. To attempt to analyse each individual farm and from such an analysis develop options so that decisions can be made at the policy and business level is not always practically attainable. Therefore, agricultural economists have attempted to develop various approaches and methods to enable them to construct a "typical" farm.[3] These methods range from using expert input to factor and cluster analyses (Köbrich, Rehman & Khan, 2003).

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[2] *Various other examples exist in both academic and non-academic literature, such as the models developed by Prof. DB Louw, Mr P Pienaar, Dr J Lombard and Mr B Grove.*

[3] *It becomes clear, based on a review of available literature on the subject, that there is a distinct difference between a typical or representative farm and an "average" farm.*

For the purpose of validating the farm model and its linkage to the sector model presented in this article, an attempt was made to construct a representative farm for the Eastern Free State. The representative farm is based on producer data obtained from a farmer co-operative in the region: Vrystaat Koöperasie Beperk (VKB). The period for which data were collected was 1996 to 2003. Data collection was done by the Agricultural Economic Advisory Department of VKB. Since the data were collected over a period of eight years, the sample size varied from year to year as farmers either stopped farming or new entrants decided to take part in the data collection exercise. The average sample size over the period was 25 participants. The representative farm was constructed by attempting to calculate either a modus or median where possible. If this was not possible, an average was calculated. After the farm structure had been set up, it was presented to an agricultural expert panel consisting of various people operating within the region. The experts ranged from agricultural economic advisors to credit officials. The necessary adjustments were then made to the farm structure based on feedback received from the expert panel, after which simulation started.

2.3 Structure of the model

Based on the "top down" approach by Richardson (2003), the key output variables to be simulated are the ending cash surplus or deficit, as well as the debt to asset ratio. The ending cash surplus is simulated since it indicates the operational liquidity of the farm (Louw, 1979), while the debt to asset ratio is simulated in order to analyse the solvability of the farm. Therefore, analysing the solvability and liquidity of the farm indicates to an extent the financial survivability and growth "ability" of the farm.

The model output consists of a set of financial statements in order to calculate the key output variables. Underlying the financial statements is a basic model of the production structure of the farm. The model consists of three basic blocks, namely an input block, a calculations block and an output block. The input block consists of two sections: a section on managerial or control variables and a section on exogenous variables as simulated by the sector-level model. The calculation block consists of several sheets on the different grains and livestock enterprises as produced by the representative farm. The sheet on the replacement of moveable assets and the repayment of long-, medium- and short-term debt forms part of the calculation block. Calculation in terms of tax, interest and land rental payments, as well as inflation on expenses and assets is done in the calculations block. The output block consists of the set of financial statements, namely the income statement, cash flow statement and the statement of assets and liabilities. A summary of the key output variables is also part of the output block. The basic structure of the farm-level model is illustrated in Figure 1.

