Agricultural Production and Technological Change

Advanced Producer Theory and Analysis: The Production of Perennials

Alexandra E. Hill

AREC 705: Week 2

Colorado State University

French & Matthews Overview

French, B.C. & Matthews, J.L. (1971). A Supply Response Model for Perennial Crops. *American Journal of Agricultural Economics, 53(3)*: 478–490.

Contributions – what question(s) is the paper addressing? –

Category – theoretical? empirical? case study? meta-study? –

Conclusions – what are the results? –

Context – what are related papers? who are the authors? –

Methods – what methods are used to analyze the problem? –

French & Matthews Questions

French, B.C. & Matthews, J.L. (1971). A Supply Response Model for Perennial Crops. *American Journal of Agricultural Economics, 53(3)*: 478–490.

Why is the price response of perennial producers interesting to economists? –

Why do they model aggregate production (rather than individual)? –

Are there limitations to (or inaccuracies in) the conceptual framework? –

Are there limitations to (or inaccuracies in) the empirical modeling? –

Anything else of note? –

What Distinguishes Perennial and Annual Crop Production?

1. Long gestation period between initial input and first output.
2. Extended period of output flowing from the initial input.
3. Eventually a gradual deterioration of productivity.

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Annual plants have:

- A shorter initial gestation period (typically <3 months)
- A shorter output period (up to a few months)
- A fairly fast deterioration in productivity

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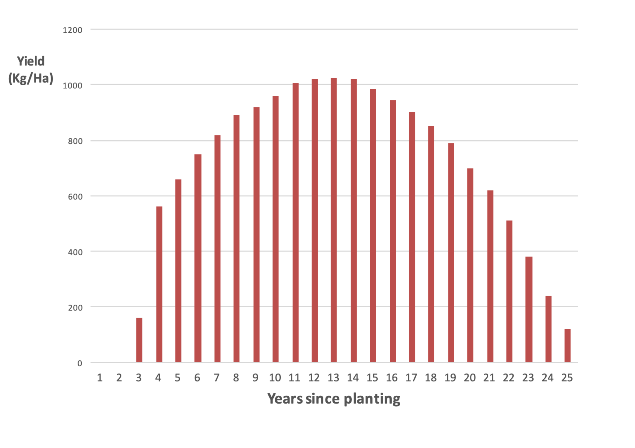
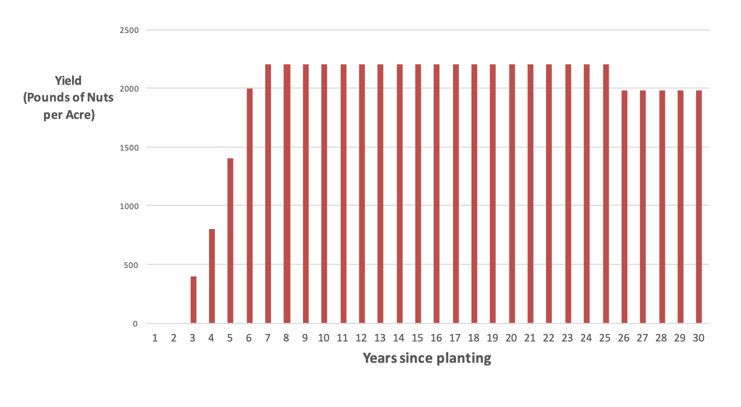
The durations of each of these stages differs by plant.

Cocoa in Ghana



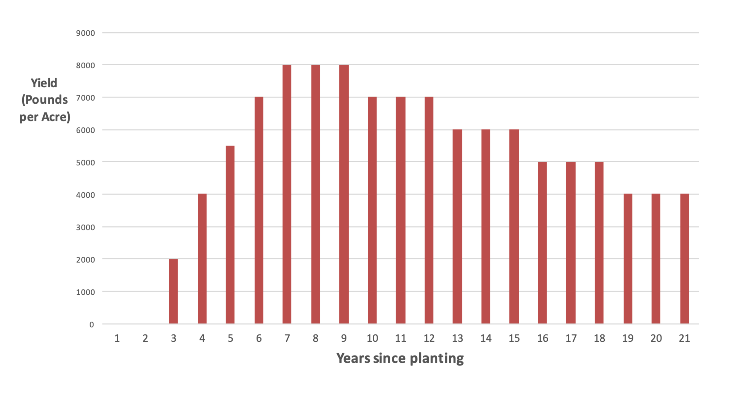
Mahrizal, Nalley, L. L., Dixon, B. L., & Popp, J. S. (2014). An optimal phased replanting approach for cocoa trees with application to Ghana. *Agricultural Economics, 45(3)*:291302. Source: Tregeagle & Simon (2018)

