Using Land Values to Predict Future Farm Income

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Background

  The value of an asset should be equal to the discounted future cash flows generated by that asset. Research in agricultural finance has attempted to explain agricultural land prices based on the simultaneous movement of land prices and another measure of cash flow (usually land rents or income per acre including crop sales, other revenues and government payments). Some increasingly sophisticated models have attempted to integrate spatial correlation to account for the possibility of future development of agricultural lands.

  Featherstone and Baker identified land price bubbles in their model. In the paper the model defines real asset values based on *lagged* returns and previous asset values (1987). That is they are using previous cash flows to explain today's asset value. This formulation is directly counter to the efficient market hypothesis.

  Indeed, accounting research has shown that Price-to-Earnings (P/E) ratios can predict future earnings as reported in GAAP based accounting statements. This model reflects that some information regarding companies' operating performance becomes public and is incorporated into stock prices months before the officially audited financial statements required by the SEC. Thus, the model uses current P/E ratios to explain future cash flows.

Objectives

  The goal of this paper is to understand the relationship between current land prices and future returns to agricultural assets. With the understanding that purchasers of agricultural land are best suited to determining the expected returns, this analysis should identify the extent to which purchasers are correct in their expectations. In addition, it might help to uncover some of the inconsistencies between land values and the discounted cash flows that have existed in the literature.

It is expected that the price of land will be a good predictor of future returns to agricultural land. This assumes that buyers of agricultural land are building their future expectations into prices paid rather than simply using historical returns as a guide for pricing. There might be some limitations to the estimates as the model is based on annual data. The accounting research uses quarterly or monthly data on stock returns for their models, which may provide more robust results.

Literature Review

The accounting literature has provided evidence that a firm's stock price tends to lead accounting earnings (Ou and Penman). The consensus suggests that information embedded in the stock price has already realized much of the information reported in quarterly accounting statement. Operating performance is revealed as it occurs to market participants with information regarding the firm. The information is accordingly built into the price of the stock, even in the absence of audited financial statements. Market participants may revise the stock price if the audited statements reveal inconsistencies in the performance. Evidence exists that market participants are knowledge of operating performance before audited statements are released, as participants often release guidance reports before the date of release.

Data and Methods

Following Schmitz (1995), the economic relationship we seek to model is

$$\triangle \ln(E_t[CF_t]) = \triangle \ln\left[V_t\left(\frac{r_t}{1+r_t}\right)\right]$$

in which in which $E_t[CF_t]$ represents the expected return on farmland in period t given information at the beginning of period t, $\triangle \ln V_t = (\ln V_t - \ln V_{t-1})$ signifies the observed change in logarithmic farmland values, and r_t is the discount rate for the farm sector in period t.

We model the influence of farmland values on expected returns using an ordinary least squares estimator (OLS), a restricted least squares estimator (RLS), and a restricted generalized method of moment (RGMM) estimator.

Letting $y_t = \Delta\, ln(E_t[CF_t])$, and $x_t = \Delta\, ln\left[V_t\left(\frac{r_t}{1+r_t}\right)\right]$, the OLS estimator is a finite distributed lag model in which expected returns are a function of the current change in farmland values and three prior changes in farmland values, or $y_t = f(\,x_t,\ x_{t-1},\ x_{t-2},\ x_{t-3}) + e_t$.

The statistical model with n=3 lags becomes

$$y_t = \delta + \beta_0 x_t + \beta_1 x_{t-1} + \beta_2 x_{t-2} + \beta_3 x_{t-3} + e_t \qquad\qquad e_t \sim (0, \sigma^2)$$

where x_t is the change in the value of land at time t, x_{t-1} is the change in the value of land at time t-1, etc., T-n vector of ones, δ denotes the intercept, and β_i are the distributed lag weights.

It is likely that decision makers consider only a finite number of previous changes in land values when formulating their expectations of returns to farmland. Following the method developed by Almon (1965), we approximate the true lag structure by a second order polynomial. Our RLS is thus a finite polynomial distributed lag model where we restrict the estimated coefficients to lie along a second degree polynomial:

$$\beta = \beta_i = \begin{bmatrix}\beta_0\\\beta_1\\\beta_2\\\beta_3\end{bmatrix} = \alpha_0 + \alpha_1 i + \alpha_2 i^2 = \begin{bmatrix}1 & 0 & 0\\1 & 1 & 1\\1 & 2 & 4\\1 & 3 & 9\end{bmatrix}\begin{bmatrix}\alpha_0\\\alpha_1\\\alpha_2\end{bmatrix} = H\alpha \quad .$$

If we let

$y = \delta + \beta_i x_{t-n} + e = Z\alpha + e$, where $Z = [x_1\ X_s H]$, and $\alpha = \begin{bmatrix}\delta\\\alpha_s\end{bmatrix}$, and s denotes explanatory parameters, then we estimate first estimate

$$\hat{\alpha} = \begin{bmatrix}\hat{\delta}\\\hat{\alpha}_s\end{bmatrix} = (Z'Z)^{-1}Z'y,$$

and recover the restricted least squares estimates using $\hat{\beta}_s = H\hat{\alpha}_s$.