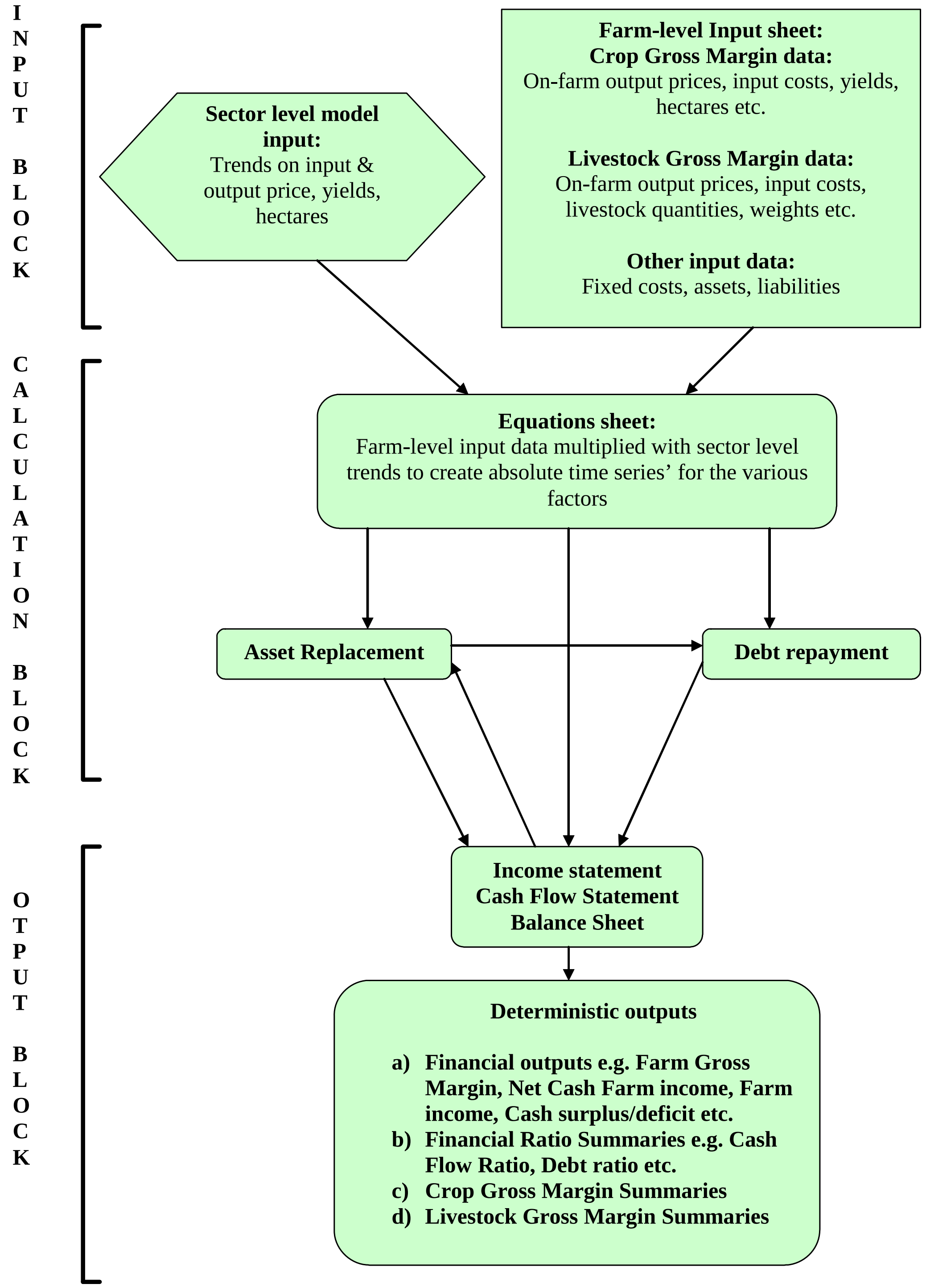

Figure 1: Structure of the farm-level model

The model takes into account the size of the operation, for example hectares and livestock numbers, tenure in terms of own land vs. rented land, enterprise composition in terms of different types of crops and livestock, costs of production for each individual enterprise, fixed costs for the whole operation, a vehicle and machinery fleet and an asset replacement strategy. The model essentially consists of accounting identities, except in the case of the asset replacement function where econometric equations are used.

The model is a recursive model in the sense that the output data of year t_{-1} is the input data for year t in order to calculate the values for year t. The model can simulate the financial position of the farm over any period of time between one and ten years. Year one is the base year whereby data as constructed through the representative farm construction process is used as input data. Output from the sector-level model in the form of indices containing information on input and output prices, yields, and hectares is used to multiply with the base year data. This creates a data series on input and output prices, yields and hectares planted that contains the absolute level as experienced on the farm, but which follows the trend as projected by the sector-level results. Therefore, movements in input and output prices, yields and hectares and also absolute differences in terms of price and yield levels between the national level and the representative farm level are captured. A key assumption underlying the farm model is that the farm structure with respect to enterprise composition essentially remains the same, and that the only changes in the enterprise composition are due to changes as simulated through the sector model. Thus, the model does not automatically simulate the inclusion of a completely new enterprise during the simulation period. A new enterprise therefore needs to be introduced manually into the model, which is quite easily done as the model is a positivistic type of model and also Excel based.

Given the structure and functioning of the model, the underlying assumptions therefore are that: 1) the quality of management remains constant over the simulation period, 2) the enterprise composition of the farm only changes as a result of changes as simulated through the sector model, 3) the physical production potential of the farm remains constant during the simulation period, 4) the farm size remains constant during the simulation period, and 5) the productivity of the production process changes according to productivity changes as simulated by the sector-level model.

3. Simulation results and performance of the model

The representative farm constructed and used in this study is a representative farm in the Reitz district, Free State Province, South Africa. The cash crops that are produced on this farm are maize, wheat, sunflower, potatoes, sorghum and soybeans. The livestock enterprises on the farm are beef, dairy and sheep. Wheat (36%) is the main cash crop contributor towards gross farm income, while beef (8%) is the main contributor from the livestock enterprises. The cash crops in total contribute 83% towards the gross farm income and the livestock contributes the remaining 17%. The farm consists of 955 hectares of arable land, 652 hectares of natural grazing, 115 hectares of cultivated grazing and 26 hectares of other land. The majority of the arable land is dry-land and, therefore, very little irrigation takes place. In terms of farm size and ownership composition, 65% of the total size of the 1 748 hectares is the model farmer's own land, while the remaining 35% is rented land.

In order to validate the model, data in the form of financial outputs for the period 1996 to 2003 were obtained from VKB Economic Services. The simulation vs. actual results in terms of the key output variables of ending cash surplus or deficit, as well as the debt to asset ratio are presented in Figures 2 and 3 respectively. It should be noted that VKB Economic Services calculates the cash surplus/deficit by excluding principal payments and asset replacement cash flows. Hence, the model output had to be adjusted accordingly in order to enable the authors to compare the simulation results with the actual figures. Another factor that has to be taken into account when comparing the simulation results to the actual figures is the fact that the number of farmers taking part in the study group changed over the period of the study. Such a change might lead to a change in a variable that cannot be explained by any economic factor changes. Therefore, the validation results should be interpreted with care.

