AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

A Dynamic Regional Model of Irrigated Perennial Production

Brad Franklin (UC Riverside) bfran001@ucr.edu
Keith Knapp (UC Riverside) keith.knapp@ucr.edu
Kurt Schwabe (UC Riverside) kurt.schwabe@ucr.edu

Poster prepared for presentation at the Agricultural & Applied Economics Association's 2012 AAEA Meeting, Seattle, Washington, August 12-14, 2012.

Copyright 2012 by Franklin, et al. All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.

A Dynamic Regional Model of Irrigated Perennial Production

Brad Franklin, Keith Knapp, Kurt Schwabe

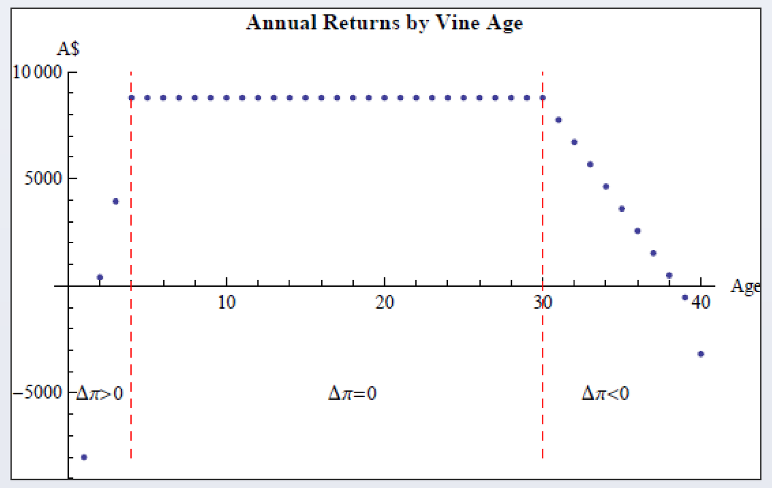
UC RIVERSIDE

AAEA Annual Meeting. August 12-14, 2012. Seattle.

Introduction

Perennial Crops as Dynamic Investment

Perennial crops are typically long-lived with commercially viable lifespans of 30 years or more. There are large fixed costs from new plantings and removals and it usually takes a number of years to reach maturity. During crop establishment there may be several years with no marketable yields. The productivity of the crop depends on the history of previous input use and exogenous factors such as weather shocks. Below is a stylized depiction of annual returns to wine grape production in South Australia assuming constant prices.



Research Question

Perennials crops are dynamic but the agricultural production programming literature is basically static.

Perennials are very important in some regions and are often irrigation-dependent. For example, they constitute roughly 1/3 of the total crop value in California.

For water scarce regions, we need a more robust model to understand agricultural water demand and perennial and annual supply response to water variability.

Goal: Vintage capital model for policy analysis.

Policy Context

Riverland region, South Australia

2/3 Irrigated area in perennials (Wine grapes)

Market power in fresh potatoes

Murray-Darling Basin river flows are highly variable

Millennium drought (1997 -2009)

Policy Questions

How will proposed water purchases by the environmental water holder (up to 25% of total rights) affect irrigated agriculture?

Model Description

Representative farming household

1 annual, 1 perennial crop

Demand curve for annuals

Land and water constrained

Joint consumption, investment decisions

Dynamic Optimization

Running Horizon algorithm approximation to infinite horizon DP

Vintage structure

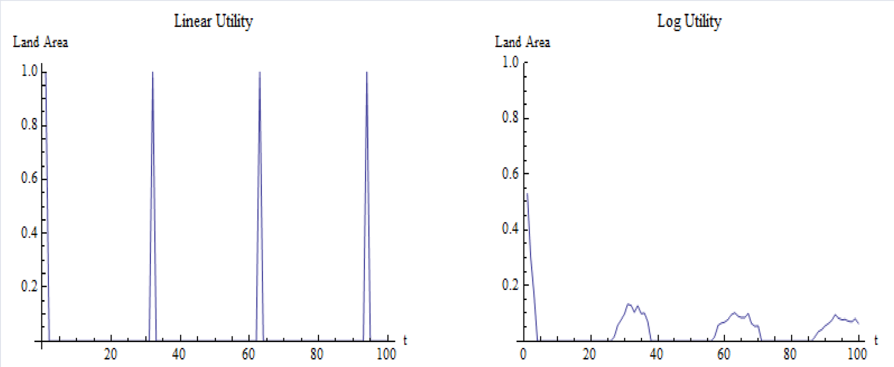
Initial age distribution of perennial crop

Utility function specified

Model Scenarios

	Land Binding	Water Binding
With Annuals	Assets	Assets
	No Assets	No Assets
No Annuals	Assets	Assets
	Mitra et al.	No Assets

