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Agricultural Risk Analysis in the Fars Province of Iran:
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Abstract

Mathematical programming methods are widely used for modelling farmers' decision-making and for economic analysis in agriculture. In this study, a MOTAD risk-programming model is applied to study the effects of risk on cropping pattern and farmers' income in Ramjerd and Sarpaniran districts near Marvdasht in the Fars Province of Iran. Primary data from 194 farmers randomly selected from 31 villages are used in this study. The results indicate that variability of crops gross margins or outcomes has a significant effect on cropping pattern but it varies over different farmers and regions with various conditions. Moreover, it was found that farm plans with more number of crops have a lower return but high degree of certainty. Based on this research, farmers' risk attitudes and expectations and using more sophisticated methods for generating time series data with dependency are some important issues which should be considered in the future studies.

Key Words: risk analysis, MOTAD model, and risk-programming model

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Introduction

The study of risk has been one of the main focuses of literatures in agricultural production analysis. Agricultural production processes are inherently risky. Risk plays an important role in farmers' decision making and therefore in output supply. In recent years, a number of empirical and theoretical studies have evolved on incorporating risk in understanding the complexities of agricultural production processes.

Programming models were prominent in early theoretical and empirical research on risk-efficient choices, beginning primarily with Freund's (1956) incorporation of risk into a quadratic programming (QP) model. Mathematical programming methods are widely used for modelling farmers' decision-making and for economic analysis in agriculture (Hazell & Norton 1986, Hardaker et al. 1991). Building on the QP formulation, subsequent model developments in agricultural economics generally dealt with introducing risk into a computationally feasible programming format, or dealt with introducing different types of risk-aversion assumptions, such as safety-first or mean-variance, into a programming format (Taylor and Zacharias, 2002).

Some of the programming formulations include quadratic risk programming (QRP), mean absolute deviation (MAD), absolute negative total deviation (ANTD), minimisation of total absolute deviation (MOTAD) in a linear programming framework, target MOTAD, direct expected utility-maximising nonlinear programming and discrete stochastic programming, among others. MOTAD model is one the popular methods and an alternative to quadratic-risk programming. It has been used in many previous studies such as Simmons & Pomareda (1975), Mruthyunjaya & Sirohi (1976), Rajagopalan & Varadarajan (1976), Brink & McCarl (1978), Schurle & Erven (1979), and Belete et al. (1993).

In Iran, the use of programming techniques in decision analysis in agriculture has been limited. Soltani (1972) applied an ordinary linear programming technique for the first time in 1969. He used this method to study the problems of choosing irrigation systems in Iran. Kehkha (1994) discussed and applied risk-programming models in agricultural economics studies for the first time in Iran. Empirical and theoretical literature on agricultural risk issues and mathematical programming modelling approaches were comprehensively reviewed in his research. After that, Torkamani and Hardaker (1996) used a non-linear discrete stochastic programming method to study the economic efficiency of a sample of farmers in Iran. This paper attempts to provide empirical evidence on the nature of risk in Iranian agriculture. In this study, a MOTAD risk-programming model is used to study the effects of risk on cropping pattern and farmers' income in the Fars Province of Iran. The effects of risk on shadow prices of scarce resources are also investigated in this study.

Area of study

This study was conducted in Ramjerd and Sarpaniran districts near Marvdasht region in the Fars Province of Iran. These two districts are characterized by different climatic, social and economic conditions. Farmers in Sarpaniran plains are faced with higher yield and price variability, which are the main sources of agricultural risks in the study regions. Climatic variability is lesser in the Ramjerd region and it has relatively better access to infrastructure facilities such as transportation and agricultural inputs and outputs markets. The contrasting environmental conditions for these two regions provide the basis for comparison of the results of using risk-programming models.

The Data

Two groups of data were used in this study: (1) primary data, and (2) secondary data. A multi-stage survey sampling method was used to collect primary data. In the first stage, villages were classified into different categories based on the per capita farming area and its distribution. In the second stage, a two-stage cluster sampling method was applied to randomly select sample villages and farmers in each region. Based on this method, a total of 21 villages and 169 farmers in the Ramjerd region were selected. An additional 10 villages, with 25 farmers were selected in Sarpaniran plain which provides to a total of 194 respondents in the survey.