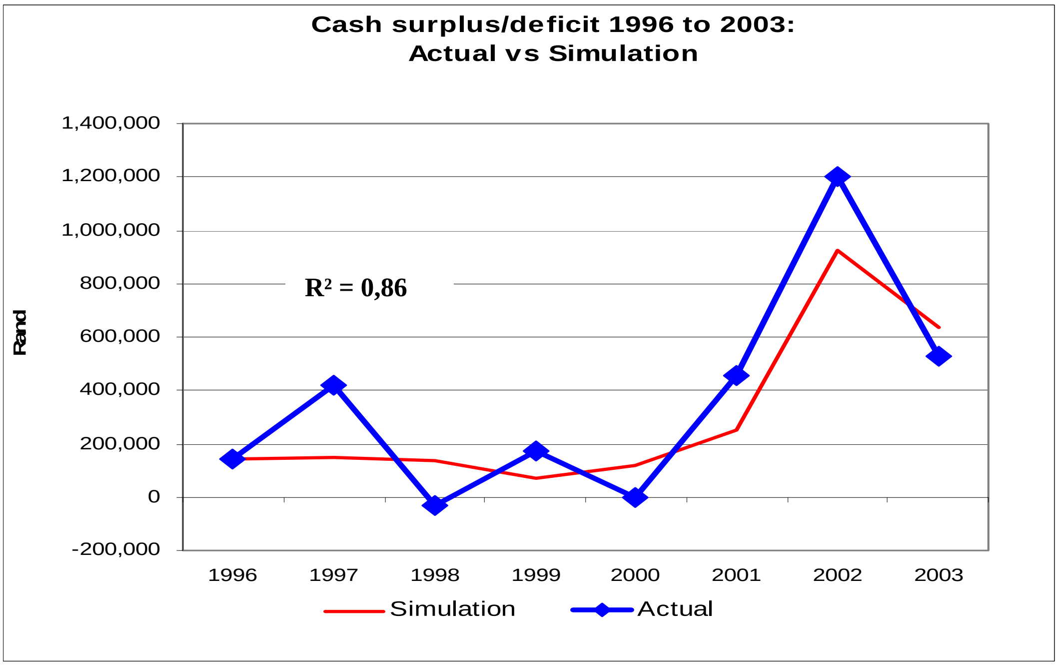

Figure 2: Ending cash surplus/deficit, 1996 to 2003

When plotting the actual cash surplus or deficit against the simulated cash surplus or deficit, it is clear that the simulation results do not have the same variability between two consecutive years that the actual figures have. However, the simulation results follow the actual numbers trend over the time period relatively accurately.

When comparing the debt to asset ratio simulated by the model against the actual numbers (Figure 3), it is clear that the simulated debt to asset ratio follows the downward trend of the actual debt to asset ratio to a certain extent.

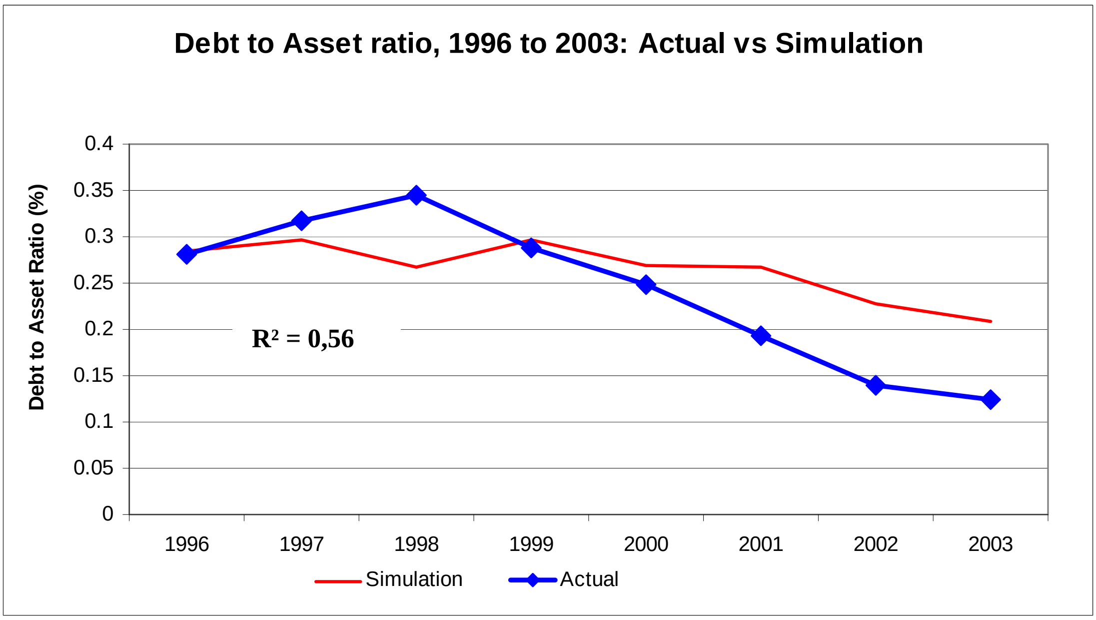

Figure 3: Debt to asset ratio, 1996 to 2003

Several reasons exist for the deviation of the simulated debt to asset ratio compared to the actual debt to asset ratio. The simulated cash surplus is lower than the actual cash surplus, especially for the period between 2001 and 2003. The cash position of the farm is often inversely related to the debt to asset ratio, depending on the level of profitability of the farm, asset replacement and debt uptake and repayment. As a result, the simulated debt to asset ratio is higher than the actual debt to asset ratio. Another reason is that simulated changes in either asset values or debt levels are not fully captured by the model, thereby resulting in a difference between the simulated and actual values. Also, due to changes in the number of respondents, the levels of the output variables could have changed, making it impossible to capture the changes by means of an economic model.

4. Baseline

The BFAP sector model has the ability to simulate projections for a range of agricultural commodities in terms of production, consumption, stocks, imports, exports and prices. The first set of the sector model projections is called the baseline, which serves the purpose of a benchmark or reference scenario. The alternative scenario results are thus compared to the baseline results in order to facilitate better understanding for decision-makers on how changes in policies and markets could impact the various key output variables. With the established link between the sector and farm-level model, some of the sector model projections are used as input for various input variables of the representative farm such as output prices, input prices, yields and area planted.

The key output variables of the representative farm are presented in Figures 4 and 5 for the period 2003 to 2010. The detailed baseline macro-economic assumptions are presented in the Appendix. The input data used for the farm-level model are the actual data of the representative farm for 2003 as developed through the process explained in section 2.2.