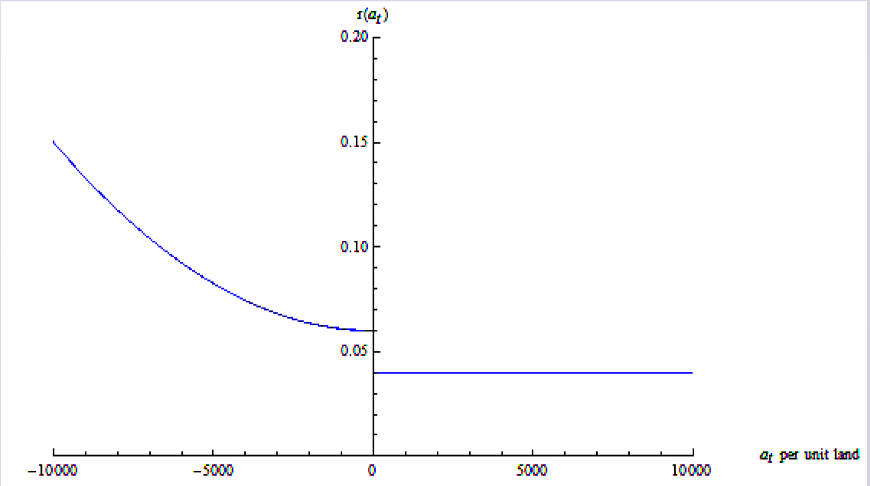
Validating the model against Mitra et al. (1991) for the case of only perennial production, no household assets, and land is the constrained resource.



The above shows that results found by Mitra et al. hold here. For linear utility, there is no convergence to a steady-state. For strictly concave utility, the program eventually converges to a steady-state with equal land area devoted to each age class.

Borrowing and Saving

- Borrowing rate > Savings rate
- Interest rate increases with debt held
- Schedule exogenous



Mathematical Description

Table 1: **Variable Dictionary**

Symbol	Description
a	Household Assets
c	Consumption
γ	Cost term
k	Age index ($k = 0, ..., 40$)
p	Output price
π	Profit term
$\bar{q}$	Total regional water
$r(a)$	Interest rate
s_k	Perennial area for age class k
w	Water required per unit land
x	Annual crop area
y	Yield
z_k	Removals of age class k

Objective function and related equations

$$\max_{c_t, s_{0,t}, x_t, z_{k,t}} \sum_{t=1}^{\infty} \alpha^{t-1} U(c_t)$$

$$c_t = (1 + r(a_t))a_t - a_{t+1} + \pi_t$$

$$\pi_t = \pi_{0,t} + \pi_{s,t} + \pi_{x,t}$$

$$\pi_{0,t} = -(\gamma_w w_0 + \gamma_0) s_{0,t}$$

$$\pi_{s,t} = \sum_{k=1}^{K} ((p_s y_k - \gamma_w w_k - \gamma_k)(s_{k,t} - z_{k,t}) - \gamma_z z_{k,t})$$

$$\pi_{x,t} = (p_x(x_t) y_x - \gamma_w w_x - \gamma_x) x_t$$

Constraints and Laws of Motion

$$s_{k+1,t+1} = s_{k,t} - z_{k,t}$$ Perennials LOM

$$a_{t+1} = (1 + r(a_t))a_t + \pi_t - c_t$$ Asset LOM

$$s_{k+1,t+1} \leq s_{k,t}$$ Cross-Vintage Constraint

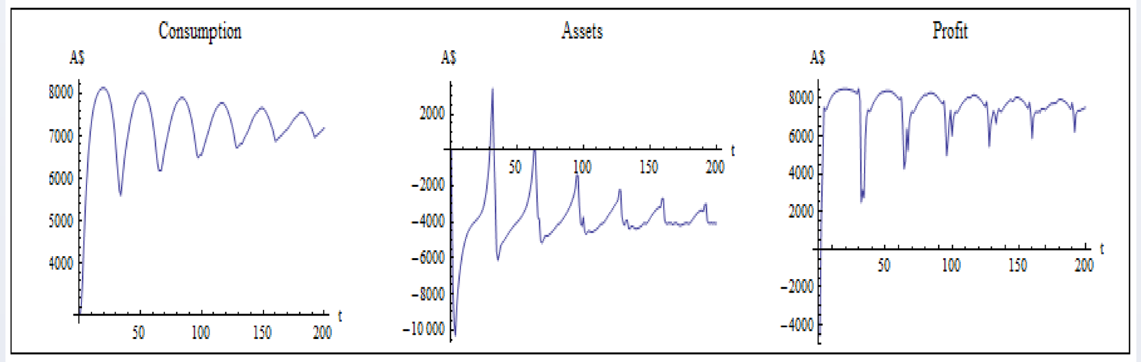
$$\sum_{k=0}^{K} (s_{k,t} - z_{k,t}) + x_t \leq 1 \ \forall t$$ Land Constraint

$$\sum_{k=0}^{K} w_k (s_{k,t} - z_{k,t}) + w_x x_t \leq \bar{q}$$ Water Constraint

