An Alternate Method for Estimating the Value of the Southern Oscillation Index (SOI) in the Northern Grainbelt

J.B. Robinson[1, 2], and D.G. Butler[3]

[1] APSRU, Dept Natural Resources, PO Box 318, Toowoomba, Qld.
[2] University Western Sydney- Hawkesbury, Locked Bag 1, Richmond, NSW.
[3] Dept Primary Industries, PO Box 102, Toowoomba, Qld.

ABSTRACT

Previous studies have identified extra profit that could result by selecting management options according to particular phases of the Southern Oscillation Index (SOI). These studies have identified optimal decisions for each phase, but may have overestimated the value of phase-based management through a lack of data for independent evaluation. This study applies a simple sampling technique, analogous to *leave-one-out* cross validation, to estimate the range of future outcomes when independent validation data are not available. In six case studies involving wheat-growing in southern Queensland, this method indicated that management according to the April-May SOI phase yielded either small long-term increases (n = 4) or decreases (n = 2) in profit. There was considerable heterogeneity among phases, and the annual variance of the outcomes was large relative to the average (long term) value in each case. This method delivers improved estimates of the mean and variance of the value of the SOI for management.

Key words

SOI, management, wheat, fertiliser, varieties.

INTRODUCTION

The five phases of the Southern Oscillation Index (SOI) are well-known climate indicators, and a survey (4) indicates that 10% of wheat farmers in the northern New South Wales always or often use climate forecasts in their N fertiliser decision making. The phases have been shown to be useful through their associations with changes in the frequency distributions of rainfall amounts (10) and frost incidence (11). Studies of managing wheat crops according to the phases have reported major benefits; “Significant increase[s] in profit (up to 20%) and/or risk (up to 35%) were associated with tactical management of N fertiliser or cultivar maturity” (3). Other studies (1, 6, 7, 9) of the phases have also found that they are valuable in crop decision making.

However, while these studies identified differences among the distributions of outcomes from SOI targeted management, these summaries were derived from the same data used to identify the optimum management strategies. These outcome distributions may be optimistic because the chosen management strategy is optimal over all cases; but would not necessarily be so for a new (independent) observation. Two methods of independent testing are available; a) test new data as they arise on an annual basis, or b) use part of the data to develop an optimum management strategy and the remainder to assess its value. We have followed the latter strategy below.

The aim of this study is to assess the economic value of SOI-targeted management strategies in the northern grainbelt when applied to observations not used in the derivation of the particular strategy.

METHODS

Six case studies are analysed to assess the value of the SOI-targeted management; selecting N fertiliser rates at Dalby with 2 levels of plant available soil water (PAW) at sowing, selecting N fertiliser rates at St George with 3 levels of PAW, and selecting wheat varieties at Dalby with 1 level of PAW. Outcomes for the management options were simulated with a wheat model (Iwheat) (9) for the period 1888 to 1997. Soil nitrogen, soil moisture and other factors were simulated in various modules within APSIM (5). Profit was calculated from the yield, protein content and assumptions about costs and prices.

At Dalby, Hartog was simulated with 60 or 90 cm of wet black vertosol (PAWC= 321 mm). Soil nitrate at sowing was 89 kg N/ha. Six fertiliser rates (0, 20, 40, 60, 80 and 100 kg N/ha) and were simulated, and three varieties (at 90 cm and 40 N). Frost was simulated by the method of Hammer *et al.* (3) in the variety example. At St George, 60, 90 or 120 cm of wet grey vertosol (PAWC=215 mm) were simulated with soil nitrate equal to 59 kg N/ha and three rates of fertiliser (0, 20 and 40 kg N/ha). The sowing date was 1 June in all simulations. Profits ($/ha) were calculated from the following data. Fertiliser cost $1.00 per kg N. For rates of 40 kg N/ha and higher, an extra pre-plant application cost of $10/ha was included. Wheat prices, net on-farm, varied with grain protein; < 10% = $120/t, ≥10% and < 11.5% = $150/t, ≥ 11.5% and <13% = $175/t and ≥ 13% = $200/t. Non-fertiliser variable and fixed costs were assumed to be $100/ha and $100/ha respectively at St George, and $150/ha and $200/ha respectively at Dalby.