Almonds in California



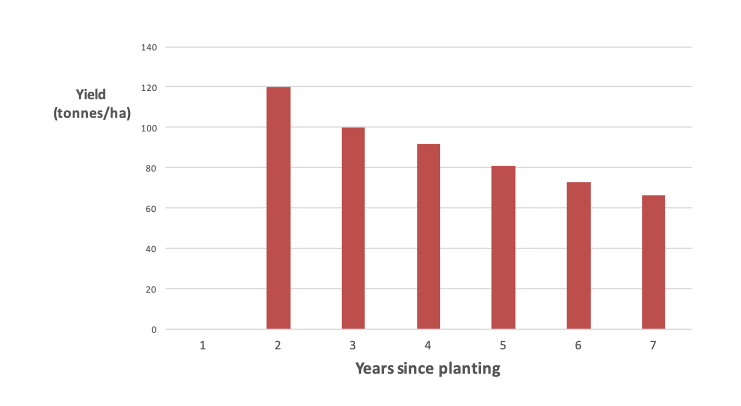
Klonsky, K., Livingston, P., & Tumber, K. (2016). Tree Loss Value Calculator - Almonds, Sacramento Valley. Source: Tregeagle & Simon (2018)

Blueberries in North Carolina



Safley, C.D., Cline, W.O., & Mainland, C.M. (2006). Evaluating the Profitability of Blueberry Production. Source: Tregeagle & Simon (2018)

Sugarcane in Brazil



Margarido, F. B. and Santos, F. (2012). Sugarcane Bioenergy, Sugar and Ethanol Technology and Prospects, Source: Tregeagle & Simon (2018)

What Distinguishes Perennial and Annual Crop Production?

1. Long gestation period between initial input and first output.
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The optimal timing of new plantings and removals will depend on the specific yield curve of the plant.

Note that for annuals there are no removal decisions, and costs associated with removal are included in costs for next planting.

Before we go into the perennial planting model in French & Matthews...

The Nerlove Model

> *"Nerlove's famous formulation of agricultural supply response is certainly one of the most successful econometric models introduced into the literature."*
>
> *(Braulke 1982)*

Nerlove, M. (1956), "Estimates of elasticities of supply of selected agricultural commodities," *Journal of Farm Economics 38*:496-509.

Nerlove, M. (1958c), The Dynamics of Supply: Estimation of Farmers' Response to Price (Johns Hopkins University Press, Baltimore, MD).

The Nerlove Model of Agricultural Supply

$$A_t - A_{t-1} = \gamma(A_t^* - A_{t-1})$$
$$P_t^* - P_{t-1}^* = \beta(P_{t-1} - P_{t-1}^*)$$
$$A_t^* = \alpha_0 + \alpha_1 P_t^* + \alpha_2 Z_t + U_t$$

Where A_t and A_t^* are actual and "desired" area under cultivation at time t,
P_t and P_t^* are actual and "expected" price per crop unit at time t,
Z_t are observed, presumably exogenous factors,
and U_t are unobserved "latent" factors

β and γ are "coefficients of expectation and adjustment" reflecting the responses of expectations to observed prices and observed areas under cultivation in equilibrium areas.

The Nerlove Model of Agricultural Supply – Issues

"The statistical problems of estimating a model such as (1)-(3), particularly of identifying relevant observed exogenous variables, not subject to expectational lags, and problems due to serially correlated disturbances, are well known. In addition, the use of area cultivated, one input in the production process to represent planned output, the problem of choosing the relevant price or prices, and other issues of specification, such as the inclusion of expected yields, weather conditions, and price and yield variances to take account of elements of risk, have been widely discussed in the literature (see, for example, inter alia [Just (1974), Askari and Cummings (1976, 1977)])."

(Nerlove & Bessler 2001)

The French & Bressler Model of Perennial Crop (Lemon) Production

$$\frac{N_t}{B_{t-1}} = b_0 + b_1 \pi^*_{t-1} + b_2 \frac{A_{t-1}}{B_{t-1}} + v_{t-1}$$

Where N_t is acres planted at time t,
B_{t-1} is bearing acres at time $t-1$,
π^*_{t-1} is long-run profit expectation at time $t-1$,
A_{t-1} is acres of bearing trees over an age that indicates likely removal (e.g., 25 years),
v_{t-1} accounts for the combined effect of other omitted variables

b_2 gives the effect of anticipated removals on the new plantings of trees.