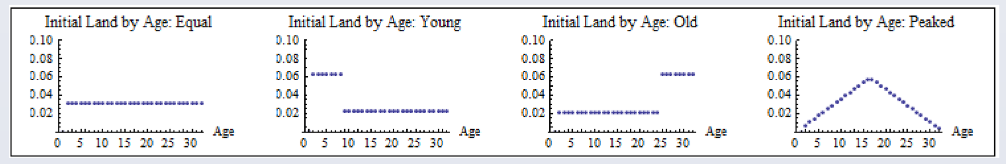
$$a_t + \sum_{n=1}^{K} \frac{\pi_{s,t+n}}{(1 + r(a_{t+n}))^n} \geq 0$$ No-Ponzi-Game

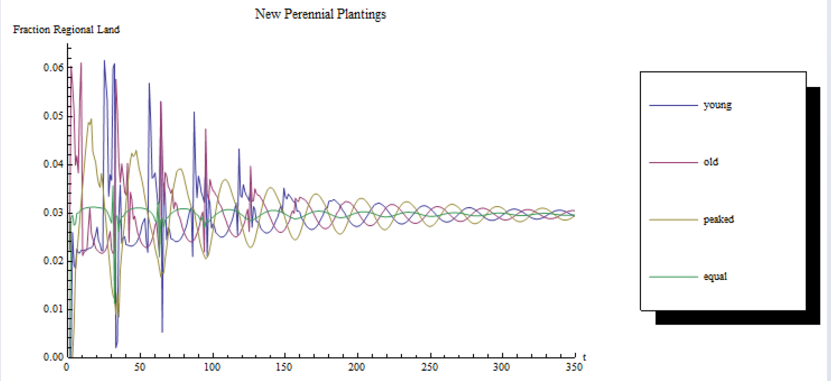
Results

The below shows selected results from a run of the full model. The household starts with no perennials and no financial assets and borrows a large amount initially to establish the perennial crop. As the crop matures, profit increase, allowing the household to increase consumption and accumulate savings. At the optimal removal age, the cycle begins anew. Log utility causes consumption smoothing over time and eventual convergence to steady-state land distribution. Also, a relatively high discount rate implies that it is optimal for the household to hold debt.



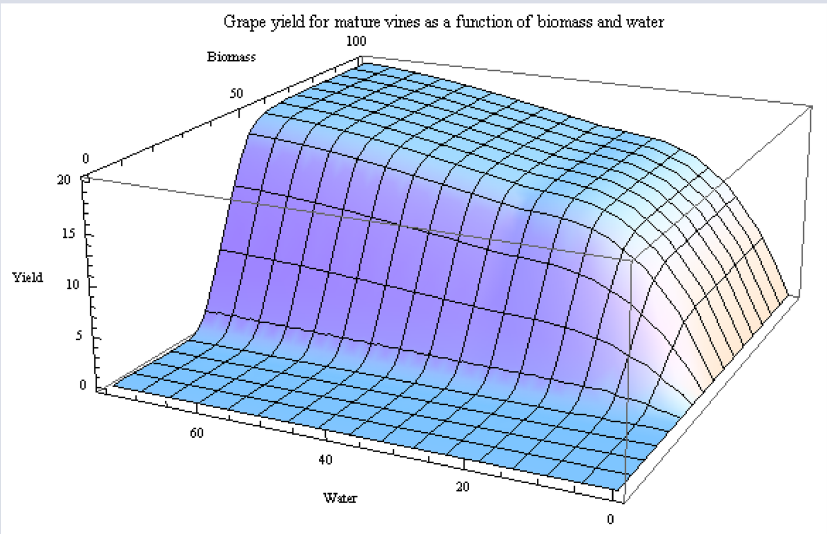
As in the simplest version of the model, the initial age distribution of perennial land use does not affect model convergence to steady-state using concave utility function. However, time to convergence to the steady-state increases with more unequal initial land distribution. Note that age-yield relationship determines optimal removal age (32 years old).





Extensions

One obvious extension to the model is to allow for deficit irrigation. Using a field-level DP model, the plot below shows grape yield as a function of current period water application and biomass index, which encapsulates water history of the crop. The dynamics implied by this model can be summarized and included in the regional model for each age class in production.



References

Mitra, Tapan, Ray, Debraj and Roy, Rahul, (1991), The economics of orchards: An exercise in point-input, flow-output capital theory, *Journal of Economic Theory*, 53, issue 1, p. 12-50.

Contact Information

Corresponding author:

Brad Franklin, Ph.D. Candidate

Department of Economics, UC Riverside

bfran001@ucr.edu

www.PosterPresentations.com