Each month, the SOI can be in any one of five phase states (consistently negative - 1, consistently positive - 2, rapidly falling - 3, rapidly rising - 4 or near zero - 5 (10). The phase state in both March-April and April-May of each year was investigated, though April-May is considered a better indicator of subsequent seasonal conditions (Roger Stone, pers. comm.).

The model was used to estimate yield, protein and profit for each N rate or variety in each year. The economic value of SOI-targeted management, over and above the most profitable long-term (“fixed”) N rate or variety, was calculated from these data by two separate methods;

1. Fitted values. The annual value ($/ha/year) of adjusting the fertiliser rate or variety was assessed against the best fixed management strategy (ie. across the 5 phases). We use $\hat{F}_i$ to represent the empirical distribution function (EDF) of the extra profit for year *j* (*j* = 1988, … , 1997) from using the best strategy for phase *i* instead of the fixed strategy. Optimal management for each phase *i* and for the long-term were the ones with highest average profit. These values are referred to subsequently as the **fitted** outcomes (**F**).

2. Predicted values, where SOI-targeted management is fitted to all but one year, then is valued for that year. We use $\hat{P}_i = \hat{F}_i^{-j}$ to represent the EDF of values derived in the same way as the fitted outcomes, but with the j^{th} year omitted from the rule-making (the value is calculated for year j). This is analogous to the leave-one-out method of cross-validation (see 2, Chapter 17). These are subsequently referred to as **predicted** values (**P**).

To explore the range of potential outcomes from the two methods in the six examples studied, 100 sets of randomly selected phase labels (ie. dummy labels) for the years 1888 to 1997 were valued. The resultant distributions of profit from random number-targeted management are denoted $\hat{R}_f$ and $\hat{R}_p$ below (for fitted and predicted values, respectively).

RESULTS

The distributions of outcomes for the April-May SOI phase vary in central tendency, range and skewness between phases for all examples (Figure 1). Estimates of the average value of each phase for the data in Figure 1 are given in Table 1. The value of the phases varies widely between examples and is not always positive. The estimated long-term values are consistent between fitted and predicted outcomes for phase 1 in all examples and for various other combinations. While the medians are identical for pairs of fitted and predicted distributions, where the distributions differ in range and/or skewness there is a general tendency for the average value of the fitted outcomes to be optimistic relative to the predicted values.

The average (optimum) fitted values over all phases are always positive and range from $1.10 /ha (St George 120) to $14.00 /ha (Dalby Variety). The average predicted values are less optimistic (-$15.10 to $5.50), with economic losses for both Dalby 90 and St George 90 examples.

The March-April SOI phase is acknowledged as having less predictive skill with respect to the subsequent cropping season (Roger Stone, pers. com.). Using the fitted values the outcomes for these phases (not shown) compared favourably with the April-May phases for 3 examples (Dalby variety selection, St George 60 and St George 90) but is economically useful in only 1 of the 6 cases (St George 60) as estimated by the predicted outcomes. The phases in April-May were a little more valuable (Table 1), with an increase in overall profit in 4 of the 6 cases from the predicted values ranging up to $5.50/ha/year (Table 1). However, these changes in profit are small, especially in relation to the annual variability.

The annual sequence of predicted outcomes (P, $/ha) for the phases in April-May for Dalby 60 is shown in Fig 2. This case, where SOI-adjustments were most profitable (Table 1) demonstrates the occurrence of both frequent annual losses (41% of years) and gains (42% of years). The overall gain is strongly influenced by the benefits of phase 1 years (Figure 1). The small size of most of the losses is because they represent expenditure on fertiliser that does not result in a yield or protein/price response (commonly -$20/ha for 20 kg N/ha without benefit). The average increase in profit of $5.50/ha/year is small relative to the annual variability (Figure 2).

