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.*

C1

1988

The Effect of Risk on the Rental Value of Agricultural Land

UNIVERSITY OF CALIFORNIA
DAVIS
JAN 06 1989
Agricultural Economics Library

by

Joyce A. Hall

and

B. Wade Brorsen

Rents

Joyce A. Hall is a graduate research assistant at Purdue University and B. Wade Brorsen is an associate professor at Purdue University. 14

Selected paper of the American Agricultural Economics Association Annual Meetings, July 31 - August 3, 1988, Knoxville, Tennessee.

3/5

#1505

Abstract

A theoretical model determining the rental value of agricultural land under risk aversion is developed. Land rent is modeled as a function of expected output price, input price and risk. Cross sectional time series data for the Corn Belt states (1970-1986) are used assuming a corn-soybean rotation. Farm programs are included as contingent claims.

The Effect of Risk on the Rental Value of Agricultural Land

The wide fluctuation in land values during the 1970's and 1980's and the importance of land value to the solvency of the farm operation have brought forth several recent efforts to better understand the factors influencing land value (Alston; Burt; Featherstone and Baker). However, little empirical work has tested the impact of risk on land values. Also, few attempts have been made to model risk and government price support programs in the same research even though stabilizing producers' incomes is often cited as an objective of government programs (Just, 1974). The purpose of this paper is to determine the influence of risk on the rental price of agricultural land in the presence of government price supports. Price support programs are modeled as contingent claims; therefore, an implicit value can be estimated for the program and this value incorporated into price expectations.

A usual assumption, arising from capitalization theory, is that the price of land equals the discounted present value of the expected returns from the land (Burt; Robison et. al.). Historically, farmland prices were linked closely with net farm income. However, after 1950 and increasingly so in the 1970's, the relationship between farmland prices and net farm income weakened (Shalit and Schmitz). Efforts to explain farmland prices have shown that government programs (Boxley and Anderson; Harris; Boehlje and Griffin), technological change (Herdt and Cochrane), real estate debt (Shalit and Schmitz; Boehlje and Griffin), capital gains (Melichar; Castle and Hoch; Robison et. al.), and inflation and taxes (Castle and Hoch; Robison et. al.) are significant factors explaining farmland prices.

White and Ziemer examined the impact of risk on farmland price using a capital asset pricing model and found risk to be an important factor.

However, they only included direct government payments in farm income without explicit consideration of government price support programs. Risk has been included in agricultural supply response equations with somewhat inconclusive results (Nieuwoudt et.al.; Brorsen et. al. (1985); Bailey and Womak). Brorsen et. al. (1987) found little effect of risk on rice acreage and suggested the possibility that land prices may have absorbed the main effects of risk. This paper extends previous research by estimating the effects of risk on the cash rental value of agricultural land in the presence of government support programs.

A theoretical model to determine the rental value of agricultural land under risk aversion is developed. Under the theory of perfect competition, cash rent is the value of the marginal product of land. Current rent need not reflect future changes in market conditions, but only the intersection of current supply and the value of the marginal product (Castle and Hoch). The influence of factors affecting the rental value of agricultural land is estimated using a cross section time series analysis. State level data for the Corn Belt (Illinois, Indiana, Iowa, Missouri, and Ohio) are used for the period 1970 to 1986. Government programs are included as contingent claims. The results suggest risk is a significant factor in explaining variation in the rental value of agricultural land. This suggests a need to include risk in agricultural policy analysis.

THEORETICAL MODEL

In this section, a theoretical model is developed to determine the rental price of agricultural land under risk aversion. Initially, we assume an industry composed of identical competitive and risk averse producers with free entry and exit. The notation used throughout this section follows:

p_o = output price x_o = output

p_1 = rental price of land x_1 = quantity of land

p_2 = price of variable inputs x_2 = quantity of variable inputs

$p_o x_o$ = revenue $p_1 x_1 + p_2 x_2$ = costs

π = profit $(p_o x_o - p_1 x_1 - p_2 x_2)$

Assuming the producer does not know output price, p_o, with certainty at the time of the input decision; the risk averse producer, then, is concerned with the expected utility of wealth. To simplify the discussion, assume production is certain and denote the implicit production function by $f(x)=0$.[1] The expected utility of wealth can be expressed as:

$$EU[W_0 + \pi] \mid f(x)=0$$

where E is the expectation operator over the random variable p_o, U is a Von Newmann Morgenstern utility function satisfying $U_w = \partial U/\partial w > 0$ and $U_{ww} = \partial^2 U/\partial w^2 < 0$, therefore implying risk aversion. Initial wealth is designated by W_0.

