

NONSTRUCTURAL ESTIMATION OF PRODUCERS' RISK ATTITUDES IN RAMJERD DISTRICT OF FARS PROVINCE

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(Received: August 12, 2000)

ABSTRACT

Producers' risk attitudes in Ramjerd district of Fars province were estimated by using the nonstructural approach. The results indicated that, at the population mean, these farmers were both Arrow-Pratt and downside risk averse. Risk-aversion coefficient can be used in the analysis of farmers' behavior and preparing risk-efficient strategies for water and other resources.

Key words: Agricultural production, Iran (Ramjerd), Nonstructural estimation, Risk attitudes.

تحقیقات کشاورزی ایران

۲۰:۱۶۷-۱۸۰ (۱۳۸۰)

تخمین غیر ساختاری تمایلات ریسکی زارعین در دشت رامجرد استان فارس

منصور زیبایی و جواد ترکمانی

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چکیده

تمایلات ریسکی زارعین در دشت رامجرد استان فارس با روش غیرساختاری، تخمین زده شد. نتایج نشان داد که زارعین مورد مطالعه، در میانگین جمعیت بر اساس هر دو معیار ریسک گریزی ارو-پرات (AP) و به سمت پایین (DS) ریسک گریز بودند و می‌توان از ضریب ریسک گریزی برای تحلیل رفتار زارعین و تعیین استراتژی‌های ریسک کارایی آب و دیگر منابع بهره جست.

INTRODUCTION

Agricultural production processes are naturally risky and farmers face production risk from the weather, crop and livestock performance, and pests and diseases, as well as government-controlled institutional risk, and personal or human risk. These jointly with price or market risks, comprise business risk which is further related to financial risk (6, 7, 10, 11, 12)

When farmers are risk-averse, as is naturally the case, they allocate controllable in such a way as to decrease the impact of risk. Therefore, it may be important to include risk in models of farmer behavior (6, 7, 10, 11, and 12).

The first step of this way is to determine the risk attitude of individual agricultural producers. A variety of techniques have been expanded to measure the risk attitudes of individual agricultural producers (1, 2, 5, 6, 9, 11, and 15). These techniques may be classified into two main approaches: experimental and econometric. The experimental approach, for example was used by Dillon and Scandizzo (10) to elicit risk attitudes of subsistence farmers in northeast Brazil, and by Binswanger (7, 8), and Quizon et al. (17) to analyze of fairly large-scale experiment, with real significant payment, in rural India. The economic approach has been used in a variety of situations. Moscardi and De Janvry (14) and Shahabuddin et al. (19) used such an approach in which the decision-makers were supposed to follow a safety-first rule. Antle (1, 2), Bardsley and Harris (4),

Love and Buccola (13), Pope and Just (16), Saha et al. (18) and Bar-shira et al. (6) used an econometric method to examine the risk attitudes of decision – makers assuming expected utility maximization. In present study, nonstructural approach proposed by Antle (2) was used to estimate producers' risk attitudes in Ramjerd district of Fars province. This approach will be described below. This nonstructural model needs less modeling assumptions than the structural model. Instead of the detailed input quantity and price data necessitated in the structural method, the nonstructural method uses pooled data on net returns and other observable feature of the farm. Also, in the nonstructural method to risk attitude, the center of attention is shifted from the individual to the population following the random utility approach of Antle (1).

The first section of the paper describes the theoretical and econometric model. The second section applies the econometric model to estimate risk attitudes in Ramjerd district of Fars province and compares them with the results of other studies.

MATERIALS AND METHODS

Theoretical and Econometric Model

To show the nonstructural approach, think about the case of a farmer with a negative exponential utility function $U(\pi) = 1 - \exp(-2\gamma\pi)$ with profit π normally distributed. The certainty equivalent (CE) is defined as the value of π that satisfies $U(CE) = EU(\pi)$. Taking the expectation and solving for CE, $CE = \mu_1 - \gamma\mu_2$, where μ_i is the i -th moment of the profit distribution and γ is the Arrow-Pratt absolute risk aversion coefficient. The term $\gamma\mu_2$ is labeled as the risk premium. Let us think about the changes in CE from one period to another. Supposing the risk attitude parameter γ is fixed over time (Antle (2)): $\Delta CE = \Delta\mu_1 - \gamma\Delta\mu_2$

We can see that estimating an individual's risk attitude parameter γ in this model is similar to measuring the trade-off between mean and variance at the same time as holding utility constant with setting $\Delta CE = 0$ (Antle (2)).

