Comparison of Production Risks in State-Contingent Framework: Application to Balanced Panel Data Set

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Introduction

In the absence of complete insurance markets, producers bear risks under uncertainty. The extent of optimal production risks depends on the production technology, nature of state contingency, and producer's attitudes toward risks. In economic theory, the state-contingent (SC) representation of uncertainty allows a general treatment of production decisions under uncertainty through the interactions between a feasible production set and risk preferences of the producer (Chambers and Quiggin, 2000). This study develops an empirical methodology to adopt this general framework for analyzing production risks from balanced panel data on production decisions. The current application compares the stochastic technologies of confinement and grazing dairy systems in Maryland.

Uncertainty Representations: SC v.s. OS Frameworks

A). State-Contingent (SC) Framework

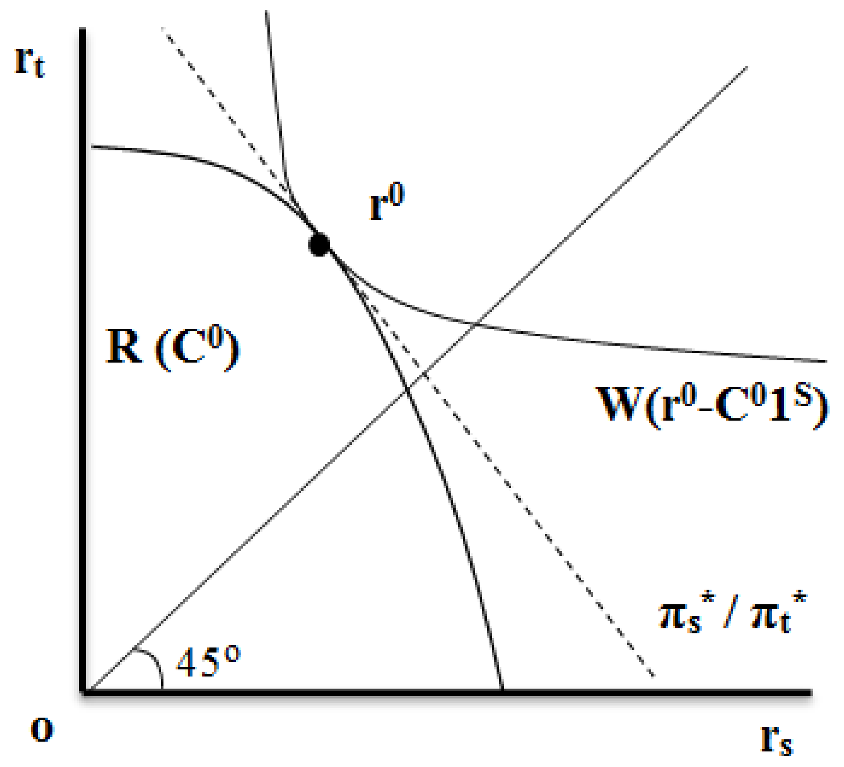
- States of nature $\Omega = \{1, .., S\}$ with state probabilities $\{\pi_1, .., \pi_S\}$
- Portfolio of state-contingent incomes $\mathbf{y} \in \Re^S$ chosen by a producer;

$$\max_{\mathbf{y}} \{W(\mathbf{y}) : \mathbf{y} = \mathbf{r} - C(\mathbf{r})\mathbf{1}^S\}$$

for risk preferences $W : \Re^S \rightarrow \Re$ and cost function $C : \Re^S_+ \rightarrow \Re$

Optimal Portfolio Choice (Pictured)

- Indifference Curve $W(\mathbf{r}^0 - C^0\mathbf{1}^S)$
- Iso-cost SC Revenue Feasibility $\mathbf{R}(C^0) = \{\mathbf{r}' \in \Re^S : C(\mathbf{r}') \leq C^0\}$
- Optimal SC revenues: $\mathbf{r}^0$
- Risk-neutral probability (shadow values of states): $\boldsymbol{\pi}^*$



B). Outcome-State (OS) Framework

- States defined by the distribution of potential outcomes $\mathbf{y} \in \Re^S$
- Portfolio of state-contingent incomes $\mathbf{y} \in \Re^S$ given to a producer
- Special case of SC framework under no technological substitutability

Empirical Setup for SC Framework

Goal

- Comparing riskiness of two or more stochastic technologies

Empirical Difficulties

- Defining empirical states of nature
- Handling unobserved/omitted states of nature

Proposed DEA-like Nonparametric Technology Estimation

- Consistent estimation under omitted states
- Efficiency measured in the direction of observed states

Key Assumptions on Balanced Panel Data

- Stationarity of state contingency, technology, risk preferences
  - Identical optimal decisions on SC portfolios across time periods
- Cross-sectionally identical state realizations
  - e.g. Market and weather shocks shared across producers

which allow us to;

- View panel data on *ex post* outcomes as cross-sectional *ex ante* SC portfolios
- Estimate technical feasibilities of SC portfolios
- Simulate optimal production risks under assumed risk structures

