WESTERN AGRICULTURAL ECONOMICS ASSOCIATION

PAPERS OF THE

1989 ANNUAL MEETING

WESTERN AGRICULTURAL ECONOMICS ASSOCIATION

COEUR D'ALENE, IDAHO

JULY 9-12, 1989

SESSION 11

Rational Expectations without Equilibrium: the Case of Rice Production in Taiwan

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How expectations are formed by economic agents is of great interest in economic literature not only because it has close relationship with decision makings, but because this topic is academically worthwhile. Most researchers were used to making priori assumption about expectations formation in their analyses without varifying its validity until the rational expectations hypothesis (REH) attracted economists' attentions in late 1970. Up to now REH has been frequently adopted for modeling both macro- and micro-economic phenomena and tested against other typical forms of expections (e.g., static, adaptive, and extrapolative expections). However, no unanimously favorable testing results for REH had been achieved. To a great extent, they were likely to depend on research topics and regions, characteristics of data, and the ways of model formulations. As far as the REH testing for agricultural supply is concerned, similar results were observed (e.g., Fisher and Tanner (1978), Duyne (1982), Marsh (1983), Eckstein (1981, 1984), etc.).

To the author's knowledge, there was no work that simultaneously took into account the following important factors and examined whether or not they significantly affect testing results: (a) the functional form of production and the structure of the cost adjustment terms, (b) ways of specifying the laws of motion for exogenous variables, (c) market equilibrium condition, and (d) various goals of farming. One may suspect that these factors might have certain influence on testing results.

In this paper we firstly set up five models in which different structures of the first three factors mentioned above are explicitly considered. Then the null hypothesis of REH for each model is tested. Finally the goodness of fit of these models are judged and some findings discussed.

The Models

Five models are set up in this section, among which Model II and Model III are special cases of Model I and Model V was firstly developed by Eckstein (1984). These models consist of different components of the first three factors mentioned above and their basic characteristics may be summarized as in Table 1. While we assuming that farmers are maximizing the expected total present value of profits, the explicit objective functions of these models are presented in Table 2. To derive the decision rules for each model, one needs to specify the stochastic processes of the exogenous variables (e.g., R_t and a_t in our models). Since the accuracy of such specifications have something to do with the underlined decision rules and possibly with the testing results, more attention on this matter is warranted. After conducting a careful time series analysis for R_t, its law of motion is formulated as equation (1). While the technical factor a_t is unobservable, its law of motion is specified by means of trial-and-error procedures. The final form thereby selected for Models I, II, III, and V is given by equation (2). Since Model IV contains no technical factor a_t and market equilibrium constraint $D_t = mX_t$ is imposed, we have to specify the law of motion for the stochastic term of the demand function (i.e., $U^p{}_t$). Similar to a_t, it was found that the stochastic process of $U^p{}_t$ could be well described by equation (3). Solving the objections and using the Wiener-Kolmogorov projection formula,[1] we can derive the decision rules of land allocation for rice production under rational expections.[2] The derived rules associated with these five models are, respectively, given by equations (4), (5), (6), (7), and (8).

$$R_t = \alpha_0 + v_1 M + \alpha_1 R_{t-1} + v_2 M R_{t-1} + U^R{}_t, \qquad (1)$$

$$a_t = \rho\, a_{t-1} + U^a{}_t, \qquad (2)$$

where M is a dummy variable such that M=1 for $t > t_0$ and M=0 for $t \leq t_0$; $U^R{}_t$ and $U^a{}_t$ are, respectively, white noises of R_t and a_t.

$$U^p{}_t = \theta\, U^p{}_{t-1} + e_t, \qquad (3)$$

where e_t is the white noise of $U^p{}_t$.

$$A_{1t} = \eta_0 + (\lambda_1 + \rho)A_{1t-1} - \lambda_1\rho\, A_{1t-2} - \{\alpha_0(1-\rho)w_1/(1-\lambda)\} - \{v_1(1-\rho)w_1/(1-\lambda)\}M - w_2 R_{t-1} + \rho\, w_2 R_{t-2}, \qquad (4)$$

$$A_{1t} = \eta_0 + \rho A_{1t-1} + \{(1-\rho)v_1/f_1\}M - w_3 R_{t-1} + \rho\, w_3 R_{t-2}, \qquad (5)$$

$$A_{1t} = \eta_0 + (1+\rho)A_{1t-1} - \rho A_{t-2} - \{\alpha_0(1-\rho)/w_4(1-\beta)\} - \{v_1(1-\rho)/w_4(1-\beta)\}M - \{(\alpha_1 + v_2 M)/w_4\}R_{t-1} + \{\rho(\alpha_1 + v_2 M)/w_4\}R_{t-2}, \qquad (6)$$