As a result of observing the trade-off between moments of the profit distribution at the farmers mean, it is feasible to estimate risk attitude parameters for the farmers because measuring risk attitude at the farmers mean is similar to measuring the risk attitude of an individual along a risk-return indifference curve (Antle (2)).

If we label profit to fixed factors of production for the j -th farm in the t -th period as π_{jt} , the distribution of profit is (Antle (2)):

$$F(\pi | \mu_{jt}), \quad j=1, \dots, N, \quad t=1, \dots, T \quad [1]$$

Where $\mu_{jt} = (\mu_{1jt}, \dots, \mu_{mjt})$ is a parameter vector shows the profit distribution of farmer j in year t . reminder that each farmer may have a distinct profit distribution in each period. It is supposed that individuals can precisely assess their profit distributions and that the form of the distribution is common to the farmers (Antle (2)).

Risk attitudes can be supposed to vary across individuals and also differ over time consequently the j -th farmer's utility function is (Antle (2)):

$$U_{jt} = U(\pi_{jt}, \gamma_{jt}) \quad [2]$$

Where γ_{jt} is a vector of parameters demonstrating the j -th individual's risk attitudes in period t . As a result, expected utility is:

$$\int U(\pi, \gamma_{jt}) dF(\pi | \mu_{jt}) \equiv V[\mu_{jt}, \gamma_{jt}] \quad [3]$$

Each individual is supposed to make decisions in order to maximize expected utility in each period. Therefore, the change in expected utility from period t to period $t+1$ on is (Antle (2)):

$$\Delta V_{jt} = \sum_{i=1}^m \frac{\Delta V_{jt}}{\Delta \mu_{ijt}} \Delta \mu_{ijt} \quad [4]$$

With variables other than μ_{ijt} held constant, the terms $(\Delta V_{jt}/\Delta \mu_{ijt})$ are inferred as discrete partial differentials,. Note that ΔV_{jt} calculates the change in utility for individual j from period t to $t+1$. Therefore, if μ_{1jt} is mean profits, $\Delta V_{jt}/\Delta \mu_{1jt}$ can be defined as the marginal utility of mean profit. Scaling by $\Delta V_{jt}/\Delta \mu_{1jt}$, equation [4] can be converted from units of utility to money units (Antle (2)):

$$\langle \Delta V_{jt} \rangle \equiv \sum_{i=1}^m r_{ijt} D_{ijt} \quad [5]$$

Where:

$$\langle \Delta V_{jt} \rangle \equiv \frac{\Delta V_{jt}}{(\Delta V_{jt} / \Delta \mu_{1jt})}$$

$$r_{ijt} \equiv \frac{(\Delta V_{jt} / \Delta \mu_{ijt})}{(\Delta V_{jt} / \Delta \mu_{1jt})}$$

$$D_{ijt} = \Delta \mu_{ijt}$$

The $\langle \Delta V_{jt} \rangle$ are presumed to be distributed among the farmers in year t with a mean θ_{0t} and variance σ_{0jt} :

$$\begin{aligned} \langle \Delta V_{jt} \rangle &= \theta_{0t} + \varepsilon_{0jt}, E[\varepsilon_{0jt}] = 0 \\ E[\varepsilon_{0jt}^2] &= \sigma_{0jt} \end{aligned} \quad [6]$$

As revealed by Antle (1), the changes in utility because of changes in the profit distribution can be associated with risk attitudes. Therefore, r_{2jt} can be interpreted as estimation to the absolute Arrow-Pratt measure of risk aversion, and r_{3jt} can be inferred as a rough calculation to an absolute measure of downside risk aversion.