Although there is lots of literature on risk in agriculture and related issues, but it is still difficult to find a general agreement on risk definition. Hardaker (2000) tries to relax this complexity by reviewing and critically discussing three common definitions of risk. These definitions are the chance of a bad outcome, the variability of outcomes, and the uncertainty of outcomes. He argued that the whole distribution of outcomes is probably the best for formalising risk. However, variance and consequently standard deviation of farm income is considered as a criterion of risk or income variability in this research. Moreover, it is assumed that only prices and yields of crops are risky and affect farmers' income. This assumption allows an examination of trade-off between risk (variance) and expected return. For calculating the variance of farm income or of a certain cropping plan (which is assumed as risk in this case) both variances of crop returns and covariances among them are required. Estimation of variances and covariances is difficult where farmers do not record historical data. In this case, variances of expected gross margin for each crop were separately elicited from subjective information collected from farmers. But estimation of the covariances was more complicated. In this regard, first historical data of crop prices and yields at the provincial level were collected. Using a shorter length of time series data is usually recommended when these data are directly used in the model, because farmers normally plan based on the data of the recent years, especially for prices. But in this research, since historical data were used only to determine correlations among different crops returns, a series of 19 years of regional annual data was used. Using a longer series of data was believed to represent correlation relationships better. For the given historical period of study, a 19-year-series of gross margins for each crop was calculated subject to constant variable costs. Then trend functions were separately estimated for each crop. In this function, gross margin and time (year) are dependent and explanatory variables respectively. The effects of inflation, structural changes in agricultural markets and Iran's economy, and also the effect of supportive price policies, taken by the government, were all removed from the data. For each crop, several types of functional forms were estimated and the most appropriate one with highest R^2 was finally chosen. After finalising the trend function for each crop, residual terms (e_i) for the chosen regression function were calculated. After that, normal standard values (z_i) for related e_i are calculated by using the following formula:

$$e_i \sim N(0, \sigma^2) \Rightarrow z_i = e_i / \sigma \sim N(0,1)$$

In the next step, a backward method was used to generate a new series of e_i ($\hat{e}_i$) by using subjective variances ($\hat{S}^2$) elicited from the information provided by farmers.

$$\hat{e}_i = z_i * \hat{S} \sim N(0, \hat{S}^2)$$

Farmers' expected gross margins and $\hat{e}_i$ were finally used to generate a new series of gross margins. The new modified series of gross margins has subjective expected gross margins and variances and also retains the historical correlation among the gross margins of different crops.

The Model

There are numerous models used for farm planning under risk and uncertainty circumstances (Hardaker et al, 2004). Data requirements and their availability, budget, time and other research facilities allocated to the study are important in selecting an appropriate model. Moreover, any model should be able to use available data efficiently and reflect the existing realities of the research problem simply. As previously mentioned, among all risk-programming models, Quadratic Risk Programming Model (QRPM) and its alternatives have been considered in previous studies. Because of the advantages of MOTAD model as an appropriate alternative for QRPM, a MOTAD risk-programming model was applied in this study.

The general formulation for a MOTAD model is as follows (Hazel, 1971):

$$\textit{Minimize} \qquad D = \sum_{h=1}^{t} Y_h^-$$

Subject to :

$$\sum_{j=1}^{n} C_j X_j = E \qquad \textit{for} \quad j = 1, \cdots\cdots, n$$

$$\sum_{j=1}^{n} a_{ij}X_j \le b_i \qquad for \quad i = 1,\cdots\cdots,m$$

$$\sum_{j=1}^{n} U_{hj}X_j + Y_h^- \ge 0 \qquad for \quad h = 1,\cdots\cdots,t$$

$$and \qquad Xj \, , Y_h^- \quad \ge 0$$

Where

- Y_h^- is the absolute value of the negative deviation in gross margin from its mean at h^th year.
- C_j is the expected gross margin of j^th crop or activity
- X_j is the activity level
- E is the expected total gross margin which parametrically changes from 0 to E_{max}.
- a_{ij} is the technical coefficient
- b_i is the available resource
- U_{hj} is the generated residual term of j^th crop at h^th year
- m, n, t are respectively number of activities, constraints, and sample years

