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Abstract: A risk-programming model was developed to evaluate the tradeoffs between risk and expected returns for farms along the Kızılırmak River in North Central Anatolia. Risk efficient farm structures were derived for representative farms by using minimization of the absolute deviation procedures, which permit the estimation of a farm's risk-return frontier. Research results reveal that farm plans are sensitive to the risk criteria in the research area. Rice and maize are the most high-risk activities, followed by lettuce and soybean. Wheat, sugar beet and dairy activities have a more stabilizing effect on farm income compared to others. Medium size and large farms prefer more high risk and cash crops such as rice and soybean compared to small farms. The results also suggest that the total net farm return increases for all sizes as the risk increases and that farmers tend to choose more stable farm plans in the research area.

Key Words: Decision model, profit maximization, resource allocation, risk, MOTAD

Tarım İşletmelerinde Optimum İşletme Organizasyonlarının Riskli Koşullarda Tahmini: Gerçek Sapmaların Minimizasyonu Uygulaması

Özet: Bu çalışmada, Orta Anadolu Bölgesinin kuzeyinde Kızılırmak nehri kenarında yer alan tarım işletmelerinde risk ile beklenen gelir arasındaki ilişkiyi ortaya koymak için risk programlama modeli geliştirilmiştir. Tarım işletmelerine ait optimum işletme organizasyonları ve riskleri, risk-gelir sınırının tahmin edilmesini sağlayan gerçek sapmaların minimizasyonu yöntemi ile bulunmuştur. Araştırma sonuçları, inceleme alanında işletme planlarının riske bağlı olarak değiştiğini göstermiştir. Çeltik ve mısır riskli faaliyetlerin başında gelmekte, bunları lahana ve soya takip etmektedir. Buğday, şeker pancarı ve süt sığırcılığı faaliyetleri daha istikrarlı gelir getiren faaliyetlerdir. Orta ve büyük ölçekli işletmeler, çeltik ve soya gibi riskli ürünleri küçük işletmelere oranla daha fazla tercih etmektedirler. Araştırma sonuçları ayrıca, inceleme alanında bütün işletme büyüklük gruplarında risk arttıkça, toplam net işletme gelirinin de arttığını ve çiftçilerin daha istikrarlı planları tercih etme eğiliminde olduklarını göstermiştir.

Anahtar Sözcükler: Karar modeli, kâr maksimizasyonu, kaynak dağıtımı, risk, MOTAD

Introduction

For several decades resource allocation under uncertainty has received considerable attention. Since the efficiency of resource use is one of the drives of agricultural development, there has been much debate about resource allocation under uncertainty in agricultural production. Many farmers are very concerned with profit maximization and try to ensure this within their technological and institutional limits. In spite of the fact that some criticism has been directed at the applicability of the neoclassical approach to farm production by many authors (Lipton, 1968; Dillon and Hardaker, 1971; Upton, 1979), most earlier studies on decision models were strongly based on the assumption that farmers maximize their profits under perfect information. In the presence of imperfect information, farmers' objective functions must involve elements other than profit. Wolgin (1975) stated that traditional tests of economic efficiency in agriculture were generally mis-specified when farmers made decisions under risk. Ignoring risk may also lead to overvaluation of some inputs and incorrect prediction of technology choices (Hazell, 1982). Torkamani and Hardaker (1996) suggested that the farmer's decision-making problem might be regarded as one of the constraints of expected return optimization under uncertainty.

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Most earlier studies employed deterministic linear programming (LP) models to derive profit maximizing enterprise combinations for representative farms (Hopper, 1965; Yotopolus, 1968; Whitson, 1976; İnan, 1977; Demirci, 1978; Erkuş, 1979; Özçelik, 1985; Tatlıdil, 1987; Çetin, 1988; Erkan et al., 1989; Cinemre, 1990; İnan, 1992; Fidan, 1996; Kılıç, 1997). However, the paradigm of risk in resource allocation is a relatively unexplored area of research, particularly in developing countries. Too few, if any, less risk farm income models under the imperfect information of Turkish agricultural enterprises have been developed (Özçelik, 1988; Miran and Dizdaroğlu, 1994; Miran and Karahan, 1996; Ceyhan; 1998; Akçaöz and Akdemir, 2001; Özkan and Akçaöz, 2001). Minimization of the absolute deviation (MOTAD) programming may therefore be useful for modeling production patterns under uncertainty.