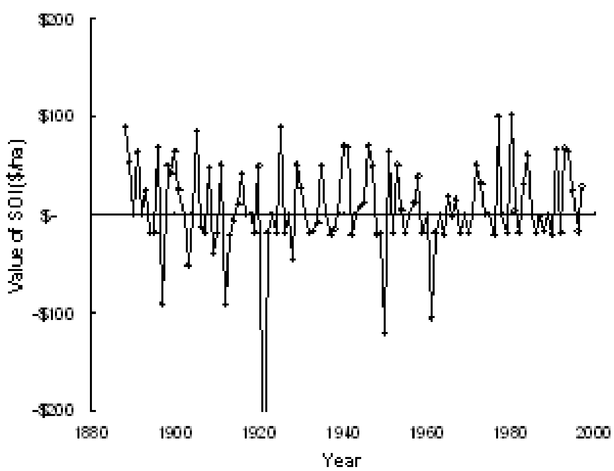

Figure 2. The predicted value (extra profit, $/ha) of the SOI phases for N fertiliser management in wheat at Dalby (60cm of wet soil at sowing).

Table 1. The mean value of SOI-based management ($/ha/year) for the fitted (F) and predicted (P) outcomes.

Case study	Method	SOI					
		1	2	3	4	5	**All years**
Dalby 60 cm	Fitted	37.10	0.00	38.60	5.80	5.10	**13.70**
of wet soil	Predicted	37.10	-24.60	38.60	-0.180	-1.00	**5.50**

Dalby 90 cm	Fitted	14.40	0.00	0.00	3.30	0.380	**3.20**
of wet soil	Predicted	14.40	0.00	-13.40	-2.10	-11.90	**-3.00**
Dalby Variety	Fitted	25.30	27.00	33.10	0.00	0.00	**14.00**
	Predicted	25.30	27.00	33.10	-46.40	0.00	**3.00**
St George 60 cm	Fitted	4.90	0.00	0.00	5.60	0.00	**2.10**
of wet soil	Predicted	4.90	0.00	-6.90	5.60	0.00	**1.20**
St George 90 cm	Fitted	0.00	3.20	0.00	2.40	0.50	**1.40**
of wet soil	Predicted	0.00	-16.50	-9.10	-18.70	-23.10	**-15.10**
St George 120 cm	Fitted	6.50	0.00	0.00	0.00	0.00	**1.10**
of wet soil	Predicted	6.50	0.00	0.00	0.00	0.00	**1.10**
Number of years		18	23	14	26	29	**110**