$$A_{1t} = \eta_0 + (\lambda_1 + \theta)A_{1t-1} - \lambda_1\theta A_{1t-2} + \{\alpha_0(1-\theta)w_1/(1-\lambda)\} + \{v_1(1-\theta)w_1/(1-\lambda)\}M - w_2R_{t-1} + \theta w_2R_{t-2}, \quad (7)$$

$$A_{1t} = \eta_0 + (\lambda_1 + \rho)A_{1t-1} - \lambda_1\rho A_{1t-2} + \{\alpha_0(1-\rho)w_1/(1-\lambda)\} + \{v_1(1-\rho)w_1/(1-\lambda)\}M + w_2R_{t-1} - \rho w_2R_{t-2}, \quad (8)$$

where $w_1 = \lambda_1/d\{1-(\alpha_1+v_2M)\lambda\}$;
$w_2 = (\alpha_1+v_2M)w_1$;
$w_3 = (\alpha_1+v_2M)/f_1$;
$w_4 = d\{1-(\alpha_1+v_2M)\beta\}$; and
$\lambda = \beta\lambda_1$.

Obviously, the coefficient structures of each independent variable vary across models. But it is interesting to note that the decision rule of Model I (i.e., equation (4)) is equivalent to that of the model developed by Eckstein (i.e., equation (8)).

Empirical Results

The decision rule of A_{1t} in Table 2 and equation (1) are estimated simultaneously for each model by employing full information maximum likelihood (FIML) method.[3] The estimates of all relevant parameters (i.e., λ_1 , ρ , d, f_1, v_1, v_2, α_0 , α_1 , θ , and η_0) associated with each model are reported in Table 3. To test REH, the likelihood ratio test (LRT) is used. The computed values of the LRT statistic, LR, are also presented in Table 3,[4] which clearly indicate that REH can not be rejected at 5% significance level, regardless of the differences in model specifications.

Given the above findings, one may question which model could explain better the behavior of rice producers in Taiwan. To compare the goodness of fit of these models, Akaike information criterion (AIC) is used, where AIC is defined as follows.

$$AIC = -2\log(L) + 2n, \quad (9)$$

where L represents the value of the maximum likelihood function of the estimated equation system associated with each model; and n is the number of parameters estimated in the model.

According to the computed AIC that is listed in the last row of Table 3, Model III seems working better. In addition, the following findings are observed.

(a) Even though the estimate of the parameter λ_1 in Model I is equal to that in Model V, the null hypothesis H_0: $\lambda_1 = 1$ could not be rejected in either case. This furhter confirms the goodness of Model III which is exactly the special case of Model I with the constraint $\lambda_1 = 1$.

(b) As the only model including market equilibrium constraint, Model IV has the highest AIC and an unrealistic estimate (i.e., $\alpha_1 > 1$). This justifies the situation of excess supply of rice in Taiwan in the past few years.

(c) Models I and V are essentially identical with the only exception that the signs of d in both models be reversed, positive for the former and negative for the latter. Given the estimated ρ, both cases lead to a positive λ_1, which implies that land allocation for rice production exihibits positive first-order and second-order autoregressions. Note that positive autoregression also holds for Model III. This is different from Eckstein's (1984) findings with respect to the land allocation in Egyptian agricultural sector.[5]

Conclusions

Since no unanimous testing results about rational expectations hypothesis (REH) had been achieved, it was suspected that previous empirical conclusions from testing REH might be caused by their failure in considering the following factors that might affect the testing results to some extent: (a) functional forms of production and the structure of adjustment cost term, (b) ways of specifying the laws of motion for exogenous variables, (c) market equilibrium condition, and (d) assumptions of farming goals. To be exempt from such possibilities, this paper established five models of which each displays different structure of the above factors. A simultaneous equation system was estimated for each of the five models by employing full information maximum likelihood method. The likelihood ratio test revealed that REH could not be rejected under these models in spite of their structural differences, and that land allocation for rice production exhibited positive first-order and second-order autoregressions. However, there was one model dominated others in terms of the goodness of fit. Most importantly, the model with market equilibrium constraint resulted in the worst fit. This justified the situation of excess supply of rice in Taiwan in the past few years.