Given the macro-economic assumptions and the baseline projections of commodity prices from the BFAP sector model (see Appendix), the ending cash surplus of the representative farm increases from a level of R522 881 to reach a maximum surplus level of R1 340 716 during 2007 (Figure 4). However, when analysed in more detail, it becomes evident that the increase in the cash surplus during the period 2003 to 2007 occurs at a decreasing rate. From 2007 onwards, the cash surplus follows a declining trend and ends at a level of R1 154 542 during 2010. The reason for the decreasing trend of the ending cash surplus is the inflation on inputs increasing at a greater rate than the increase in farm output prices. More important, however, is the increase in interest payments due to the increase in the debt to asset ratio up to 2007, as presented in Figure 5.

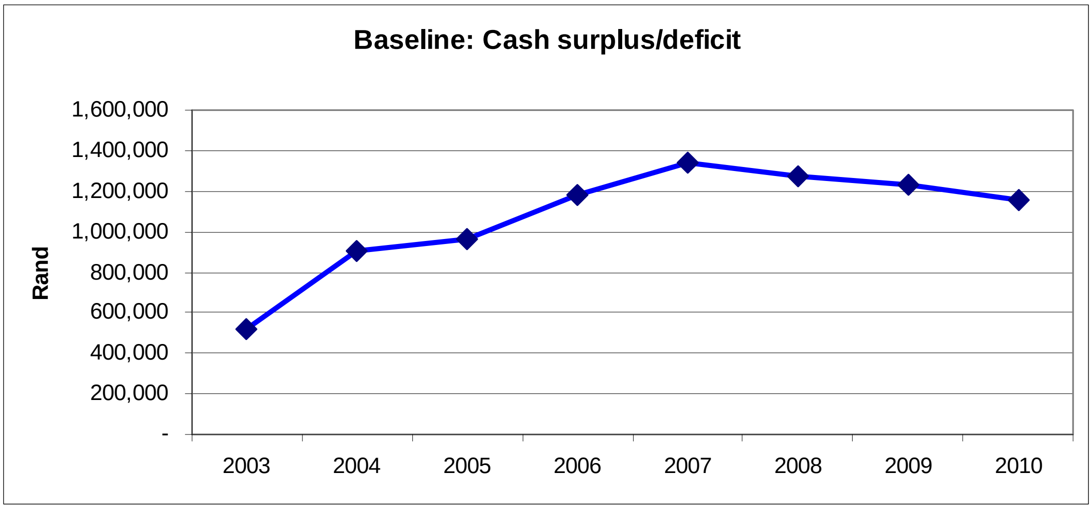

Figure 4: Baseline ending cash surplus/deficit, 2003 to 2010

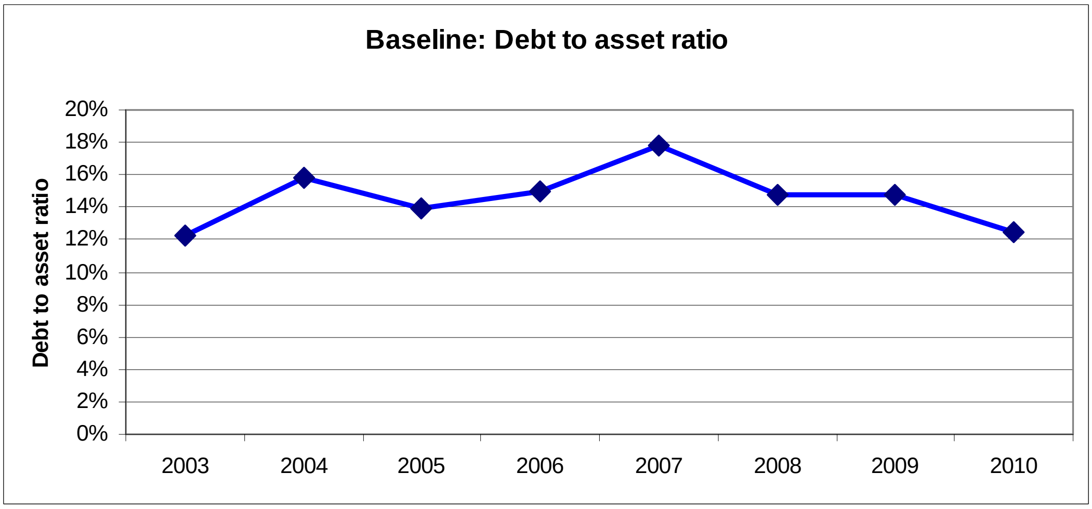

Figure 5: Baseline debt to asset ratio, 2003 to 2010

The debt to asset ratio (Figure 5) varies between 12% and 18% during the simulation period. During 2003, the debt to asset ratio is 12%, after which it increases to reach a maximum of 18% during 2007. From 2007 onwards, the debt to asset ratio declines to end at a level of 12% again. The increase in debt up to 2007 is due to a general increase in the gross farm income of the farm. This leads to an increase in asset replacement, which in turn results in more debt incurred. However, from 2008 onwards the debt to asset ratio decreases because very little asset replacement takes place. This is because the liquidity of the farm is under pressure (see Figure 4). Therefore no additional debt is taken up due to asset replacement. The result is an interesting situation where the cash position and the debt to asset ratio actually follow the same trend and not an inverse trend. The implication is that the profitability of the farm is high enough to repay current debt obligations, and as a result to prevent carryover debt, but not high enough to stimulate asset replacement and simultaneously the take up of additional debt.