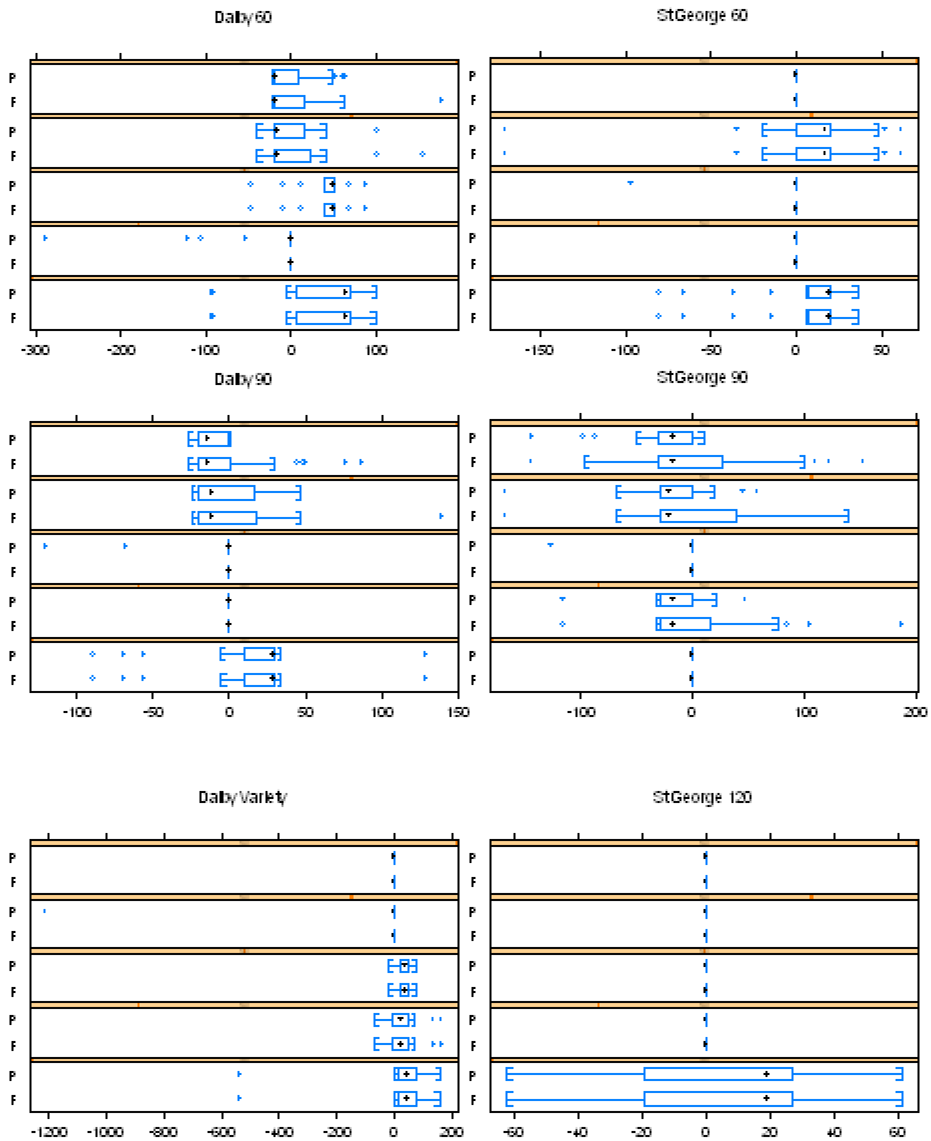

Figure 1. The distribution of outcomes (X axis, $/ha) from fitted (F) and predicted (P) outcomes. Note that the scales vary between boxes. The solid dot, box, whiskers and hollow dot represent the median, mid quartiles, 95%ile range and outliers (>95%iles), respectively. The phases are ordered from 5 at the top to 1 at the bottom of each box.

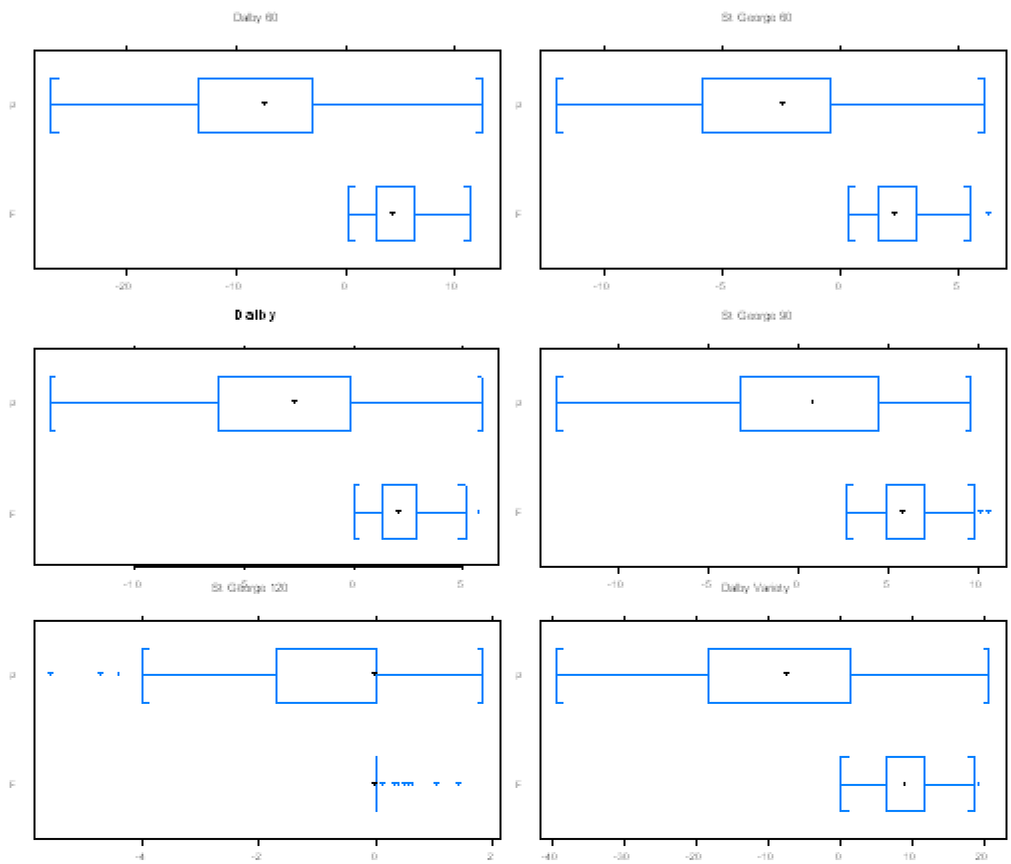

Figure 3. The distribution of fitted (F) and predicted (P) outcomes for “dummy” SOI phases (random numbers) in the six case studies.