A competitive producer under price uncertainty and risk aversion will maximize (1) with respect to x to find the optimal choice functions $x^*(W_0, \bar{p}_o, p_1, p_2, \sigma)$ where $\bar{p}_o = E(p_o)$. The parameter σ measures price uncertainty (or revenue uncertainty where both output price and quantity are uncertain). Assume that σ satisfies $p_o = \bar{p}_o + \sigma e$ where e is a random variable with mean zero. The optimal choice functions x^* are partial equilibrium short run functions.

In the derivation of the short run optimal choice functions, x^*, producers take all prices as given. However, in a long run equilibrium analysis, free entry and exit play an important role in the determination of industry equilibrium (Silberberg). With free entry and exit, the industry will be in equilibrium only if

$$2)\quad EU[W_0 + \pi\ ] = U(w).$$

If the expected utility of production is less than U(w), then producers would exit the industry. And, if the expected utility of producing is greater than U(w), incentives exist for other producers to enter the industry. Entry in the industry would tend to increase the aggregate supply of output and the demand for inputs. Thus, downward pressure is exerted on output prices and upward pressure is exerted on input prices.

The above theory is appropriate to model the behavior of an industry with no fixed factors in the long run. However, if an industry uses a factor that is fixed in the long run, such as land in agriculture, then entry or exit in the industry can be expected to be associated with adjustment in the pricing of the fixed factor. Consider, each producer having a fixed factor x_1, land, with p_1 being the cash rental price of land. At equilibrium, the rental price of land, p_1, must satisfy equation (2). The solution is denoted here by $p_1^*(W_0,\bar{p}_o,p_2,\sigma,x)$. Here, p_2 will denote an aggregate price for all inputs except p_1. Under free entry, this equilibrium occurs where the price of land takes its largest possible value, p_1^e, with respect to the choice variables x, i.e.:

$$3)\quad p_1^e = \text{Max}_x\, p_1^*(W_0,\bar{p}_o,p_2,\sigma,x).$$

We can denote $x^e(W_0,\bar{p}_o,p_1,p_2,\sigma)$ as the solution to (3). Therefore, the rental price of land can be modeled as a function of initial wealth, expected output price, input price, and risk.

If, $p_1^* < p_1^e$ for a producer, then from (2) there is an incentive for other producers to enter the industry since an entrant, making production decisions according to (3), would earn expected utility greater than U(w). Thus, producers would enter, bidding up the rental price of land to the point where $p_1^* = p_1^e$.

By differentiating (3) and using the envelope theorem, it follows that:

$$4a) \quad \frac{\partial p_1^e}{\partial \bar{p}_o} = \frac{\partial x_o^e}{\partial x_1^e} > 0$$

and

$$4b) \quad \frac{\partial p_1^e}{\partial \sigma} = \left.\frac{\partial x_o EU_w(p_o - \bar{p}_o)}{\partial \quad x_1 EU_w}\right| < 0 \ .$$

Thus, an increase in the expected output price increases the rental price of land while an increase in risk reduces the rental price of land. Result (4b) follows since Sandmo has shown that $EU_w(p_o - \bar{p}_o) < 0$ under risk aversion. Thus, risk averse producers must receive a risk premium to compensate for the risk they take. The risk premium is affected by price uncertainty in such a way that an increase in price risk, σ, necessarily decreases the price of land (Baron; Ishii.)

PROCEDURE AND DATA

From the theoretical model rent is modeled as a function of expected output price, input price, risk, and initial wealth. As initial wealth cannot be measured its effect is assumed to be negligible. Rent data is for cropland rented for cash. The data used is for a cross section of states including Illinois, Indiana, Iowa, Missouri, and Ohio for the period 1970 to 1986. Only corn and soybean data are considered for this model; therefore, the rent is considered to be the return to a combined acre of corn and soybeans. A corn-soybean rotation is assumed.