Risk attitudes are supposed to be distributed among the farmers as follows (Antle (2)):

$$\begin{aligned} r_{ijt} &= \theta_{it} + \varepsilon_{ijt}, E[\varepsilon_{ijt}] = 0 \\ E[\varepsilon_{ijt}^2] &= \sigma_{ijt}. \end{aligned} \quad [7]$$

Substituting [6] and [7] into [5], we have:

$$\theta_{0t} + \sum_{i=1}^m \theta_{it} D_{ijt} = \omega_{jt} \quad [8]$$

Where:

$$\omega_{jt} = \varepsilon_{0jt} - \sum_{i=2}^m \varepsilon_{ijt} D_{ijt} \quad [9]$$

the left-hand side of [8] is defined as representing of systematic changes in welfare over time among the farmers, Since the assumptions in [6] and [7] show that $E[\omega_{jt}] = 0$. Equation [8] illustrates that these systematic changes are attributed to changes in the moments of individuals' profit distributions and to other

systematic changes in welfare symbolized by θ_{0t} . The random variation in welfare changes is indicated by the error term ω_{jt} . Random changes in welfare are decomposed into two parts: random variation in individuals' behavioral parameters, represented by the ε_{ijt} , $i=2, \dots, m$; and other random events characterized by ε_{0jt} based on equation [9] (Antle (2)).

One must be careful to use standardized units, in comparing risk attitude estimates across regions. The θ_{it} in [8] indicate mean absolute risk attitudes between farmers. For instance θ_{2t} is an estimation of the mean absolute Arrow-Pratt coefficient $-U''/U'$. So, The partial Arrow-Pratt coefficient $-\pi(U''/U')$ is unit-free because the units of this term are the reciprocal of the units of profit π (Antle, 1989). In view of the fact that both π and the Arrow-Pratt coefficient are random variables among the farmers, their joint distribution must be estimated with the purpose of verify the distribution of the partial risk-attitude coefficient. This can be achieved by a suitable transformation of model [8]. Reminder that the r_{ijt} defined in [5] are in units of $(\pi)^{1-i}$ and the D_{ijt} are in units $(\pi)^i$ therefore $r_{ijt} D_{ijt}$ is in units of π . Consequently $r_{ijt} (\mu_{1jt})^{i-1}$ is unit free and $D_{ijt}(\mu_{1jt})^{1-i}$ is in units of π . Hence, by redefining the terms in [5] as (Antle (2)):

$$r_{ijt} = \frac{(\Delta U_{jt} / \Delta \mu_{ijt})}{(\Delta U_{jt} / \Delta \mu_{1jt})} \times \left((|\mu_{1jt}| + |\mu_{1j,t+1}|) / 2 \right)^{i-1} \quad [10]$$

$$D_{ijt} = \Delta \mu_{ijt} \left((|\mu_{1jt}| + |\mu_{1j,t+1}|) / 2 \right)^{i-1}$$

$i = 2, \dots, m$

The θ_{it} can be defined as the farmers' means of the partial risk-aversion coefficients and the σ_{ijt} can be interpreted as the farmers' variances of the partial risk-aversion coefficients (Antle (2)).

Estimation of the moments of the profit distribution [1] and estimation of equation [8] and [9] are required for econometric estimation of the θ_{it} , the γ_{ijt} and possibly other covariance's (Antle (2)). In this study, the profit distribution is characterized by its first three moments. The moments of the profit distribution are assumed to be functions of a set of observed variables from each farm. The

functions are presumed to be quadratic in land in crop, total amount of fertilizer that is used in crop production, labor force input, and machinery input. The estimation of the moments of the net return distribution is according to the method given in Antle (1).