Footnotes

1. The Wiener-Kolmogorov formula was clearly described in Sargent (1979), pp. 262 - 263.
2. Sufficient conditions for the transversality conditions to hold are that $\{R_t\}$ and $\{a_t\}$ be exponential order less than $1/\sqrt{\beta}$, and that the solution for $\{A_{1t}\}$ be exponential order less than $1/\sqrt{\beta}$.
3. Eckstein (1984) explained satisfactorily the reasons why $\{A_{1t}\}$ and $\{R_t\}$ should be estimated simultaneously.
4. The LRT statistic, LR, is defined as:

$$LR=2\{\log(L)_u - \log(L)_r\},$$

where $\log(L)_r$ and $\log(L)_u$ are, respectively, the logrithms of the maximum likelihood functions with and without restrictions on coefficient structures.
5. Eckstein (1984) found that d is positive and   negative.

Table 1. Characteristics of the Selected Models

	Models*				
	I	II	III	IV	V
Production functions	$X_t=(f_o+a_t)A_{1t-1} - \frac{f_1}{2}A^2_{1t}$	Same as Model I	$f_1=0$	$X_t=f_oA_{1t}$	X_t : same as Model I $Y_t=(f_o+a_{2t})A_{2t}$
Adjustment costs	$\frac{d}{2}(A_{1t}-A_{1t-1})^2$	$d=0$	Same as Model I	Same as Model I	$d(1-\frac{A_{1t-1}}{\bar{A}}-\frac{A_{1t}}{\bar{A}})A_{1t}$
Market equilibrium	Not imposed	Not imposed	Not imposed	Imposed	Not imposed

* Definitions of the symbols in these models are as follows. X_t is the production of rice at time t; a_t is the shock to production of rice at time t; A_{1t} is the land allocated at time t-1 for the production of rice at time t; Y_t is the production of other crops at time t; a_{2t} is the shock to production of other crops at time t; and $\bar{A}$, the total available cultivated land at time t, is identical to $A_{1t}+A_{2t}$.

Table 2. Objective Functions Underlined the Selected Models

	Objective Functions
Model I *	$\text{Max } E_0 \sum_{t=0}^{\infty} \beta^t [f_0+a_t)A_{1t}-f_1 A^2_{1t}-\frac{d}{2}(A_{1t}-A_{1t-1})^2-R_t A_{1t}]$
Model II	Special Case of Model I with $d=0$
Model III	Special Case of Model I with $f_1=0$
Model IV **	$\text{Max } E_0 \sum_{t=0}^{\infty} \beta^t [P_t \cdot f_0 A_{1t}-\frac{d}{2}(A_{1t}-A_{1t-1})^2-NR_t \cdot A_{1t}]$
	S.T. $P_t=s_0+s_1 D_t+U^p_t$
	$D_t= m \cdot X_t$
Model V ***	$\text{Max } E_0 \sum_{t=0}^{\infty} \beta^t [(f_0+a_t)A_{1t}-\frac{f_1}{2}A^2_{1t}-\frac{d}{\bar{A}}(\bar{A}-A_{1t-1}-A_{1t})A_{1t}-$
	$R_t A_t + R_t \bar{A}]$

* E is the mathematical expectation operator, where $E_0(X)=E(X|\Omega_0)$ and Ω_0 is the imformation set available for farmers at time 0; $0<\beta<1$ is the objective discount factor; and R is the " real" shadow rent for rice land allocations.

** P_t is the price that farmers receive for the production of rice at time t; NR_t ,the " nominal" rent for rice land allocations,is equal to $P_t \cdot R_t$; D_t is the market demand for rice; U^p_t is the shock to price at time t; and m is the total unmber of rice producers.

*** This model was originally developed by Eckstein(1984).

Table 3. FIML Estimates of Parameters in Models

Parameters	FIML Estimates*				
	Model I	Model II	Model III	Model IV	Model V
η_0	264,960	37,024	90,106	318,950	264,960
λ_1	0.794	———	———	0.684	0.794
ρ	-0.210	0.948	-0.170	———	-0.210
θ	———	———	———	-0.162	———
d	0.144	0	0.479	2.174	-0.144
α_0	722.30	606.35	547.77	561.18	722.30
α_1	0.822	0.861	0.886	1.298	0.822
v_1	-1,264.0	483.30	-557.02	-2,025.4	-1,264.0
v_2	0.321	-0.110	0.121	-0.204	0.321
f_1	———	26.34	0	———	———
Log(L)	-400.6	-408.2	-399.2	-455.1	-400.6
LR**	1.49	2.95	2.71	2.13	1.49
AIC	817.2	830.4	812.3	926.2	817.2

* In the estimation process, a value of 0.90 is assumed for the discount factor.

** Degrees of freedom for LRT under these models are 1, 1, 2, 1, and 1, respectively.

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