This model minimizes the sum of the negative deviations of gross margins below the mean (trend in this case) or consequently the sample Mean Absolute Deviation (MAD) for a given level of expected value of farm income (E). Standard deviation (Ŝ) of the expected gross margin of a given cropping pattern obtained from the model solution is approximately calculated by the following formula:

$$\hat{S} = M \left[\frac{\Pi * t}{2(t-1)} \right]^{1/2}$$

Where t is the number of sample years, M = 2D/t is the sample MAD, and π is the mathematical constant. Farm income variance ($\hat{S}^2$) can be also estimated by the following equation:

$$\hat{S}^2 = M^2 \left[\frac{\Pi * t}{2(t-1)} \right]$$

This model is able to determine the combination of activities which has the least variance for a given level of income. By changing E parametrically, the efficient frontier or E, V efficient set can be determined. This model has been used to investigate the research objectives.

Since model building for each farmer is time and budget-consuming and rather unnecessary, farmers were classified into five homogeneous groups. In order to increase homogeneity of the farmers within a group, relationships between average gross margin per hectare and all production factors and also general farm characteristics such as size, soil quality and water resource features were analysed by using analysis of variance and t-test methods. Then, a representative farm model was built for each group of farmers. Table 1 shows average areas of crops in the different groups of farmers in this study.

Table 1- Average area under crops in different representative farms (ha.)

Crop	Ramjerd			Sarpaniran	
	Group 1	Group 2	Group 3	Group 1	Group 2
Wheat	3.05	4.63	12.50	3.25	5.40
Barley	0.25	1.25		0.24	
Rice*	0.40	0.40	0.65		
Sugarbeet		0.75			
Sunflower		0.25			0.20
Pea		0.13			
Alfalfa				0.50	0.70
Potato					
Tomato			0.40	0.25	0.30
Sesame				0.40	
Rockmelon		0.13	1.11		
Sorghum					
Corn					0.50
Fallow			1.13		
Total	3.70	7.54	14.66**	4.64	7.10

* Farmers are not legally allowed to plant more that 0.65 ha. rice In Ramjerd region

** without fallow

Results

As previously mentioned, in this study risk is measured by the variance of total gross margin (TGM). Analyses of the correlation matrix of the crops gross margins shows that the correlation coefficient ranges from –0.48 to +0.75. Negative (or relatively smaller) correlation or covariance among gross margins affects negatively the variance of TGM or income instability. In other words, variance of TGM decreases when the numbers of crops with negative or smaller covariances increase in a certain cropping plan. The results show that the number of crops with negative covariance in Sarpaniran is less than in Ramjerd.

Additionally, comparison of variance-covariance matrix based on the subjective data and historical data reveals that the provincial historical data are not able to appropriately reflect farmers' expectations in this regard. Subjective variances and their range of variations are much bigger than the figures obtained from the historical data. However, crop orders are the same based on their variances obtained from historical and subjective data. Moreover, results show that government policies regarding input subsidies and output guaranteed prices have caused a significant imbalance in the crops' income relationships so that some crops, such as wheat, have high income with low variance which is normally unexpected.

Tables 2 to 6 present the results obtained from the risk programming models developed for different groups of the farmers studied. The results indicate that variability of crops gross margins or outcomes has a significant effect on cropping pattern. Moreover, cropping patterns with more number of crops have a lower return but a high degree of certainty. Unlike Sarpaniran, farmers in the Ramjerd area have more choices of farm plans because climatic conditions in Ramjerd allow them to plant more crops. As previously mentioned, increasing the number of crops with negative covariances or lower correlation enhances this opportunity for farmers in this region. Additionally, farmers in Sarpaniran obtain relatively lower expected income with higher risk or variability of outcomes per hectare on average. Climatic conditions of Sarpaniran do not allow farmland to be planted twice a year while in Ramjerd it does. Also rice, as a high-income crop, cannot be planted in Sarpaniran because of water and climatic constraints. Results analysis between the groups of a region shows that bigger farms gain a given income with lower risk. In other words, small farmers are exposed to more risk for obtaining the higher levels of income.

