

Explaining Differences in Farmland Values based on Quality of Land: A Cointegration Analysis of Indiana Farmland Values

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Introduction

- Farmland values have been a persistent topic of research in agricultural economics since the inception of the discipline.
- Farmland values dominate the agricultural balance sheet. Currently farmland values account for over 80 percent of agricultural asset values.
 - Farmer wealth and the solvency of the agricultural sector are largely subject to factors affecting farmland values.
 - The single-industry nature of the demand for farmland may also contribute to period boom/bust cycles observed in farmland prices (Schmitz 1995).

Purpose

- In our analysis the price for different qualities of farmland we estimate cointegrating relationships.
- This approach tests whether linear vectors explain a equilibrium between the different prices.

Empirical Model

- As a starting point, consider the stylized model of farmland values:

$$V_t^i = \frac{R_t^i}{r_t}, \quad (1)$$

where i represents the cases examined.

- In log-linear form we have:

$$\begin{aligned} \ln(V_t^H) &= \beta_{01} + \beta_{11}\ln(R_t^H) + \beta_{21}\ln(r_t) + \epsilon_t^H \\ \ln(V_t^A) &= \beta_{02} + \beta_{12}\ln(R_t^A) + \beta_{22}\ln(r_t) + \epsilon_t^A \\ \ln(V_t^L) &= \beta_{03} + \beta_{13}\ln(R_t^L) + \beta_{23}\ln(r_t) + \epsilon_t^L. \end{aligned} \quad (2)$$

Cointegration Analysis

- We start by computing the potential cointegration relationship for each time process (Johansen and Juselius, 1990)

$$x_t = \Gamma_1 x_{t-1} + \Gamma_2 x_{t-2} + \dots + \Gamma_p x_{t-p} + \epsilon_t, \quad (3)$$

$$\Delta x_t = \Pi x_{t-1} + \sum_{r=1}^{p-1} \Gamma_r \Delta x_{t-1} + \epsilon_t. \quad (4)$$

- Determine potential cointegration relationship among different qualities of farmland

$$\begin{bmatrix} \Delta \ln(V_{H,t}) \\ \Delta \ln(V_{M,t}) \\ \Delta \ln(V_{L,t}) \\ \Delta \ln(r_t) \end{bmatrix} = \mathbf{c} + \Pi \begin{bmatrix} \ln(V_{H,t-1}) \\ \ln(V_{M,t-1}) \\ \ln(V_{L,t-1}) \\ \ln(r_{t-1}) \end{bmatrix} + \sum_{r=1}^p \Gamma_r \begin{bmatrix} \Delta \ln(V_{H,t-r}) \\ \Delta \ln(V_{M,t-r}) \\ \Delta \ln(V_{L,t-r}) \\ \Delta \ln(r_{t-r}) \end{bmatrix} + \epsilon_t \quad (5)$$

Testing for Stationarity (Augmented Dickey Fuller)

- We test for non-stationarity and determine the order of integration
 $\Rightarrow$ the individual time process are integrated of order 1 (i.e. $x_t \sim I(1)$)

Variables	Levels	Differenced
Farmland Quality:		
$\ln(V_t^H)$	0.789	-4.379***
$\ln(V_t^A)$	1.083	-3.337**
$\ln(V_t^L)$	1.131	-3.217**
Returns to farmland:		
$\ln(R_t^H)$	0.924	-4.551***
$\ln(R_t^A)$	0.730	-4.437***
$\ln(R_t^L)$	-0.462	-6.586***
Interest rates:		
$\ln(aaa_{rate})$	-0.042	-4.407***
$\ln(farm_{rate})$	-1.095	-3.076**

Note: (*), (**), and (***) denote variables significant at 10%, 5%, and 1% level of confidence, respectively.

Cointegration rank

- Based on test-statistics (trace and maximum eigenvalue) we conclude that individual time processes have a single cointegration vector

High Quality Land			Critical values	
Null	Alternative	Statistic	5%	1%
aaa bond rate:		<u>trace</u>		
$r=0$	$R \geq 1$	36.216	24.31	29.75
$r=1$	$R \geq 2$	10.098 ^{*1,*5}	12.53	16.31
		<u>max λ</u>		
$r=0$	$R \geq 1$	26.118	17.89	22.99
$r=1$	$R \geq 2$	7.368 ^{*1,*5}	11.44	15.69
farm-specific rate:		<u>trace</u>		
$r=0$	$R \geq 1$	25.179 ^{*1}	24.31	29.75
$r=1$	$R \geq 2$	5.717 ^{*5}	12.53	16.31
		<u>max λ</u>		
$r=0$	$R \geq 1$	19.462	17.89	22.99
$r=1$	$R \geq 2$	4.863 ^{*1,*5}	11.44	15.69

Cointegration rank (cont.)