5. The scenarios

Scenario 1: Appreciation of the Rand/ US Dollar exchange rate

Drastic movements in the Rand/US Dollar exchange rate during the period 2001 to 2004 partly caused significant variability in output and input prices. During 2002, the Rand depreciated to an average of 1047 cents against the US Dollar, and then started appreciating to an average level of 658 cents against the US Dollar during 2004. The long-term effect of an appreciating exchange rate on the survivability of the representative farm needs to be understood in order to develop strategic and action plans to mitigate the possible negative effect of an exchange rate appreciation. Hence, the simulation of a scenario where a Rand/US Dollar appreciation takes place is simulated and analysed.

The assumption in this scenario that causes the deviation from the baseline is an appreciation of the Rand/Dollar exchange rate during 2004, from the level of 658 cents/US Dollar to 500 cents/US Dollar. From there onwards, a gradual depreciation of the exchange rate takes place at the same rate as that of the baseline.

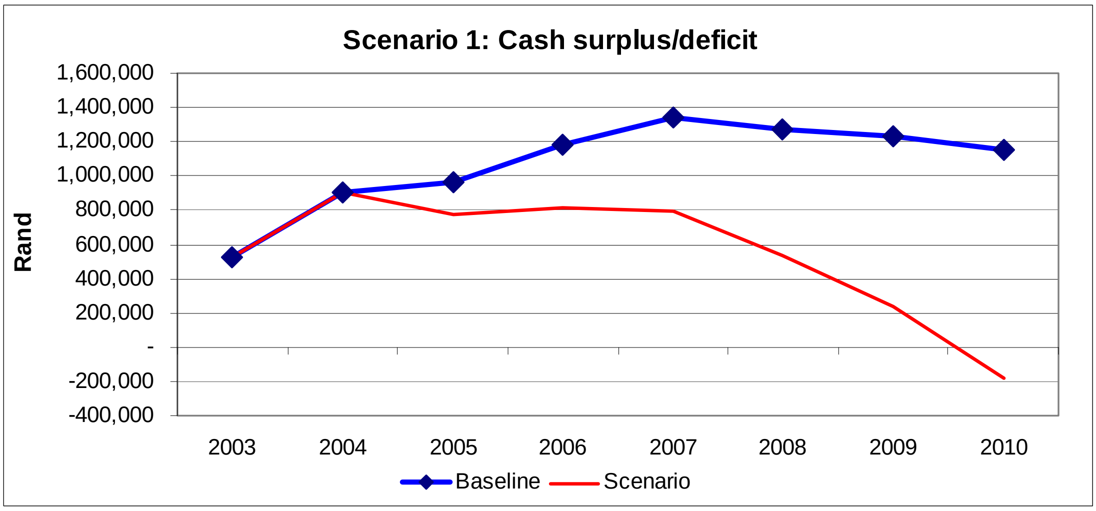

Figure 6: Scenario 1: Ending cash surplus/deficit, 2003 to 2010

The effect of the Rand/Dollar appreciation on the ending cash surplus/deficit during 2004 is presented in Figure 6. It is evident that the immediate effect of the exchange rate appreciation is zero, since the farm-level model is an annual model and simulates the financial position of the farm at the end of each period. Hence, the effect becomes visible only during 2005. As expected, due to a drop in commodity price levels because of the appreciation, profitability levels of the different farm enterprises decrease significantly. Over time, the effect increases due to increasing debt, which in turn is a result of low profitability and the resultant uptake of additional debt to remain liquid, as well as the occurrence of carryover debt (Figure 7). The increase in debt results in larger interest and debt payments. This has the effect of ending cash levels decreasing at an increasing rate, until the ending cash level during 2010 becomes negative. It can, therefore, be concluded that the general impact of a Rand/Dollar appreciation is likely to be negative over the long-term for the financial position and, thus, the survivability of the representative farm.

One important point to note is that the effect of the exchange rate appreciation on input costs is taken into account to a limited extent only, due to the fact that inflation on inputs is lower because of appreciation. However, no significant decreases in input prices are simulated. The reason for this is because the sector model does not simulate the impact of exchange rate movements directly on input prices, but rather indirectly through adjusted inflation rates.