Due to expected "frictions" in the land rental market, a partial adjustment model is assumed. Therefore, lagged cash rent is also included. The model was specified as a linear equation:

$$5) \quad Rent_{it} = b_o + b_1 Rent_{i,t-1} + b_2 EPoutput_{it} + b_3 Pinput_{it} + Risk_{it}$$

where i refers to the state and t is time. A cross section time series analysis was used. The method used (Parks; TSCSREG; SAS) assumes a first-order autoregressive model with contemporaneous correlation between cross sections. Due to autocorrelation in the model, an instrumental variable was constructed for the lagged cash rent variable and this value substituted into the above equation.

Expected output prices are comprised of two parts: a component for the expected market price and a component for the value of the government program. An expected market price was calculated as follows: First, a seasonal average price was determined as the average of monthly prices for October, November, December, January, and February. Second, the expected market price is defined as last year's seasonal average price.

6) $EPmarket_{jit} = P_{ji,t-1}$

where j refers to corn or soybeans, and i and t are, respectively, state and time.

The government program is modeled as a contingent claim. Past research has generally relied on calculating a support price and either selecting the maximum of the market price or the support price or calculating a weighted average of the two prices (Bailey and Womak; Duffy et. al.; Houck and Ryan). However, selecting the maximum value of the support or market price undervalues the farm program (Irwin). Using a contingent claim model allows the program to take on a value even if the market price exceeds the support price and avoids the complication of deciding appropriate weights to assign the market and support prices.

The Black model is used to estimate an implicit value of the program. This model assumes that the producer would make the decision to participate in the program on April 15 (i.e., by the last day of sign-up for the program) and for simplification we assumed the producer will sell the crop during the harvest season; therefore, we have not included storage costs.

7) $PO_{jit} = e^{-rt}(SP_{jt}(N(-d1))-EP_{jit}(N(-d2)).$

7a) $d1 = [\ln(EP_{jit}/SP_{jt}) + (SD_{jt}^{2}/2)T]/(SD_{jt})T^{1/2}.$

7b) $d2 = [\ln(EP_{jit}/SP_{jt}) - (SD_{jt}^{2}/2)T]/(SD_{jt})T^{1/2}.$

where

j, i, and t are respectively, crop, state, and time,

PO is the implicit value of the government program,

SP is the support price,

EP is the expected market price during the harvest season,

SD is the standard deviation of the log of the daily price change for November soybeans futures or December corn futures taken for 90 days prior to the April 15th deadline,

r is the riskless interest rate taken as the interest rate on a six month treasury bill and,

T is time (in years) taken as the number of trading days from April 15 until October 15 for soybeans or November 15 for corn.

For soybeans, which have only a loan rate, the support price is the loan rate. For corn, the support price is the loan rate for the years when only a loan rate was in effect. For years where the loan rate was in effect and participating producers were paid an additional direct payment on acres diverted, the actual support price is calculated as the loan rate plus the direct support payment. For years where a target price was in effect the target price is the support price (Rasmussen; USDA AIB 471; USDA AIB 472).

To arrive at the expected output price, the value of the government program is added to the expected market price:

8) $EPoutput_{jit} = EPmarket_{jit} + PO_{jit}.$

In the case of corn this total is adjusted downward by acreage restrictions when present. Following our assumption of a corn-soybean rotation, a weighted output price was determined as follows:

$$9)\quad WP_{it} = 0.50 * EPoutput_{cit} + 0.50 * EPoutput_{sit}.$$

Cost of production data were used as a proxy for input prices.[2] These were calculated from farm production expenses published in Farm Income Data: A Historical Perspective. As this is aggregate data for all farming enterprises, including livestock, costs were attributed to a combined acre of corn and soybeans based on their relative value as a percent of cash receipts. For example, the category seed, which is unique to crops, was allocated to a combined corn-soybean acre based on their relative value as a percent of crop cash receipts. The category hired labor, which could be attributed to both crops and livestock, was allocated to a corn-soybean acre based on their relative value as a percent of total cash receipts and so forth. The categories feed, livestock costs, and net rents were excluded. The cost of production was then put on a per acre basis by dividing by the acres planted to corn and soybeans. This variable is denoted as COP_t.