Table 2- E,S efficient farm plans for group 1 farmers in the Ramjerd region

	Cropping patern					
	1	2	3	4	5	6
Total expected value(E) (1000Rials)	2289	2993	3432	3839	4009	4244
Standard deviation(S) (1000Rials)	136	204	272	340	408	614
Area under crops (ha.)						
Wheat	0.21	0.52	1.00	1.73	1.92	3.30
Barley	0.61	1.00	1.12	1.17	1.41	0.40
Rice	0.19	0.28	0.38	0.39	0.40	0.40
Sugarbeet	0.13		0.07	0.34	0.06	
Sunflower	0.47	0.60	0.51			
Pea						
Alfalfa						
Potato	0.04	0.08	0.06	0.07	0.11	
Tomato	0.07	0.10	0.08	0.05	0.11	
Sesame	0.61	0.57				
Rockmelon		0.14	0.16	0.09	0.13	
Sorghum	0.09					
Corn	0.57	0.42	0.42	0.06		

Table 3- E,S efficient farm plans for group 2 farmers in the Ramjerd region

	Cropping patern					
	1	2	3	4	5	6
Total expected value(E) (1000Rials)	2322	4624	6722	7361	8080	8391
Standard deviation(S) (1000Rials)	136	272	544	714	1224	1798
Area under crops (ha.)						
Wheat	0.33	0.66	2.56	3.56	6.22	6.33
Barley	0.62	1.23	1.95	2.50	0.13	0.22
Rice	0.18	0.36	0.40	0.40	0.40	0.40
Sugarbeet	0.21	0.41	0.88	1.09		
Sunflower	0.39	0.78				
Pea			0.19	0.06		
Alfalfa						
Potato		0.01	0.10	0.14	0.27	
Tomato					0.37	1.02
Sesame	0.18	0.35	0.08			
Rockmelon			0.04	0.15	0.50	
Sorghum	0.04	0.08				
Corn	0.80	1.60	1.31			

Table 4- E,S efficient farm plans for group 3 farmers in the Ramjerd region

	Cropping patern					
	1	2	3	4	5	6
Total expected value(E) (1000Rials)	1103	10176	11856	13640	14122	14705
Standard deviation(S) (1000Rials)	68	680	1088	1632	1904	8160
Area under crops (ha.)						
Wheat	0.17	2.05	4.97	9.66	10.60	
Barley	0.29	2.77	4.15	2.17	2.20	
Rice	0.09	0.65	0.65	0.65	0.65	0.65
Sugarbeet	0.10	1.01	1.75	0.76		
Sunflower	0.23	1.78			0.16	
Pea		0.28		0.92	0.55	
Alfalfa						
Potato		0.61	0.16	0.21		
Tomato					0.05	
Sesame	0.07	0.63				
Rockmelon			0.05	0.621	1.318	12.00
Sorghum	0.02					
Corn	0.41	3.55	2.03			
Fallow	1.13	1.13	1.13	1.13	1.13	1.13

Table 5- E,S efficient farm plans for group 1 farmers in the Sarpaniran region

	Cropping patern					
	1	2	3	4	5	6
Total expected value(E) (1000Rials)	1405	2724	3541	4331	4616	4814
Standard deviation(S) (1000Rials)	136	272	408	680	986	1428
Area under crops (ha.)						
Wheat	0.08	0.48	1.30	3.54	3.60	3.61
Barley	0.25	1.34	1.10	0.05		
Sunflower	0.50	0.56	0.53			
Pea		0.01	0.29			
Alfalfa	0.25	0.00		0.49		
Potato	0.02	0.10	0.18	0.20	0.40	
Tomato		0.02	0.13	0.21	0.53	1.02
Sesame	0.14	0.96	1.11	0.19		
Corn	0.99	0.72				