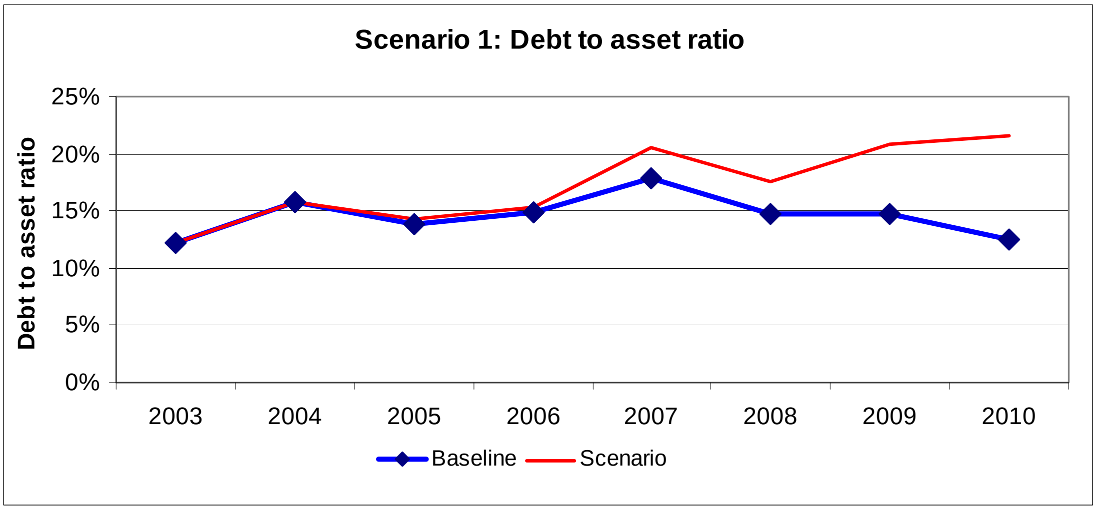

Figure 7: Scenario 1: Debt to asset ratio, 2003 to 2010

Scenario 2: Wheat import tariff

In this scenario, the authors draw on the sector results of a study on an alternative wheat import tariff (BFAP, UP, US, UFS & Department of Agriculture Western Cape, 2005). The proposal for an alternative tariff regime for the wheat industry is based on three arguments: firstly, the world reference price used to trigger the tariff mechanism should be a true reflection of the actual prices of imported wheat in South Africa; secondly, the tariff mechanism should be Rand based and not US Dollar based, due to the extreme fluctuations in the Rand/Dollar exchange rate, and thirdly, the tariff has to be triggered on a frequent and transparent basis due to the high volatility in domestic wheat prices.

In this scenario, the assumption is made that the alternative tariff mechanism is introduced during 2004; therefore the first effects only become visible during 2005 and onwards. Due to the formula by which the mechanism works, price fluctuations are curbed to a certain extent, while the average price of wheat marginally increases. The effect of the marginal increase in the mean of the wheat price has a positive impact on wheat profitability and as a result the cash position of the representative farm improves, as illustrated in Figure 8.

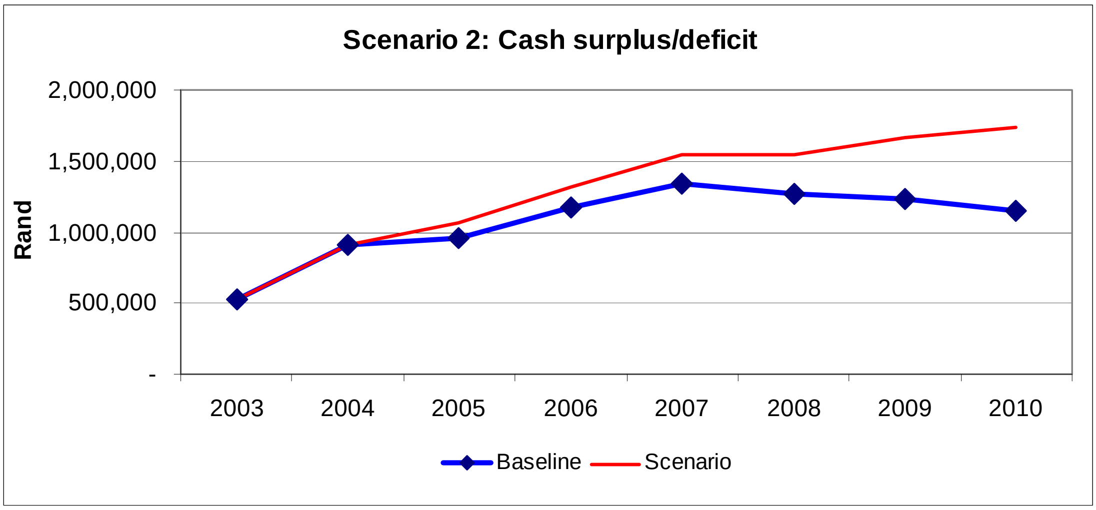

Figure 8: Scenario 2: Ending cash surplus/deficit, 2003 to 2010

Due to the improved profitability and the resulting improved cash position of the representative farm, a decrease in the debt to asset ratio is visible in Figure 9. The farm business, therefore, needs less debt to finance production activities due to better profitability. The impact of the lower debt levels is increasingly positive due to debt payments decreasing from the baseline. As a result, interest payments also decrease, but at an increasing rate. Interestingly, the debt to asset ratio does not decrease to the same extent as the increase in the cash position, since asset replacement and therefore the uptake of debt are stimulated to some extent due to improved profitability. Therefore, the overall impact of the alternative tariff mechanism is likely to be positive on the financial position and, therefore, the survivability of the representative farm.

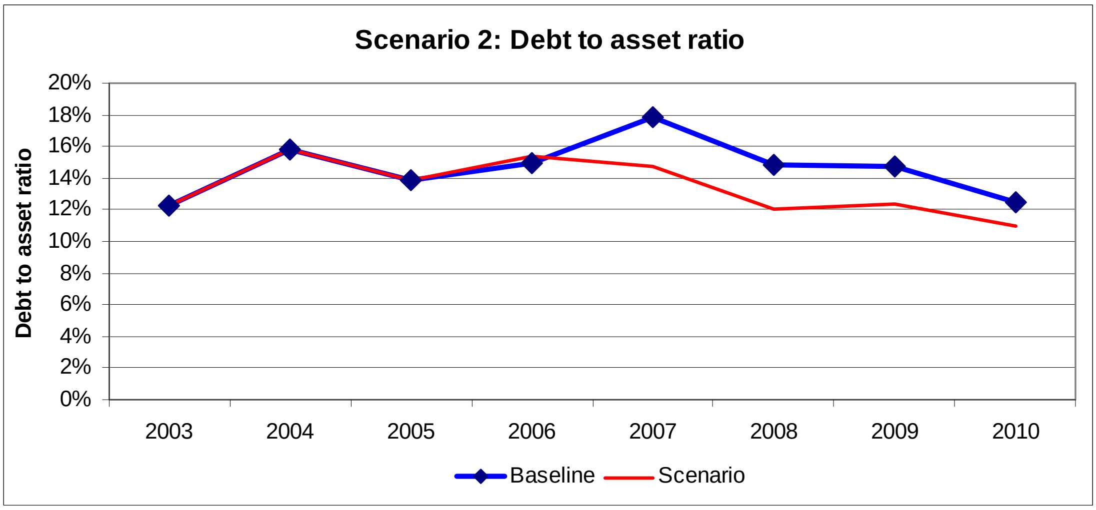

Figure 9: Scenario 2: Debt to asset ratio, 2003 to 2010

6. Summary and conclusion

The development of the farm-level model linked to a sector-level model offers policy- and business decision-makers a tool with the ability to analyse impacts of changes in markets and policies at both the sector and farm level. The results in the paper indicate that the farm model does simulate the representative farm reasonably accurately and that the results from the baseline and scenarios make sense from an economic perspective. Therefore, decision-makers can make use of the system of models. There are, however, several issues that are raised by this study.