As farmers face physical output risk as well as price risk the risk variable was chosen to reflect variation in income. The risk variable is specified as the square root of a weighted moving average, using a three year lag, of the squared relative deviation of actual income from expected income. Expected income was considered to be last year's income. Therefore,

$$10)\quad Risk_{it} = [\ \ a_k((Inc_{i,t-k} - Inc_{i,t-k-1}) / Inc_{i,t-k})^2]^{1/2}.$$

The weights, a, selected are .5, .3, and .2. Income was defined as the weighted gross income (price x yield) from corn and soybeans less costs of production plus direct government payments, i.e.,

$$11)\quad Inc_{it} = 0.50*(P_{cit}*Y_{cit}) + 0.50*(P_{sit}*Y_{sit}) - COP_t + GOVPAY_t.$$

Direct government payments were taken as those payments to feed and oilseeds and were expressed on a per acre basis by dividing by acres planted to corn and soybeans.

RESULTS OF ECONOMETRIC MODEL

The results of the econometric model of the cash rental price of agricultural land, equation (5), are presented in Table 1. The estimated fit of the equation is relatively good. All explanatory variables are significant and standard errors are low. The expected output price has a positive sign and risk has a negative sign as would be expected from the theoretical model. Lagged rent is positive, as expected, and highly significant indicating that rents do not adjust instantaneously. The expected cost of production is significant and positive. As cost of production data were used as a proxy for input price, the cost of production variable also captures changes in input quantity; therefore, it is not unlikely that this sign is positive.

The short and long run elasticities were computed at the mean values. These elasticities suggest that in the short run rental price is quite responsive to expected output price. In the short run, a one percent increase in expected output price increases cash rents by 0.198%. This elasticity more than doubles to 0.553% in the long run. The relatively low elasticity of risk suggests that, while risk is a significant factor in explaining the variation of cash rents, cash rents are not overly responsive to risk in either the short or long run. The short run elasticity for risk is only -.016% and the long run elasticity is -.044%.

SUMMARY AND CONCLUSIONS

The effect of risk on the rental value of agricultural land, in the presence of government support programs, was estimated. A theoretical model determining the rental price of agricultural land under risk aversion was developed which specifies cash rent as a function of expected output price, input price, and risk. Government programs were modeled as contingent claims, thereby avoiding the complications encountered in much of past research in designing a single price series to incorporate market prices and support prices. A cross section time series analysis was performed using state level data for the states of Illinois, Indiana, Iowa, Missouri, and Ohio for the years 1970 to 1986.

The results suggest that risk is a significant factor in explaining the variation in the rental value of agricultural land. As risk increases, the rental value of land decreases. Since the price of land is tied heavily to the rental value of land this would imply that land price would also decrease (Alston). If risk reduction is an objective of government support programs, models which ignore risk may not be appropriate (Just, 1975). The significance of risk in explaining cash rents suggests that risk should be included in agricultural policy analysis.

Table 1: Results of Econometric Model of Cash Rent.

Variable	Parameter estimates	T statistic	Standard Error	Short Run Elasticity	Long Run Elasticity
Intercept	7.127	1.54	4.631		
$LAGRENT_t$	0.642	10.05	0.063		
WP_t	3.603	5.26	0.685	0.198	0.553
COP_t	0.037	3.01	0.012	0.155	0.433
$RISK_t$	-0.855	-2.35	0.022	-0.016	-0.044

M.S.E. = 0.982

Endnotes

1) While this simplifies discussion, it does not alter the implications of the model. If production were risky, as it certainly is for agriculture, then x_o would denote expected output and p_o would be revenue per unit of expected output.

2) Costs of production were deemed more appropriate than input price indexes that are available. Input indexes were felt to include information that is not relevant to the production of corn and soybeans and are not readily available at the state level. Cost of production data does, however, capture changes in input quantities.

References

Alston, Julian M. "Analysis of Growth of U.S. Farmland Prices, 1963-82." American Journal of Agricultural Economics, Vol. 68 (1986): 1-9.

Bailey, K. W., and A. W. Womak. "Wheat Acreage Response: A Regional Econometric Investigation." Southern Journal of Agricultural Economics, Vol. 17,2 (1985): 171-80.

Baron, D. P. "Price Uncertainty, Utility, and Industry Equilibrium in Pure Competition." International Economic Review, Vol. 11 (1970): 463-80.

Boehlje, Michael and Steven Griffin. "Financial Impacts of Government Support Price Programs." American Journal of Agricultural Economics, Vol. 61 (1979): 285-96.

Boxley, Robert F. and William Anderson. "The Incidence of Benefits from Commodity Price-Support Programs: A Case Study of Tobacco." in Government Spending and Land Values. C. Lowell Harriss, ed., pp. 77-103, The University of Wisconsin Press, 1973.