There was considerable variability in predicted values of the phases for managing N fertiliser decision-making at St George. An overall loss of $15.10 was calculated for the St George 90 example using the April-May SOI. This value was due to less profitable decisions in 47% of years and a high average cost of these losses. SOI-adjusted management increased profit in only 9% of years in this example and was the only case where management targeted at phase 1 was economically neutral. Economic benefits with 60 cm or 120 cm of wet soil were modest, especially in relation to the annual variability. All phases except 1 were economically neutral at St George 120.

The results for the random phases show the average estimated return is consistently lower and the variance higher for the predicted values (Figure 3). This illustrates the potential for *artificial skill* when assessing the impact of targeted management in the absence of independent validation data.

DISCUSSION

The variability between years within phases results in a range of optimum strategies in the predicted (P) method. This, in turn, gives rise to many annual outcomes that are less profitable than those obtained from a single strategy optimised over all years in each SOI phase. The difference in all-years value across the cases between the fitted and predicted outcomes ranged from $0 /ha/year to -$16.50 /ha/year. Although not conclusive, for the cases presented in this study it seems the value of managing according to the SOI phases is less than previously estimated.

When viewed across all phases there seems little or no extra profit to be made from SOI targeted management. However, this simplification obscures potential benefits that seem to exist in specific phases and cases. For example, targeted management for phase 1 is always neutral or profitable in the long term. One response to this information could be to adopt an SOI-based strategy for phase 1 years, and adopt a neutral or more conservative approach otherwise.

The values attributed to valueless random numbers (Figure 3) also suggest that the conclusions of previous studies (e.g. 1, 3. 6, 7) have overvalued SOI targeted management. However, that is not to say there is no value; the average results for some of the examples tend to fall in the positive tail of the distributions in Fig 2, providing some evidence of real skill. Examination of Table 1 and Figure 1 again suggest that phase 1 is largely responsible for the positive results.

What are the sources of the differences between the fitted and predicted values? Figure 1 shows that the median values of F and P are similar, and that the differences in the mean values (Table 1) are caused by i) some very bad choices under P (e.g. Dalby variety, phase 4) and ii) failing to make some of the really good choices of F (e.g. St George 90, phases 2,4 and 5). The differences between F and P hinge on the differences in the data sets used and the consequences of different choices. The data sets differ only by single year, and the differences are partly a reflection of the small number of years and high variability in each SOI category (Table 1). The consequences of choice varied between examples (e.g. choice could be very important in the Dalby variety example). Therefore, in the six cases studied, the associations between the SOI phases and management options are not sufficiently uniform to consistently make gains or avoid losses.

Managing fertiliser rates and varieties according to the SOI can be compared with the value of other management changes or resources. One extra mm of soil moisture available at sowing is worth about $5/ha/year of extra profit at Dalby and St George (based on differences between 60 cm and 90 cm of wet soil, above). Therefore, the maximum value of phase targeted management in these case studies was equivalent to storing an extra 1.1 mm and 0.25 mm of soil moisture at Dalby and St George, respectively.

From a farmer perspective, it could not be recommended to use the SOI phases to adjust management in cases such as those examined here

CONCLUSIONS

Previous studies have identified structure in the distribution of outcomes from SOI targeted management but may have overestimated the value of tactical management because of the lack of independent evaluation data. The method described here attempts to overcome this by evaluating apparently optimal management strategies on years not included in the development of the rule. This approach recognises the heterogeneity within phases and that the (apparently) optimal rule for a given phase may change with the composition of the phase.

This study also suggests the existence of a real, possibly useful, long-term advantage of targeted N fertiliser and variety management for years with an April-May SOI phase of 1 (consistently negative).

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