Average Quality Land			Critical values	
Null	Alternative	Statistic	5%	1%
aaa bond rate:		<u>trace</u>		
$r=0$	$R \geq 1$	27.165 ^{*1}	24.31	29.75
$r=1$	$R \geq 2$	7.410 ^{*5}	12.53	16.31
		<u>max λ</u>		
$r=0$	$R \geq 1$	19.755	17.89	22.99
$r=1$	$R \geq 2$	4.921 ^{*1,*5}	11.44	15.69
farm-specific rate:		<u>trace</u>		
$r=0$	$R \geq 1$	27.563 ^{*1}	24.31	29.75
$r=1$	$R \geq 2$	4.5611 ^{*5}	12.53	16.31
		<u>max λ</u>		
$r=0$	$R \geq 1$	23.002	17.89	22.99
$r=1$	$R \geq 2$	3.418 ^{*1,*5}	11.44	15.69

Cointegration rank (cont.)

Low Quality Land			Critical values	
Null	Alternative	Statistic	5%	1%
aaa bond rate:		<u>trace</u>		
$r=0$	$R \geq 1$	32.962	24.31	29.75
$r=1$	$R \geq 2$	9.021 ^{*1,*5}	12.53	16.31
		<u>max λ</u>		
$r=0$	$R \geq 1$	23.941	17.89	22.99
$r=1$	$R \geq 2$	6.593 ^{*1,*5}	11.44	15.69
farm-specific rate:		<u>trace</u>		
$r=0$	$R \geq 1$	30.9539	24.31	29.75
$r=1$	$R \geq 2$	4.8459 ^{*1,*5}	12.53	16.31
		<u>max λ</u>		
$r=0$	$R \geq 1$	26.108	17.89	22.99
$r=1$	$R \geq 2$	3.192 ^{*1,*5}	11.44	15.69

VEC model results

- We fit an error-correction model for each cointegration relationship.

Parameter estimates VEC model for high quality land

	<u>Cointegration vector</u>		<u>Adjustment parameters</u>		
	$\ln(\text{rental rate}_t)$	$\ln(\text{interest}_t)$	α_V	α_R	α_r
Case 1:					
aaa-rate	-0.848 (0.133)	1.501 (0.259)	-0.259 (0.048)	-0.102 (0.029)	0.044 (0.057)
Case 2:					
farm-specific	-0.821 (0.152)	1.46 (0.289)	-0.259 (0.083)	-0.031 (0.046)	-0.177 (0.072)

VEC model results (cont.)

Parameter estimates VEC model for average quality land

	<u>Cointegration vector</u>		<u>Adjustment parameters</u>		
	$\ln(\text{rental rate}_t)$	$\ln(\text{interest}_t)$	α_V	α_R	α_r
Case 1:					
aaa-rate	-0.38 (0.268)	2.369 (0.500)	-0.132 (0.032)	-0.060 (0.022)	0.050 (0.045)
Case 2:					
farm-specific	-0.551 (0.190)	1.939 (0.3443)	-0.123 (0.050)	-0.013 (0.033)	-0.166 (0.055)

VEC model results (cont.)

Parameter estimates VEC model for low quality land

		<u>Cointegration vector</u>		<u>Adjustment parameters</u>		
		$\ln(\text{rental rate}_t)$	$\ln(\text{interest}_t)$	α_V	α_R	α_r
Case 1:						
aaa-rate		6.369	14.376	-0.028	-0.008	-0.0007
		(1.507)	(2.657)	(0.005)	(0.006)	(0.007)
Case 2:						
farm-specific		0.406	3.505	-0.093	-0.019	-0.107
		(0.33)	(0.58)	(0.034)	(0.022)	(0.031)

Conclusions – Discussion

- Consistent with previous results:
 - Farmland values and returns tend to be non-stationary.
 - Interest rates are marginally non-stationary.
- The results for high and average quality land are consistent with the valuation model while the results for low quality land is not consistent.
 - The signs of the cointegrating vector are correct ($-\ln(\text{Rental Rate}) + \ln(\text{interest rate})$).
 - There are discrepancies with the magnitude (-1 and 1).
 - The signs are inconsistent for low quality land ($+\ln(\text{Rental Rate}) + \ln(\text{interest rate})$).
- The inconsistency in the low quality land equation means that the land values for different qualities do not move together.