The estimated error variance σ^2 is obtained using

$\hat{\sigma}^2 = \frac{(y-Z\hat{a})'(y-Z\hat{a})}{T-n-q-2}$ and $c\hat{o}v(\hat{a}) = \hat{\sigma}^2(Z'Z)^{-1}$. Finally,

$c\hat{o}v(\hat{\beta}_s) = Hc\hat{o}v(\hat{a}_s)H'$.

      The OLS and RLS estimators are biased and inefficient if any explanatory variable

correlates to the model's error term. To circumvent distributional assumptions, we employ the

use of GMM and instrumental variables to recoup the population moments.

      For our GMM estimator we set $\beta_4 = 0$, to eliminate the influence of lags beyond three

periods,

$\beta_4 = \alpha_0 + \alpha_1 4 + \alpha_2 4^2 = 0$.

This also reduces the number of estimated parameters by one since

$\beta_i = -\alpha_1 4 - \alpha_2 4^2 + \alpha_1 i + \alpha_2 i^2$.

Having made this substitution, the estimated RGMM model is

$y_t = (-\alpha_1 4 - \alpha_2 4^2)(x_t + x_{t-1} + x_{t-2} + x_{t-3}) + \alpha_1(x_{t-1} + 2x_{t-2} + 4x_{t-3}) + \alpha_2(x_{t-1} +$

$\qquad\qquad 4x_{t-2} + 9x_{t-3})$

$\qquad\quad \beta_i = \alpha_0 + \alpha_1 i + \alpha_2 i^2$

      For convenience, it is necessary to change notation for the RGMM estimator. Let

$y_t = x_t'\alpha + u_t \quad t = 1,2,\dots,T$

$u(\alpha) = y - x\alpha = u_t$

$Q(\alpha) = \{T^{-1}u(\alpha)'Z\}W\{T^{-1}Z'u(\alpha)\}$

where $\hat{\alpha}_T = argmin_{\theta \in \Theta} Q_T(\alpha)$

$Q_T(\alpha) = T^{-2}\{y'ZW_TZ'y + \alpha'X'ZW_TZ'X\alpha - 2y'ZW_TZ'X\alpha\}$

The first order conditions require

$$(T^{-1}X'Z)W_T(T^{-1}Z'y) = (T^{-1}X'Z)W_T(T^{-1}Z'X)\hat{\alpha}_T$$

The RGMM estimator

$$\hat{\alpha}_T = \{(T^{-1}X'Z)W_T(T^{-1}Z'X)\}^{-1}(T^{-1}X'Z)W_T(T^{-1}Z'y)$$

where Z is a T x q matrix of instruments containing x_{it}, x_{it}^2, $x_{it}x_{jt}$.

Based on distribution theory, Hall (Year) demonstrates the asymptotic variance of the

GMM estimator can be obtained by

$$c\hat{o}v(\hat{\alpha}_s) = \{E[x_t z_t']WE[z_t x_t']\}^{-1}E[x_t z_t']WSWE[x_t z_t']\{E[x_t z_t']WE[z_t x_t']\}^{-1},$$

which converges in distribution to

$$T^{-\frac{1}{2}}(\hat{\alpha}_T - \alpha_o) \xrightarrow{d} N(0, MSM')$$

Results

An initial and brief interpretation of the results from the RGMM estimator suggests that if

the value of agricultural land increases by a percent for three consecutive years, and is expected

to increase a percent during the current year, expected return will increase by approximately .26

percent ($\approx$ .013 + .095 + .066 + .048 + .04). The OLS and RLS models would expect to see a

.25% increase in returns under the same scenario.

Parameters	OLS	RLS	RGMM
Intercept	-0.00302	-0.00304	0.01274 ***
	(0.00367)	(0.02621)	(0.00417)
X_t	0.08634 ***	0.08334 ***	0.09458 ***
	(0.02565)	(0.02621)	(0.01266)
X_{t-1}	0.05872 **	0.06683 ***	0.06615 ***
	(0.02752)	(0.02370)	(0.01511)
X_{t-2}	0.06236 **	0.05438 **	0.04769 ***
	(0.02760)	(0.02399)	(0.01499)
X_{t-3}	0.04257	0.04599 *	0.03921 ***
	(0.02709)	(0.02757)	(0.01146)

Numbers in parentheses are standard errors
*** Indicates statistical significance at the $\alpha = .01$
** Indicates statistical significance at the $\alpha = .05$
* Indicates statistical significance at the $\alpha = .10$

Discussion

This is an alternative way to look at agricultural land prices, given that traditionally agricultural finance researchers have used current or previous earnings to explain current agricultural land values. This paper uses current agricultural prices to explain future earnings. The results will be meaningful for agricultural policy which may aim to reduce the volatility of agricultural asset prices.

Citations

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