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Yield Response to Nitrogen with Time Trend and Nonnormality

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Objective

- Estimate the profit maximizing level of nitrogen with a nonnormal stochastic plateau and a time trend
- Determine whether the increased cotton yield is due to increased efficiency of nitrogen use or increased ability to use nitrogen

Motivation

- Cotton has shown increased yields over time and recommended levels of nitrogen per bale have decreased
- Past literature on crop yield assumed normality of error terms while evidence exists that yield has non zero skewness
- Stochastic plateau model with time trend enables investigation of yield response to both physical inputs and unobservable structural changes.

Econometric Model

The following stochastic plateau model is used:

$$(1)\quad y_{it} = \min(\bar{\alpha}_0 + \bar{\alpha}_1 N_i, \bar{P} + v_t) + u_t + \varepsilon_{it}$$

y_{it}: observed yield in year t for ith treatment
$\bar{\alpha}_k = \alpha_k + \delta_k T, k = 1,2$ and $\bar{P} = P + \delta_3 T$,
T = time proxy; $v_t \sim Beta(0, \theta)$ and $u_t \sim N(0, \sigma_u^2)$ are plateau and intercept year random effects, and $\varepsilon_{it} \sim N(0, \sigma_\varepsilon^2)$ is the equation error term.

Methods

1.Maximum likelihood methods

- The mixed stochastic plateau model is used with beta distributed plateau random effects
- SAS PROC NLMIXED is used to fit the model and assign the beta distribution to the plateau error term
- A Gaussian quadrature approximation is used to maximize the likelihood integrated over the random effects

2.Bayesian estimation methods

- All the random effects are normally distributed except the plateau random effect, which is beta distributed
- A noninformative prior is used so that the main purpose of using Bayesian methods is to avoid convergence issues associated with maximum likelihood
- SAS PROC MCMC is used to estimate the parameters

Results and Conclusions

Parameter	MLE	SE	Bayesian	SE
α_0	325.2	.007	452.0	35.20
α_1	1.04	.000	-1.5	0.200
δ_1	10.7	.000	9.6	1.30
δ_2	2.0	.000	0.2	0.01
δ_3	28.4	.000	14.0	3.54
P	736.8	.008	982.9	2.15

- The impact of time trend is more accentuated in the plateau than in the other parameters.
- The increase in the ability to use more nitrogen explains more of the increase in yield over time, but all parameters increase over time.
- Convergence is still a problem in both the maximum likelihood and in the Bayesian models.

References

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