ENSO Forecast Value, Variable Climate and Stochastic Prices

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Value of Information

Problem: Choose farming practices, $a$, to maximize utility of expected wealth: $E\{U(W(a))\}$ or its certainty equivalent $W_{ce}(a)$.

Value of information (VOI) is the difference in $W_{ce}$, with and without use of climate forecasts:

$$VOI = W_{ce}(a|x) - W_{ce}(a|c)$$

where $c$ is climatology.
What’s New?

Historic vs. linked-modeling approaches.

Sources of risk besides ENSO phase:
• price variability; and
• inter-event variability.
Farm Scale Forecast Valuation

- Identifying "optimal" strategies by ENSO phase.
- Synthetic weather data; crop simulation models.
- Crop mix, fertilizer amount, and planting date.
- Price variability, risk aversion, variable climate.
Price Simulation

• Synthetic distributions of four crop prices, consistent with historic variability (1979-2000) centered on 1996-98 levels.

• Each series deflated, de-trended and de-seasonalized.

• Principal components decomposition of price matrix.

• Kernel filter fitted an empirical density function for each of the four time series of principal components.

• Sampled 36,000 values for each crop.

• Synthetic values combined and back-transformed to reconstruct prices.
Problem Statement

Farmer allocates land among 21 crop and management alternatives to maximize expected utility of year-end wealth:

(1) \[ \max_x E\{U(W_0 + \prod_j)\} \] Maximize expected utility of final wealth

(2) \[ U(W_F) = W_F^{(1-R_r)} / (1 - R_r) \] Constant relative risk aversion

(3) \[ \prod = \sum_{j=1}^{m} x_j \pi_j - C - T \] Income

(4) \[ \pi_j = Y_j P_j - c_j \] Income per hectare

subject to land and labor availability constraints.
Case Study - Argentine Agriculture
A Few Basic Results

Maize favored crop for favorable conditions, e.g., warm events and risk neutrality.

Soybeans favored in neutral and cold events.

Sunflower is favored hedge, since its returns have low variability and low correlation with those of maize.

Diversification increases with risk aversion, but not dramatically.
Optimal Management: Fixed Prices

Risk aversion induces diversification.

Maize favored in warm and neutral years.

Soybeans and sunflower favored in cold years.
Optimal Management: Variable Prices

Risk aversion induces diversification.

Maize favored in warm and neutral years.

Sunflower and wheat favored in cold years.
Forecast Value by ENSO Phase and $R_r$

A: Fixed Prices

VOI ($/ha)

$R_r=1$

warm
neutral
cold
all

$R_r$ values: 0, 0.5, 1, 2, 3, 4

VOI values: 7.5, 7.2, 2.8, 8.2, 9.5, 12.5, 15.4

0 0.5 1 2 3 4

$R_r$ axis
Forecast Value by ENSO Phase and $R_r$

B: Variable Prices

![Graph showing VOI ($/h^2$) vs. $R_r$ for different ENSO phases, including warm, neutral, cold, and all. The graph indicates varying values for each phase at different $R_r$ levels.](image)
Thirty VOI Estimates

The graph shows the distribution of VOI ($ ha\(^{-1}\)) estimates among 30 samples. The x-axis represents the VOI values, while the y-axis indicates the frequency of occurrence. The bars and the line graph together depict the percentage of samples falling into different VOI ranges.
Forecast Value Distributions

A: By ENSO Phase, for $R_f=1$
Forecast Value Distributions

B: $R_r$ for all years
Conclusions

Forecasts shift probabilities of outcomes.

• Long-term value, but VOI in any given season may be < 0.

• High intra-phase variability in extra-tropical regions.

• Level and spread of VOI important to potential users.

Omitting price variability may give misleading results:

• can reinforce or offset climate variability in any given year;

• defensive versus offensive forecast responses;

• on average raises level of risk and value of forecasts.
ENSO Signal

Climate


Crop Yields

Rainfall Anomalies vs. Crop Yield Anomalies

Source: Podesta et al. 1999
Farmer uses climate forecast, $x$, to update probability distribution for a climate event, $s$, according to Bayes rule:

$$p(s|x) = \frac{p(x|s)\pi(s)}{\sum_{s} p(x|s)\pi(s)}$$