π^*_{t-1} is approximated by $\frac{1}{5}\sum_{i=t-1}^{t-5} \pi_i$

The French & Bressler Model of Perennial Crop (Lemon) Production

$$\frac{R_t}{B_t} = a_0 + a_1\pi'_t + a_2\frac{A_t}{B_t} + \frac{K_t}{B_t} + u_{t-1}$$

Where R_t is acres removed at time t,
B_t is bearing acres at time t,
π'_t is short-run profit expectation at time t,
A_t is acres of bearing trees over an age that indicates likely removal (e.g., 25 years),
$\frac{K_t}{B_t}$ is acreage removed for urban expansion

a_2 gives the effect of anticipated removals on removals.

π'_{t-1} is approximated by current returns and $\frac{1}{5}\sum_{i=t-1}^{t-5}\pi_i$

$B_t = B_{t-1} + N_{t-5} - R_{t-1}$

Arak Overview

Arak, M. (1968). The price responsiveness of Sao Paulo coffee growers. Food Research Institute Studies 8, 211-223.

Contributions – what question(s) is the paper addressing? –

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The Arak Model

What is different about the Arak model of new plantings?

$$N_t^* = T_t^* - \sum_{-\infty}^{t-1} N_j$$

$$N_t = \gamma_1 D_t \left(T_t^* - \sum_{-\infty}^{t-1} N_j \right) + \gamma_2 \left(D_t - \lambda \right)$$

Where D_t is the percent of trees over ten years of age,
λ is a parameter representing the proportion of trees over 10 that indicate the tree stock is “relatively old”

The Arak Model

What parameter gives the price effect on new plantings?

$$T_t^* = a_0 + a_1 p_t \implies$$

$$N_t = c_0 + c_1 D_t + c_2(D_t p_t) + c_3(D_t \sum N_j)$$

Where

$$c_0 = -\gamma_2 \lambda$$

$$c_1 = \gamma_1 a_0 + \gamma_2 - \gamma_1 S_0$$

$$c_2 = \gamma_1 a_1$$

$$c_3 = -\gamma_1$$

The Arak Model

Removals – What are the two key roles of age in the plant removal decision?

Removals – how does age enter the removal decision model?

$$R_t^* = (d_0 + d_1 p_t + d_2 F_{t-1}) T_{t-1}^E$$

The Arak Model

Removals – What are the two key roles of age in the plant removal decision?

Removals – how does age enter the removal decision model?

$$R_t^* = (d_0 + d_1 p_t + d_2 F_{t-1}) T_{t-1}^E$$

Where T_{t-1}^e is the number of coffee trees in the age group for which the removal (rather than abandonment) is the rational alternative to the maintenance of the existing tree

F_{t-1} is an indicator for a frost occurrence

How to identify T_{t-1}^e?

The Arak Model

Abandonments – Why would coffee trees be abandoned rather than removed?

Abandonments – Is this relevant in the US (today)?

$$\frac{A_t}{T_{t-1}} = (b_1 + b_2 p_t)\frac{T^M_{t-1}}{T_{t-1}} + (b_3 + b_4 p_t)\frac{T^Y_{t-1}}{T_{t-1}} + b_0$$

The French & Matthews Model of Perennial Crop Production

What sets this model apart from prior work?

Are there any new variables in this model that were left out from prior work?

What framework does this model primarily pull from?

What are some key differences in the framework compared with others?

The French & Matthews Model of Perennial Crop Production

Desired Production and Acreage:

$$Q_t^* - Q_{t-1}^e = b_{11}(\pi_t^e - \pi_t^*) + b_{12}(\pi_{At}^e - \pi_{At}^*) + u_{1t}$$
$$A_t^* - A_{t-1} = b_{21}(\pi_t^e - \pi_t^*) + b_{22}(\pi_{At}^e - \pi_{At}^*) + b_{23}\Delta Y_t^e + u_{2t}$$