Firstly, positivistic simulation models have the disadvantage of validation and verification being difficult and time consuming due to the potential absence of accurate and detailed data. In this study, detailed and accurate data were available and, therefore, the model could be verified and validated with relative ease.

Secondly, the positivistic approach that is used here requires that questions such as "What is the likely outcome?" are asked. Here the assumption is that during the simulation process very few adjustments to the farm structure take place, except those that are simulated by the sector model. This, in most instances, is not correct, since farm operators attempt to adapt to changing conditions as rapidly as possible in order to ensure survival and growth. One possible solution to the problem of not being able to simulate adaptation to changing conditions might be to develop a farm model following a normative stochastic approach, which is also linked to a sector model. This normative model can be run on the same research problem as that on which the positivistic model is run. This will, in essence, supply two different perspectives on the research problem that are likely to aid decision-makers by supplying them with an increased understanding of the problem.

Thirdly, a problem specifically concerning the deterministic type of model is the fact that the model and simulation process assume that there is no risk. As pointed out in the introduction, the agricultural sector is part of a highly dynamic environment and, therefore, risk and uncertainty are inherently part of the system under study. By constructing a deterministic type of model, risk and uncertainty are, however, assumed to not be part of the farm system, which is incorrect. The most recent versions of both the sector and farm model used in this article do take risk into account and the improvements to the modelling results are significant. These results will be published in future.

Lastly, due to the nature of the positivistic approach to modelling, reality needs to be simulated as closely as possible. The modeller, therefore, needs theoretical as well as practical knowledge of the system that is being modelled and simulated. In many cases, the modeller does not have practical knowledge of the system and thus the difficulty of achieving a realistic simulation of the system increases significantly. This problem can partly be mitigated by actively involving industry specialists, as well as people with "local" knowledge to assist in the modelling and simulation process. These people can also assist with the verification and validation of the model in cases where very little or no historical data exist with which to verify and validate the model.

References

BFAP, UP, US, UFS & Department of Agriculture Western Cape (2005). *The competitiveness of wheat production in the Western Cape, South Africa*. A report to Grain South Africa.

Bureau for Food and Agricultural Policy (2005). *Baseline 2005.* General publication by the Bureau for Food and Agricultural Policy [online]. www.bfap.co.za (Accessed 22/6/2005).

Cutts M, Reynolds S, Meyer F & Vink N (2007). *Modelling long-term commodities: the development of a simulation model for the South African wine industry within a partial equilibrium framework*. American Association of Wine Economists, Working Paper No. 12, Paper presented at Agricultural Economics Association of South Africa, September 2007, Fourways, South Africa.

FES (Financial-Economic Simulation Model) (2004). *FES Model documentation.* http://www.lei.dlo.nl/sites/FESmodel/ (Accessed 26/5/2004).

France J & Thornley JHM (1984). *Mathematical models in agriculture*. London: Butterworths.

Hardin ML (1978). A simulation model for analyzing farm capital investment alternatives. PhD dissertation, Oklahoma State University.

Held LJ & Helmers GA (1981). Growth and survival in wheat farming: the impact of land expansion and borrowing restraints. *Western Journal of Agricultural Economics* 6(2):207-216.

Johnson SR & Rausser GC (1977). Systems analysis and simulation: a survey of applications in agricultural and resource economics. In: Judge GG, Day RH, Johnson SR, Rausser GC & Martin LR (eds), *A survey of agricultural economics literature* (Vol. 2). Minneapolis: University of Minnesota Press.

Köbrich C, Rehman T & Khan M (2003). Typification of farming systems for constructing representative farm models: two illustrations of the application of multi-variate analyses in Chile and Pakistan. *Agricultural Systems* 76(1):141-157.

Louw A (1979). Groeistrategie vir boerdery-ondernemings (*Growth strategy for farm businesses*). DSc (Agric) dissertation, University of Pretoria, South Africa.

Meiring JA (1994). Die ontwikkeling en toepassing van 'n besluitnemingsondersteuningstelsel vir die ekonomiese evaluering van risikobestuur op plaasvlak. PhD dissertation, University of Free State, South Africa.

Meyer FH (2002). Modelling the market outlook and policy alternatives for the wheat sector in South Africa. MSc (Agric) thesis, University of Pretoria, South Africa.

Meyer FH & Westhoff P (2003). The South African grain, livestock and dairy model. Presentation at the Maize Trust Meeting, Pretoria.

Meyer FH, Westhoff P, Binfield J & Kirsten JF (2006). Model closure and price formation under switching grain market regimes in South Africa. *Agrekon* 45(4):369-380.

Patrick GF & Eisgruber LM (1968). The impact of managerial ability and capital structure on growth of the farm firm. *American Journal of Agricultural Economics* 50(3):491-506.