Table 6- E,S efficient farm plans for group 2 farmers in the Sarpaniran region

	Cropping patern					
	1	2	3	4	5	6
Total expected value(E) (1000Rials)	1341	3779	5243	6285	7009	7334
Standard deviation(S) (1000Rials)	136	408	68000	952	1632	2212
Area under crops (ha.)						
Wheat	0.11	1.47	3.38	4.89	5.57	5.61
Barley	0.16	1.24	1.53	0.34		
Sunflower	0.65	0.66	0.21			
Pea						
Alfalfa	0.25			1.09	0.06	
Potato	0.01	0.07	0.07	0.30	0.41	1.49
Tomato		0.01	0.02	0.17	0.96	
Sesame		0.57		0.16		
Corn	1.14	2.05	2.21	0.00		

For better understanding, figures for the E, S efficient frontiers for each of the study groups are provided (Figure 1). As the figures show, feasible farm plans (area under E, S graph) increase as the amount of available resources increase[1]. Regionally, this area (area under E, S graph) is much bigger for farmers in Ramjerd because of the several reasons discussed previously. Another point is that the slope of all frontiers is greater or equal to zero but it changes along the curves. The slope of curves decreases gradually and it is approaching to zero where the maximum expected income can be obtained. The analysis also shows that slope of the figures at the same point for bigger farms is more which confirms that they suffer from lower risk for obtaining more income compared to small farms. Also figures for Sarpaniran farmers comparatively show that they are relatively exposed to a higher risk for obtaining a higher income.

[1] Note that farmers in the both regions were grouped according to farm size, with the higher the group number indicates a larger farm size.