Equations [8] and [9] offer the foundation for the econometric estimation of the parameters of the risk attitude distribution. In the rest of this section and in the empirical results, it is supposed that mean risk attitudes, characterized by the parameters θ_{it} , are constant over time in such a way that $\theta_{it}=\theta_i$ for all i and all t . With the aim of interpret the model [8] in standard econometric form, it can be written (Antle (2)):

$$D_{1it} = -\theta_{0t} - \sum_{i=2}^m \theta_i D_{ijt} + \omega_{jt}$$

Because $\theta_1=1$ in equation [8] and the parameter θ_{0t} is defined as a linear function $\theta_{0t}=\theta_{00}+d_t\theta_{01}$, where d_t is a vector of dummy variables to estimate year-specific change in the mean welfare of the farmers. The model can be written in the vector form as (Antle (2)):

$$D_{1j} = D_{2j}\theta + \omega_j$$

$$j = 1, \dots, N$$

where D_{1j} is a $(T \times 1)$ vector, D_{2j} is a $(T \times g)$ matrix of the D_{ijt} for farm j , θ is the corresponding $(g \times 1)$ vector of parameters, and ω_j is the $(T \times 1)$ vector of the ω_{jt} . Including the D_{1j} and ω_j into $(NT \times 1)$ vectors D_1 and ω , and D_{2j} into an $(NT \times g)$ matrix D_2 , we can be write (Antle (2)):

$$D_1 = D_2\theta + \omega \tag{11}$$

An suitable estimator can be made using the two-stage least squares version of Hansen's generalized method of moments (GMM) estimator to account for the possible endogeneity of the D_{ijt} , also for the no scalar structure of the covariance matrix that may be induced by the random coefficient structure of the model because in this model the error term ω shows variation across individuals and over time due to differences in risk attitudes. Under the supposition that the error

vectors ω_j are uncorrelated with a vector of variables y_j , the estimator of θ is described as (Antle (2)):

$$\theta^e = (W'D_2)^{-1} W'D_1$$

Where

$$W = Y(Y'Y)^{-1}Y'D_2$$

and Y is the matrix including the vectors Y_i , organized so as to be consistent with the definition of D_2 (Antle (2)).

Data:

The data used in this study were collected from a sample of forty farmers during four years (1988-92). To select the sample, two-stage cluster sampling was used. At the first stage eight villages were selected from Ramjerd district. In the second stage, by using a systematic random sampling method, forty farmers were selected for interview. The interview was repeated for four successive years starting in 1988. Thus, 160 observations were used for the estimation of the net return distribution (first three moments). After estimating the net return distributions and putting them in difference form for estimation of the risk-attitude equation, there were three observations over time for each sample farm. Thus, 120 observations were used for the estimation of the risk-attitude equation. In practice due to econometric problems only 138 observations were used for the estimation of the net return distributions and 110 observations were used for the estimation of the risk-attitude equation.

Two kinds of information are required to estimate the models of this study. First, data correlated with net returns are needed to estimate the net return distribution. Variables measuring land in crop, total fertilizer quantity used in crop production, machinery input, labor force input, would be appropriate. The moments of the net return distributions were assumed to be quadratic functions of these variables for each farm.

Second, a set of instrumental variables is required for estimation of the distribution of risk attitudes. These instruments should be correlated with net returns, but at

least in the limit, uncorrelated with risk attitudes. In this study, the instruments were farm size, acreage, annual dummy variables and farmer education variables.

RESULTS AND DISCUSSION

Parameters of the various moments were estimated by using general least squares (GLS) method. The results are presented in Tables 1, 2 and 3.

Table 1. GLS estimates for parameters of the first moment.

Variable	Coefficient	Standard error	t-value	Significance†
Constant	2334.698	29851.836	0.078	NS
(Land)	6221.538	804.429	7.734	***
(Fertilizer)	0.007	0.002	3.172	***
(Machinery)	-70.630	31.787	-2.222	**
(Labor)	8.310	2.582	3.218	***
(Rain)	-67.267	163.362	-0.412	NS
(Land) ²	-42.030	10.614	-3.960	***
(Fertilizer) ²	-2.872E-06	1.0692E-06	-2.687	**
(Machinery) ²	0.061	0.014	4.327	***
(Labor) ²	-1.775E-03	7.194E-04	-2.467	**
(Rain) ²	0.142	0.214	0.665	NS