Where $Q_t^* =$ *desired* production,
$Q_{t-1}^e = Y_{t-1}^e A_{t-1} =$ *expected* average production,
$\pi_t^e =$ *expected* long-run profitability (per unit),
$\pi_t^* =$ normal long-run equilibrium profit (per unit),
$\pi_t^e =$ *expected* profitability per unit of product for the alternative land use,
$\pi_t^* =$ normal profitability per unit of product for the alternative land use,
$\Delta Y_t^e = Y_t^e - Y_{t-1}^e =$ change in expected yields,
u_{1t}, $u_{2t} =$ disturbance terms

The French & Matthews Model of Perennial Crop Production

Desired New Plantings:

$$N_t^* = A_{t+k}^* - A_{t-1} + R_{kt}^e - N_{kt-1}$$

Where $N_t^* =$ *desired* acreage of new plantings desired by growers in year t,
$k =$ the interval of time in years between initial planting and bearing,
$R_{kt}^e =$ *expected* removals during the next k years,
$N_{kt-1} = \sum_{i=1}^{k} N_{t-1} =$ nonbearing but planted acreage, i.e., total acreage planted after year $t - k - 1$

Actual New Plantings:

$$N_t = \alpha N_t^* + \beta(1 - \alpha)N_{t-1} + e_t$$

The French & Matthews Model of Perennial Crop Production

Plug A_t^* and R_{kt}^e into N_t^* into N_t with $\beta = 0$ to arrive at...

Actual New Plantings:

$$N_t = b_{51}(\pi_t^e - \pi_t^*) + b_{52}(\pi_{At}^e - \pi_{At}^*) + b_{53}\Delta Y_t^e + b_{54}A_{t-1}^0 + b_{55}N_{kt-1} + b_{56}A_{t-1} + u_{5t}$$

Actual Removals:

$$R_t = b_{60} + b_{61}A_t^0 + b_{62}A_t^0(\pi_t^s - \pi_t^*) + b_{63}A_t^0(\pi_{At}^s - \pi_{At}^*) + b_{64}Z_t + b_{65}A_t + u_{6t}$$

Where R_t = acreage removed at the end of year t ,
A_t^0 = Acreage over a particular age (after which productivity declines),
π^s = short-run profit expectations,
Z_t = variable to account for institutional or physical factors of importance

The French & Matthews Model of Perennial Crop Production

Total Change in Acreage:

$$A_t - A_{t-1} = (1 - b_3 2)N_{t-k} - R_{t-k} + v_{1t}$$

Plug N_t and R_t^e into N_t^* to arrive at...

$$\begin{aligned} A_t - A_{t-1} = \; & b_{70} + b_{71}(\pi^e_{t-k} - \pi^*_{t-k}) + b_{72}(\pi^e_{At} - \pi^*_{At}) + b_{73}\Delta Y^e_{t-k} \\ & + b_{74}A^0_{t-k-1} + b_{75}A^0_{t-1} + b_{76}A^0_{t-1}(\pi^s_t - \pi^*_t) + b_{77}A^0_{t-1}(\pi^s_{At} - \pi^*_{At}) \\ & + b_{78}Z_{t-1} + b_{79}N_{kt-k-1} + b_{710}A_{t-k-1} + b_{711}A_{t-1} + u_{7t} \end{aligned}$$

The French & Matthews Model of Perennial Crop Production

Then make a bunch of assumptions and simplifications to generate measures of actual (rather than expected or desired) variables.

Then estimate the models with **what simplifications**?

What is the final estimating equation?

Assignments for Next Time

Advanced Producer Theory and Analysis I: Perennials

1. Wickens, M.R. & Greenfield, J.N. (1973). The Econometrics of Agricultural Supply: An Application to the World Coffee Market. *The Review of Economics and Statistics, 55(4)*: 433–440. `https://www.jstor.org/stable/1925665`
2. Akiyama, T. & Trivedi, P.K. (1987). Vintage Production Approach to Perennial Crop Supply: An Application to Tea in Major Producing Countries. *Journal of Econometrics, 36*: 133–161. `http://www.sciencedirect.com/science/article/pii/0304-4076(87)90047-9`
3. Devadoss, S. & Luckstead, J. (2010). An Analysis of Apple Supply Response. *International Journal of Production Economics, 124*: 265–271. `https://www.sciencedirect.com/science/article/abs/pii/S0925527309004277`
4. Gotsch, N. & Wohlgenant, M.K. (2000). A Welfare Analysis of Biological Technical Change under Different Supply Shift Assumptions: The Case of Cocoa in Malaysia. *Canadian Journal of Agricultural Economics, 49*: 87–104. `https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1744-7976.2001.tb00292.x`