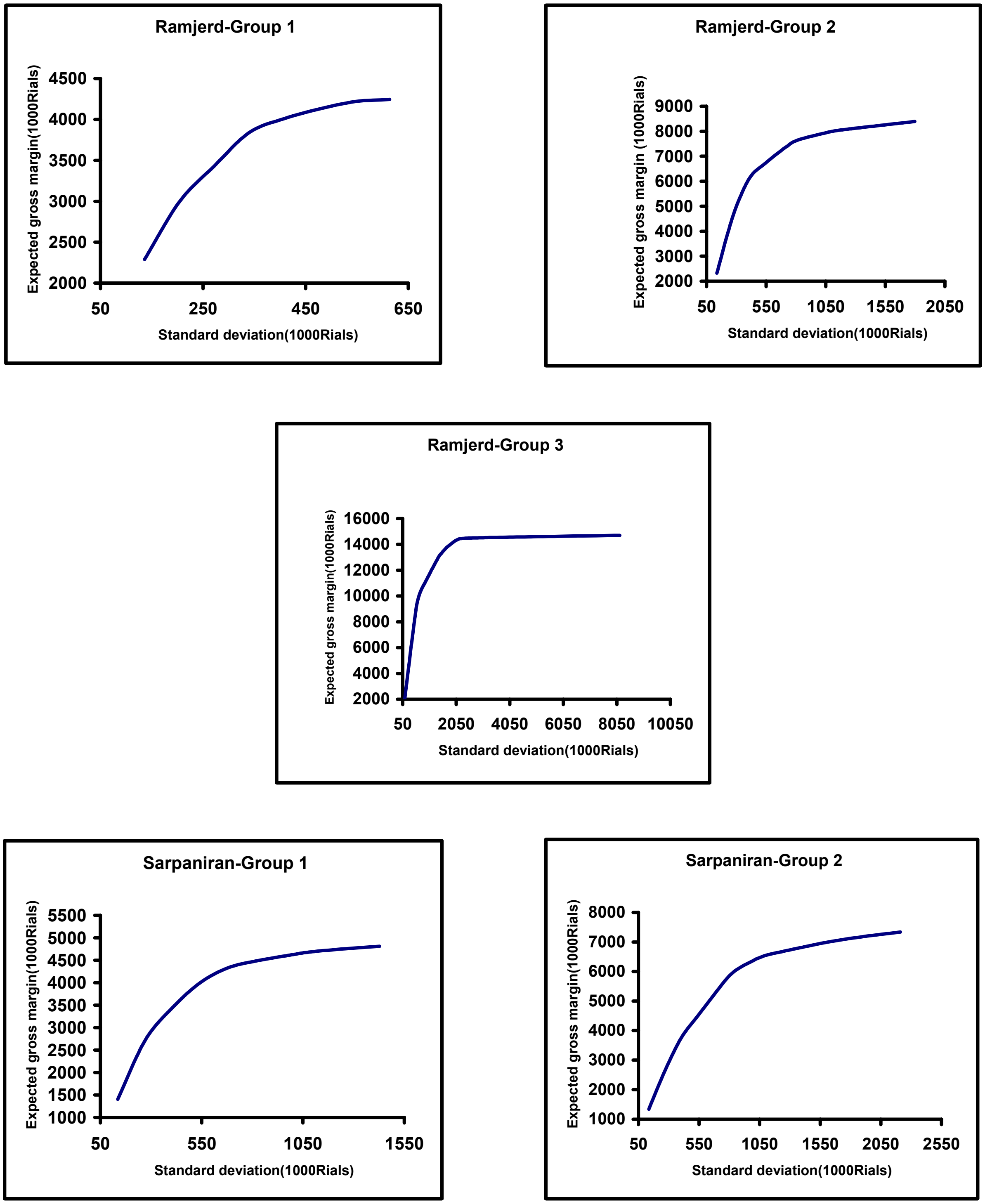

Figure 1- E,S efficient frontiers for representative farms

The effects of risk on shadow prices of scarce resources have been also investigated in this study, of which only the results for water resources are presented (Table 7). This information is necessary for making decisions regarding resource development and management. The results verify that the higher the expected income and risk the higher the shadow price of water except for farmers of group two in Ramjerd. Comparing the characteristics of this group to the others reveals that shadow price of water or any other scarce resources depend on many factors. For instance, amount of available resources and farmers risk attitudes, which determine farmers' performance in relation to trade-off between risk and expected income, are of important issues. Moreover, at the same level of risk or expected income, water shadow prices for small farmers are higher. But this figure is overall greater for bigger farms that can perform at high levels of income due to their enjoyment of more resources. Results show that water value for farmers in Sarpaniran is more than in Ramjerd on average. When farmers' risk attitudes dictate the crops raised in winter and spring, water value in spring is higher than summer, which is normally unexpected. If farmers are risk neutral, their water requirement for cropping pattern in summer is higher and consequently the value of water in summer is more than that in other seasons.

Table 7 - Water shadow prices for various E,S efficient plans in different representative farms

Ramjerd-Group 1	E,S efficient plans				
	1	2	3	4	5
Total expected value(E) (1000Rials)	2289	3432	4009	4127	4244
Standard deviation(S) (1000Rials)	136	272	408	476	614
Shadow price(Rials/M^3)	0	37	64	69	70
Ramjerd-Group 2					
Total expected value(E) (1000Rials)	2322	6722	7647	7982	8391
Standard deviation(S) (1000Rials)	136	544	816	1088	1798
Shadow price(Rials/M^3)	0	40	63	72	50
Ramjerd-Group 3					
Total expected value(E) (1000Rials)	1103	11856	13640	1444	14705
Standard deviation(S) (1000Rials)	68	1088	1632	2176	8160
Shadow price(Rials/M^3)	0	35	55	70	84
Sarpaniran-Group 1					
Total expected value(E) (1000Rials)	1405	2724	4331	4481	4814
Standard deviation(S) (1000Rials)	136	272	680	816	1428
Shadow price(Rials/M^3)					
Spring	0	0	102	96	86
Summer	0	26	32	36	98
Sarpaniran-Group 2					
Total expected value(E) (1000Rials)	1341	2671	5915	7009	7334
Standard deviation(S) (1000Rials)	136	272	816	1632	2212
Shadow price(Rials/M^3)					
Spring	0	0	56	104	79
Summer	0	40	37	34	100

Summary and Conclusions

This paper presents an application of MOTAD risk programming model in the Fars Province of Iran. The model was used to explore the effects of risk on cropping pattern and farmers' income. Risk effects on resource shadow prices have been also investigated in this study. The results indicate that variability of crops gross margins or outcomes has a significant effect on cropping pattern, but it varies over different farmers and regions with various conditions. Diversification is an important tool for farmers' to increase income certainty and to make trade-offs between risk and expected income. This research also reveals that government interference and policies have enhanced the competitive position of some crops, fixing them in cropping patterns. Moreover, disregarding risk and farmers' risk attitudes means that resource prices are inaccurately estimated and resource development investments evaluated incorrectly.