Brorsen, B. Wade, Jean-Paul Chavas, and Warren R. Grant. "A Market Equilibrium Analysis of the Impact of Risk on the U.S. Rice Industry." American Journal of Agricultural Economics, Vol. 69 (1987): 733-39.

Brorsen, B. Wade, Jean-Paul Chavas, Warren R. Grant, and L.D. Schnake. "Marketing Margins and Price Uncertainty: The Case of the U.S. Wheat Market." American Journal of Agricultural Economics, Vol. 67 (1985): 521-28.

Burt, O. R. "Econometric Modeling of the Capitalization Formula for Farmland Prices." American Journal of Agricultural Economics, Vol. 68 (1986): 10-26.

Castle, Emery N. and Irving Hoch. "Farm Real Estate Price Components, 1920-78." American Journal of Agricultural Economics, Vol. 64 (1982): 8-18.

Duffy, Patricia A., James W. Richardson, and Michael K. Wohlgenant. "Regional Cotton Acreage Response." Southern Journal of Agricultural Economics, Vol. 19 (1987): 99-109.

Featherstone, Allen M. and Timothy Baker. "The Effects of Reduced Price and Income Supports on Farmland Rent and Value." North Central Journal of Agricultural Economics, January 1988.

Harris, Duane G. "Inflation-Indexed Price Supports and Land Values." American Journal of Agricultural Economics, Vol. 59 (1977): 489-95.

Hert, Robert W. and Willard W. Cochrane. "Farm Land Prices and Farm Technological Advance." Journal of Farm Economics, Vol. 48 (1966): 243-63.

Houck, J. P. and M. E. Ryan. "Supply Analysis for Corn in the U.S.: The Impact of Changing Government Programs." American Journal of Agricultural Economics, Vol. 54 (1972): 184-91.

Irwin, Scott H. "Economic Analysis of Commodity Futures and Options as Alternatives to Loan and Target Price Programs." Ph.D. dissertation, Department of Agricultural Economics, Purdue University, May 1986.

Ishii, Yasunori. "On the Theory of the Competitive Firm Under Price Uncertainty: Note." American Economic Review, Vol. 67 (1977): 768-69.

Just, Richard. "An Investigation of the Importance of Risk in Farmer's Decisions." American Journal of Agricultural Economics, Vol. 56 (1974): 14-28

Just, Richard. "Risk Aversion under Profit Maximization." American Journal of Agricultural Economics, Vol. 57 (1975): 347-52.

Melichar, Emanuel, "Capital Gains Versus Current Income in the Farming Sector," American Journal of Agricultural Economics, Vol. 61 (1979): 1084-92.

Nieuwoudt W.L., S.R. Johnson, A.W. Womack and J. Bruce Bullock. "Measurement of Importance on Supply Response of Corn and Soybeans." Agricultural Economics Report, Department of Agricultural Economics, University of Missouri-Columbia, 1985.

Rasmussen, Wayne D. and Gladys L. Baker. "Price-Support and Adjustment Programs From 1933 Through 1978: A Short History." USDA, ESCS. AIB No. 424, February 1979.

Robison, L.J., D.A. Lins, and R. VenKataraman. "Cash Rents and Land Values in U.S. Agriculture." American Journal of Agricultural Economics. Vol. 67(1985): 794-805.

Sandmo, Agnar. "On the Theory of the Competitive Firm Under Price Uncertainty." American Economic Review, Vol. 61 (1971): 65-73.

Shalit, Haim and Andrew Schmitz. "Farmland Accumulation and Prices." American Journal of Agricultural Economics, Vol. 64 (1982): 710-19.

Silberberg, E. "The Theory of the Firm in Long-Run Equilibrium." American Economic Review, Vol. 64 (1974): 734-41.

White, Fred C. and Rod. F. Ziemer. "Farm Real Estate Pricing Under Risk: An Empirical Investigation." Southern Economic Journal, Vol. 48 (1982): 77-87.

United States Department of Agriculture, Economic Research Service, AIB No. 471, "Corn: Background for 1985 Farm Legislation," September 1984.

United States Department of Agriculture, Economic Research Service, AIB No. 472, "Soybeans: Background for 1985 Farm Legislation," September 1984.

United States Department of Agriculture, Economic Research Service, "Farm Income Data: A Historical Perspective."

United States Department of Agriculture, Economic Research Service, "Farm Real Estate Market Developments: Annual Summaries."