Richardson JW (2003). *Simulation for applied risk management with an introduction to the Excel simulation add-in: Simetar©*. Texas A & M University, College Station, Texas.

Richardson JW & Nixon CJ (1986). *Description of FLIPSIM V: a general firm level policy simulation model*. Texas Agricultural Experimental Station, Bulletin B-1528.

TIPI-CAL (Technology Impact and Policy Impact Calculations) (2003). *Documentation of the Model TIPI-CAL 3.0, Handbook Part 4*. http://www.ifcnnetwork.org/04_M/Inhalt_Methods03.html (Accessed 25/5/2004).

Appendix

Table 1: Macro-economic variables: baseline assumptions (Base year = 1995)

Variable	Details	2003	2004	2005	2006	2007	2008	2009	2010
SA population	Millions	46,8	47,2	47,5	47,6	47,6	47,6	47,5	47,3
Exchange rate	SA cents/US $	757	658	614	632	670	704	732	754
CPI: food	Index	183	191	198	205	210	214	221	228
CPI: total	Index	171	179	185	191	197	201	206	213
GDP deflator	Index	178	187	193	200	205	209	215	222
Interest rate (weighted)	Index	111	117	121	125	128	131	134	139
PPI: field crops	Index	173	181	188	194	199	203	209	216
PPI: total	Index	160	168	174	180	185	188	194	200
PPI: agricultural goods	Index	166	174	180	186	191	195	201	207
Fuel	Index	285	312	355	402	454	508	573	649
Requisites	Index	212	222	230	237	244	249	256	264
Intermediate goods	Index	218	228	236	244	251	256	263	272
Implements	Index	199	208	216	223	229	233	240	248
Repairs and maintenance	Index	229	240	248	256	264	269	276	285
Irrigation equipment	Index	181	189	196	203	208	212	218	226
Feed	Index	190	199	206	213	219	223	230	237
Fertiliser	Index	225	236	244	253	260	265	272	281
Machinery and implements	Index	190	199	206	213	219	223	229	237

Source: Bureau for Food and Agricultural Policy, 2005

Table 2: International commodity prices: baseline assumptions

Variable	Details	2003	2004	2005	2006	2007	2008	2009	2010
Yellow maize, US No 2, fob, Gulf	US$/t	104	108	103	106	107	109	110	113
Wheat, US No 2 HRW fob (ord) Gulf	US$/t	151	161	148	148	149	151	154	157
Sunflower Seed Price, Lower Rhine	US$/t	325	321	326	292	291	291	291	289
Sunflower cake price, Rotterdam	US$/t	166	127	117	121	122	122	122	122
Sunflower oil, NW Europe	US$/t	660	680	657	661	662	662	662	658
Sorghum, US No 2, fob, Gulf	US$/t	111	104	104	103	104	105	106	106
Soya Bean Prod. Price: Rotterdam FOB	US$/t	312	261	237	243	244	244	243	242
Soya Bean Cake Price: Rotterdam FOB	US$/t	275	210	193	199	202	204	203	202
Soya Bean Oil Price: Rotterdam FOB	US$/t	630	547	509	507	499	493	488	485
World fishmeal price: CIF Hamburg	US$/t	590	678	701	724	745	759	780	807
Steers, Nebraska, CIF	US$/100 lb.	70	61	66	69	68	65	62	59
Broilers, U.S. 12-city	US$/100 lb.	62	62	59	59	59	59	60	60
Cheese FOB N. Europe	US$/t	1839	2145	2088	2068	2080	2104	2122	2145
Butter FOB N. Europe	US$/t	1392	1552	1517	1575	1615	1648	1684	1707
SMP FOB N. Europe	US$/t	1709	1809	1810	1765	1753	1769	1780	1817
WMP FOB N. Europe	US$/t	1747	1792	1781	1763	1774	1793	1813	1842
Hogs, U.S. 51-52% lean	US$/100 lb.	39	38	41	42	40	39	40	43

Source: Bureau for Food and Agricultural Policy, 2005

Table 3: Domestic commodity prices: baseline assumptions

Variable	Details	2003	2004	2005	2006	2007	2008	2009	2010
White maize price	Index	100	104	65	93	98	94	92	90
White maize yield	Index	100	105	118	119	120	121	122	123
White maize area planted	Index	100	88	88	65	79	82	83	84
Yellow maize price	Index	100	104	71	92	95	100	108	116
Yellow maize yield	Index	100	105	119	118	120	121	122	123
Yellow maize area planted	Index	100	98	108	102	104	99	95	92
Wheat price	Index	100	92	87	89	94	98	102	106
Wheat yield	Index	100	102	113	114	114	115	116	117
Wheat area planted (summer rainfall area)	Index	100	117	115	132	116	106	102	96
Sunflower price	Index	100	105	92	77	93	94	98	100
Sunflower yield	Index	100	92	92	93	93	94	95	96
Sunflower area planted	Index	100	85	91	126	96	102	101	100
Sorghum price	Index	100	53	52	55	61	65	69	73
Sorghum yield	Index	100	102	103	104	104	105	105	106
Sorghum area planted	Index	100	155	148	145	133	124	116	106
Soya price	Index	100	80	72	77	82	85	88	91
Soya yield	Index	100	144	141	142	144	146	147	148
Soya area planted	Index	100	113	121	121	119	117	116	115
Beef average auction price	Index	100	111	101	118	127	131	137	144
Chicken producer price	Index	100	89	79	88	94	97	102	106
Egg consumer price	Index	100	127	111	116	121	123	127	131
Pork producer price	Index	100	108	101	117	125	130	137	145

Source: Bureau for Food and Agricultural Policy, 2005