Reducing the negative effects of risk on resource allocation and farmers' income should be targeted by the public and private sectors and agencies. For this purpose, it seems that a set of appropriate policies such as crop insurance, agricultural input and output price policies should be investigated and applied in the region studied. The next research efforts should be also directed to estimate farmers' risk attitudes, eliciting farmers' expectations regarding prices and yields more precisely, and using more advanced methods for generating time series data with dependency that are required for using risk programming models.

References

Antle, J. M. 1983. 'Incorporating Risk in Production Analysis', *Am. J. Agri. Econ*. 65(5): 1098-1116.

Belete, A., J.L. Dillon and F. M. Anderson.1993. 'Efficiency of Small Farmers in Ethiopia: A Case Study in the Baso and Warana Sub-district'. *Agri. Econ*. 8 (3): 199-209.

Brink, L. and B.A. McCarl.1978. The Trade-off Between Expected Return and Risk among Corn-belt Crop Farmers.*Am.J.Agri.Econ*.60 (2): 259-263.

Freund, R. 1956. 'The Introduction of Risk into a Programming Model', Econometrica 21, 253-263.

Hardaker. J.B., 2000. Some Issues in Dealing with Risk in Agriculture. Working Paper Series in Agricultural and Resource Economics No. 2000-3, March, 18pp. http://www.une.edu.au/febl/EconStud/wps.htm

Hardaker, J.B., R.B.M. Huirne, J. R. Anderson and G. Lien.2004.*Coping with Risk in Agriculture* 2nd Edition. CABI Publishing.Wallingford,Oxfordshire, U.K. 332p.

Hardaker, J.B., S. Pandey and L.H. Pattern.1991. Farm Planning under Uncertainty: A Review of Alternative Programming Models.*Rev.Mktg.Agri.Econ*. 59(1): 9-22.

Hazell, P.B.R. and Norton, R.P. (1986), Mathematical Programming for Economic Analysis in Agriculture, Macmillan, New York.

Kehkha, A. A. 1994. The Effects of Risk on Cropping Pattern and Farmers' Income. Shiraz University, Shiraz, Iran.

Mruthyunjaya and A.S. Sirohi. 1976. Enterprise System for Stability and Growth on Drought-Prone Farms: An Application of Parametric Linear Programming, *Ind.J.Agr.Econ*.34 (1) 27-43.

Rajagopalan, V. and S. Varadarajan.1976. Impact of Risk and Uncertainty on Farm Production and Income in the Hills of the Nilgiris, Tamil Nadu, *Ind. J. Agri. Econ*. 33(4): 35-42.

Schurle, B. and B.L. Erven .1979. Sensitivity of Efficient Frontiers Developed for Farm Enterprise Choice Decisions. *Am.J.Agri.Econ*.61 (3): 506-511.

Simmons, R. L. and C. Pomareda. 1975.Equilibrium Quantities and Timing of Mexican Vegetable Exports. *Am. J.Agri.Econ*.57 (3): 472-479.

Soltani, G. R. 1972. Problems of Choosing Irrigation Techniques in a Developing Country. Water Resources Research. 8(1): 1-6.

Soltani, G. R., M. Zibaei and A.A. Kehkha. 1999. Application of Mathematical Programming in Agriculture. Agricultural Research, Education and Extension Organization. Ministry of Agriculture, Iran.

Taylor C.R. and Zacharias, T.P. (2002), 'Programming Methods for Risk-Efficient Choice', in Just, R.E. and Pope, R.D. (eds), A Comprehensive Assessment on the Role of Risk in U.S. Agriculture, Kluwer, Boston, 193-212.

Torkamani. J. and J. B. Hardaker.1996. A Study of Economic Efficiency of Iranian Farmers in Ramjerd District: An Application of Stochastic Programming. J. Agr. Econ. 14(2). 73-83.