R² = 0.973 Significance: † *** = 1% level
 \bar{R}^2 = 0.971 ** = 5% level
 F = 507.566 * = 10% level
 Significance F = 0.0000 NS = Non-significant
 Number of observations = 138

All moment functions were highly statistically significant. The estimated regression for the first moment of the net return distribution has an R² value of 0.973 indicating that 97.3% of the first moment variation is explained by the explanatory variables. Most variables had significant influence on the first moment but rain did not have a significant effect on this moment. The R² value of the second moment of the return distribution was 0.747 with a high level of significance. All variables had significant influence on this moment. The R² value of the third moment equation was 0.22. In this equation also most of variables had a significant coefficient. After estimating the net return distribution they were put in difference form for estimation of the risk attitude Eq. [11]. Because, neither a

Table 3. GLS estimates for parameters of the third moment

Variable	Coefficient	Standard error	t-value	Significance†
Constant	-2.550E+12	2.114E+13	-0.121	NS
(Land)	1.732E+12	5.698E+11	3.04	***
(Fertilizer)	-349964.589	163613.400	-2.139	**
(Machinery)	-46294666404		-2.056	**
(Labor)	4200159808.1	8866245	2.297	**
(Rain)	-9772757658	1.159E+11	-0.084	NS
(Land) ²	-293992102691	7518359469	-3.909	***
(Fertilizer) ²	2.356	0.980	2.392	**
(Machinery) ²	26714387.367	9933406-798	2.689	***
(Labor) ²	-905426.634	509569.159	-1.77	*
(Rain) ²	31940439.882	152102750.7	0.210	NS

$R^2 = 0.220$ †Significance: *** = 1 percent level
 $\bar{R}^2 = 0.158$ ** = 5 percent level
 $F = 3.579$ * = 10 percent level
 Significance $F = 0.0000$ NS = Non-significant
 Number of observations = 138

Table 4 illustrates OLS estimates of the model [11] using the data conversion defined in Eq. [10]. The parameter estimates of θ_2 and θ_3 were used to calculate the Arrow-Pratt and downside partial risk-aversion coefficients. Because these coefficients are obtained based on the formulas $AP = -2\theta_2$ and $DS = 6\theta_3$, the mean Arrow-Pratt (AP) and downside (DS) partial risk-aversion coefficients for Ramjerd district are 0.622 and 0.072, respectively. Therefore, the results indicate that at the population mean, the decision makers in study district are both Arrow-Pratt and downside risk-averse. Moreover, the Arrow-Pratt and downside partial coefficients are statistically significant at greater than 1% and 10% levels, respectively. The time dummy parameters in the model determine welfare change from one period to another at the population mean. The results provide support of significant movement in aggregate welfare in the year 1991. For comparison, Saha et al. (18) estimated the measure of relative risk-aversion for Kansas wheat farmers to be 5.4 and Antle (1) estimated the measure of partial risk aversion of Indian farmers to be in the range of 0.19 to 1.77. Binswanger (7) reported similar results. His estimated measure of partial risk aversion was between 0.32 and 1.72 for the

majority of the individuals. Bar-shira et al. (6) estimated the measure of partial risk-aversion of Israeli farmers to be in the range of 0.04 to 0.52. Thus, our sample of Ramjerd district farmer falls in the Antle (1, 2) and Binswanger (7) range but exhibits a higher degree of partial risk aversion than the Israeli farmers as reported by Bar-shira et al. (6).

Table 4: OLS estimate of the risk attitude model.