Value-added Input-Output Specification

- Modeling for the feasibility of SC portfolios $Y(\mathbf{x}^f; \Omega) \subset \Re^S$ for given short-term fixed inputs $\mathbf{x}^f$
- No direct modeling for SC revenues and short-term variable inputs

Data

Schedule F farm tax form, with additional variables

- 63 farms in MD, PA over a 1995-2009 period
  - Itemized sales and expenses
  - Acreage, farm characteristics
- Two dairy systems: confinement, grazing
- Details in Hanson et al. (J. of Dairy Sc., 2013)

Sample Means in 2006-2009 Balanced Panel

	Profit ($1k)		Milk (1k cwt)		M.Price ($)	
Year	Conf.	Graz.	Conf.	Graz.	Conf.	Graz.
2006	55.0	49.8	30.1	13.3	15.1	17.5
2007	108.0	65.9	31.9	13.0	21.1	22.9
2008	84.2	66.7	32.3	12.9	20.1	23.0
2009	32.8	52.2	32.0	13.5	13.9	18.9
Avg.	70.0	58.7	31.6	13.2	17.6	20.6

Milk price/cwt: the average received by these farmers. 17 confinement dairies, 11 grazers.

Value-Added State-Contingent Technology Estimation

DEA-like Technical Feasibility for multi-output, multi-input technologies

- $\widehat{\Omega}$: T(=4) empirical "states" corresponding to years 2006-2009
- $y_{i,s}$: profit for farm $i = 1, .., N$, year/state $s = 1, .., T$
- $\mathbf{x}^f$: fixed inputs (i.e. cow, acre), constant returns to scale

$$\widehat{Y}(\mathbf{x}_0^f; \widehat{\Omega}) = \{\mathbf{y}' \in \Re^T : \sum_i \lambda_i \mathbf{x}_i^f \leq \mathbf{x}_0^f, \ \forall s \in \widehat{\Omega}, \ \sum_i \lambda_i y_{i,s} \geq y_s', \ \boldsymbol{\lambda} \in \Re^N_+\}$$

SC technical efficiency estimates

- Conf.: mean 0.714 (s.d. 0.342), Graz.: mean 0.937 (s.d. 0.208)

Optimal Risks 1: Maxmin & Risk Neutral Preferences

- Maxmin: the most risk-averse
- Risk neutral: the least risk-averse

Simulated Optimal Profit Levels ($1k)

Inputs		Risk-Neutral			
(100-cow)	Maxmin	P-1	P-2	P-3	P-4
Confinement					
(1) 100-acre	36	57	66	57	57
(2) 200-acre	59	89	104	90	90
(3) 300-acre	62	89	106	90	90
Grazers					
(4) 100-acre	45	51	49	52	52
(5) 200-acre	88	97	93	99	99
(6) 300-acre	88	97	93	99	99

States (years) labeled as "good" or "bad" state

- Based on milk and feed price fluctuations
- Good {2007, 2008}, Bad {2006, 2009}

Scenarios (P-1 to P-4) of probabilities for states $\{2006, 2007, 2008, 2009\}$

- P-1 (equal): {0.25,0.25,0.25,0.25}
- P-2 (optimistic): {0.15,0.35,0.35,0.15}
- P-3 (pessimistic): {0.35,0.15,0.15,0.35}
- P-4 (risky): {0.35,0.15,0.35,0.15}

Optimal Risks 2: Linear Mean-MAD Preferences

Risk-averse utility structure based on mean and riskiness components

- mean (μ), mean absolute deviation (MAD: ϕ) of profits ($1k)
- Linear case under $\mu - k\phi$ for some constant k

Optimal decisions at fixed inputs of 100-cow, 200-acre

	P-1			P-2			P-3			P-4		
	$\mu - k\phi$	μ	ϕ	$\mu - k\phi$	μ	ϕ	$\mu - k\phi$	μ	ϕ	$\mu - k\phi$	μ	ϕ
I. k=0.5												
(1) Conf.	71	84	26*	88	104	32*	75	89	28*	75	89	28*
(2) Graz.	91	97	12	89	93	7	92	99	15	92	99	15
II. k=1												
(3) Conf.	60	62	2*	73	102	29*	66	78	12*	66	78	12*
(4) Graz.	88	89	1	88	88	0	88	88	0	88	88	0
III. k=2												
(5) Conf.	59	59	0	60	62	1†	60	62	1†	60	62	1†
(6) Graz.	88	88	0	88	88	0	88	88	0	88	88	0

Stat. significance between confinement and grazing operations: * $\alpha = 0.01$, † $\alpha = 0.05$.

Conclusions

- Production risks can be analyzed in SC framework with panel data
- SC and OS frameworks can lead to different implications
- MD dairy producers attain similar utility levels between confinement and grazing systems while optimal portfolios and associated riskiness may differ across these systems

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