Optimal Stocking Density and Food Safety Risks in Steer Production Enterprise

William E. Nganje, Simeon Kaitibie, B. Wade Brorsen, and Francis M. Epplin

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Background

- Estimated LRP with stochastic plateau
  - Average Daily Gain=*f*(Forage Allowance)
  - Overstocking less costly than understocking
- Food safety conflict
- Microbial shedding at high stocking densities
- HACCP system (implementation + testing
- Output price and production uncertainties

Objectives

- Determine optimal stocking density under production and output price uncertainty.
- Simulate food safety risk by penalizing output price under the assumption of high microbial shedding.

Methods

- Mathematical Models
  - Linear Response function with a stochastic plateau

$$ADG = \begin{cases} 0.48 + 66.47FA + \varepsilon, \text{ if FA} \leq 0.0105 \\ 1.18 + \varepsilon \quad \text{otherwise,} \end{cases}$$

Methods

- Total Gain Function
  - if $$\mathrm{I}_{(-\infty,\, \mathrm{GP}^{-1})}(FA_{\mathrm{critical}}) = \begin{cases} 1, \text{if FA}^* \le GP^{-1} \\ 0, \text{otherwise} \end{cases}$$

$$TG = \left\{ \left(\alpha_0 GP + \alpha_1\right)\left(1 - \mathrm{I}_{(-\infty,\mathrm{GP}^{1})}(FA^*)\right) + ADG_{\max} GP\, \mathrm{I}_{(-\infty,\mathrm{GP}^{1})}(FA^*) \right\} + \varepsilon \, \mathrm{x} \, GP.$$

$$y = f(GP) + h(GP)\varepsilon$$

Methods

- Expected Utility Maximization (follows Isik, AJAE, August 2002).

$$\max EU(W \mid GP) = EU(W_0 + (\overline{P} + \theta) \times [f(GP) + h(GP)\varepsilon] - rGP)$$

Taylor Series Approximation of Marginal Utility

$$\overline{P} f'(GP) = \frac{\phi h(GP) h'(GP) \sigma_\varepsilon^2 \left(\overline{P}^2 + \sigma_\theta^2\right) + r}{1 - \left(\phi \sigma_\theta^2 f(GP)\right) / \overline{P}}$$

Food Safety Application

- Penalize P with penalty c proportional to the level of microbial shedding

$$\max EU(W \mid GP) = EU\left(W_0 + (1-c)(\bar{P}+\theta) \times \left[f(GP) + h(GP)\varepsilon\right] - rGP\right)$$

Table 1. Optimal Stocking Density under Production and Output Price Uncertainty

Value of gain ($ per kg)	Optimal grazing pressure (steer-days per hectare)		Optimal stocking density [a] (steers per hectare)	
	Φ=0.00005	Risk neutral farmer	φ= 0.00005	Risk neutral farmer
1.36	104.3210	104.4500	0.8693	0.8704
10 % penalty	101.3090	101.3390	0.8442	0.8445
25 % penalty	99.1160	99.1300	0.8260	0.8261

[a] Optimal stocking density is based on a 120-day grazing pressure and an initial standing forage of 1,732 kg per hectare; calculated by dividing optimal grazing pressure by 120.

Table 2. Optimal Stocking Density under Different Sources of Uncertainty

Risk preference	Optimal stocking density (steers per hectare) [a]		
	$1.36	10 % Penalty	25 % Penalty
Risk neutral	0.8704	0.8445	0.8261
	φ=(0.00005)		
Production uncertainty alone	0.8704	0.8445	0.8261
Value of gain uncertainty alone	0.8694	0.8443	0.8260
Production and value of gain uncertainty	0.8693	0.8442	0.8260

[a] Optimal stocking density is based on a 120-day grazing pressure and an initial standing forage of 1,732 kg per hectare; calculated by dividing optimal grazing pressure by 120.

Table 3. Expected Cost of non-Optimal Stocking Density under Risk Aversion and Production and Output Price Uncertainty

Value of gain ($ per kg)	Stocking density (steers per hectare)	Expected profit ($ per hectare)	Expected cost of price penalty (microbial shedding) ($ per hectare)	
1.36				
	0.8693 *	258.20	-	
10 % penalty				
	0.8442 *	224.48	33.72	
25 % penalty				
	0.8260 *	175.17	83.03	

* Optimal stocking density is calculated by dividing optimal grazing pressure by 120.

Conclusions

- Optimal stocking density is marginally higher under risk neutrality than under risk aversion
- Optimal stocking density decreases with price penalty
- The magnitude of returns forgone due to price penalty is high, and increases with price penalty

Additional Work

- Re-estimate linear response plateau function as a composite model – homothetic function

  adg=*f*(FA(SD(microbial shedding)))

- Do expected utility maximization with Monte Carlo integration or Gaussian Quadrature (Risk implications)