Parameter	Coefficient	Standard error	t-value	Significance†
Constant	-0.438	0.521	-0.841	NS
θ_2	-0.311	0.109	-2.850	***
θ_3	0.012	0.006	1.984	*
Time dummies				
1990	-0.401	0.479	-0.837	NS
1991	3.413	0.855	3.991	**
$R^2 = 0.460$	†Significance:		*** = 1 % level	
$\bar{R}^2 = 0.392$			** = 5 % level	
F = 22.361			* = 10 % level	
Significance F = 0.0000			NS = Non-significant	
Number of observations = 110				

CONCLUSION

In this paper producers' risk attitudes in Ramjerd district were estimated by using the nonstructural approach proposed by Antle (2). The results indicated that the mean Arrow Pratt (AP) and downside (DS) partial risk-aversion coefficients for farmers in the Ramjerd district are 0.622 and 0.072, respectively. Thus, the decision-makers at the population mean are both Arrow-Pratt and downside risk averse. When farmers are risk-averse, they are expected to put a premium on production methods that decrease risks. Consequently, these coefficients can be used in the analysis of farmers' behavior and for preparing risk-efficient strategies of water and other resources. In addition, the coefficients can be used to estimate benefits due to risk reduction.

LITERATURE CITED

1. Antle, J.M. 1987. Econometric estimation of producers' risk attitudes. *Amer. J. Agric. Econ.* 69:509-522.
2. Antle, J.M. 1989. Nonstructural risk attitude estimation. *Amer. J. Agric. Econ* 71:774-784.
3. Arrow, K.J. 1971. *Essays in the Theory of Risk-Bearing*. Markham Publishing Co., Chicago, U.S.A.
4. Bardsley, P. and M. Harris. 1987. An approach to the econometric estimation of attitudes to risk in agriculture. *Aust. J. Agric. Econ.* 31:112-126.
5. Bar-shira, Z. 1992. Nonparametric test of the expected utility hypothesis. *Amer. J. Agric. Econ.* 74:523-533.
6. Bar-shira, Z., R.E. Just and D. Zilberman. 1997. Estimation of farmers' risk attitude: An econometric approach. *Agric. Econ.* 17: 211-222.
7. Binswanger, H.P. 1980. Attitude toward risk: Experimental measurement in rural India. *Amer. J. Agric. Econ.* 62:395-407.
8. Binswanger, H.P. 1981. Attitude toward risk: Theoretical implication of an experiment in rural India. *Econ. J.* 91:867-890.
9. Binswanger, H.P. 1982. Empirical estimation and use of risk preferences: Discussion. *Amer. J. Agric. Econ.* 64:391-393.
10. Dillon, J.L. and P.L. Scandizzo. 1978. Risk attitudes of subsistence farmers in Northeast Brazil: A sampling approach. *Amer. J. Agric. Econ.* 60:425-434.
11. Hazell, P.B. R. 1982. Application of risk preference estimates in firm-household and agricultural sector models. *Amer. J. Agric. Econ.* 64:384-390.
12. Just, R.E., E. Hochman, D. Zilberman and Z. Bar-shira. 1990. Alternative approaches for allocating observed input use among crops. *Amer. J. Agric. Econ.* 72:200-209.
13. Love, H.A and S.T. Buccola. 1991. Joint risk preference-technology estimation with a primal system. *Amer. J. Agric. Econ.* 73:765-774.

14. Moscardi, E. and A. de Janvry. 1977. Attitudes toward risk among peasants: An econometric approach. *Amer. J. Agric. Econ.* 59:710-716.
15. Pope, R.D. 1982. Empirical estimation and use of risk preferences: An appraisal of estimation methods that use actual economic decision. *Amer. J. Agric. Econ.* 64:376-383.
16. Pope, R.D. and R.E. Just. 1991. On testing the structure of risk preferences in agricultural supply analysis. *Amer. J. Agric. Econ.* 73:743-748.
17. Quizen, J. B., H. P. Binswanger, and M. J. M. Achina. 1984 Attitude toward risk: Further remarks. *Econ. J.* 94:144-148.
18. Saha, A., R. Shumway and H. Talpaz. 1994. Joint estimation of risk preference structure and technology using expo-power utility. *Amer. J. Agric. Econ.* 76:173-184.
19. Shahabuddin, Q., S. Mestelman and D. Feeny. 1986. Peasant behaviour towards risk and socio-economic and structural characteristics of farm households in Bangladesh. *Oxford Economic Papers* 38:122-130.