The objectives of this study are (i) to estimate farm structures for households along the Kızılırmak River in North Central Anatolia and (ii) to evaluate tradeoffs between risk and expected returns for farms.

MOTAD Programming Approach

There are various methods for incorporating risk in mathematical programming models in agriculture. These methods have been reviewed from many perspectives in the literature (Anderson et al., 1977; Hardaker et al., 1991; Hardaker et al., 1997). Quadratic risk programming (Freund, 1956) and its linear approximations such as MOTAD (Hazell, 1971) are the best-known applications of risk programming for whole farm planning. Since MOTAD requires only LP to arrive at solutions, it is the most widely used program in resource allocation under uncertainty (Hardaker et al., 1997). The MOTAD formulation generates the expected level of farm income using mean absolute deviations (E, M), which approximate expected values by their respective variances (E, V). There are assumptions of normally distributed net incomes for risk-averse decision makers (Collender and Chalfant, 1986) and a quadratic utility function (Hanoch and Levy, 1970) in MOTAD programming.

The MOTAD model is as follows:

maximize $E = cx - f$

subject to

$Ax \leq b$

$-Dx - Iy = u0$

$py \leq M$, M varied and $x,y \geq 0$

where E is expected net total farm return (E [TFNR]), c is a 1 by n vector of activity expected net revenues, x is an n by 1 vector of activity levels, f is fixed overhead costs, A is the technical coefficients matrix, b is a vector of resource stocks, D is an s by n matrix of deviations of activity net revenues from respective means (D = C - uc), C is a matrix of activity net revenues by each occurrence (10 in this case) and activity, I is an s by s identity matrix, y is an s by 1 vector of activity levels measuring negative income deviations by state, p is a 1 by s vector of probabilities of states and M is the mean absolute deviation of total net revenue.

Both the objective function and the first set of constraints are identical to a standard linear programming formulation: gross revenues are maximized subject to a set of farm-level constraints. The second constraint set estimates gross revenues deviations, which are weighted by the probability of their occurrence in determining mean absolute deviations.

The models constructed for representative farms in the research area included land, rotational constraints, seasonal constraints on labor and seasonal working capital, and barn and feed requirements for dairy herds and sheep. Twenty-one different crop rotations were used in the risk-programming models (Table 1). Activities in models included rice, soybean, rape seed, maize, wheat, maize for silage, sugar beet, dried beans, lentils, chickpeas, onions, tomatoes, lettuce, vetch, dairy enterprise and sheep fattening. Additional activities such as labor hiring (seasonal), borrowing working capital and buying straw and grass were also included (Tables 2-4).

After deriving risk efficient farm structures for representative farms by using MOTAD procedures, each alternative structures for the relevant range of risk was presented in both tables and graphs for selection by farmers. Farmers would have the opportunity to choose the alternatives that best satisfy their profitability and risk management objectives by means of the programming results.

The Study Area and Representative Farms

The study area was located in North Central Anatolia, Turkey. Farms are engaged in agricultural activities in the

Table 1. Crop Rotations Used in Risk Programming Model

1.	Dried bean + rice + rice + rice + vetch
2.	Lentil + rice + rice + rice + vetch
3.	Chickpea + rice + rice + rice + vetch
4.	[Wheat + lettuce (second crop)] + soybean + rice + rice + rice
5.	[Wheat + maize for silage (second crop)] + soybean + rice + rice + rice
6.	[Rape seed + lettuce (second crop)] + maize
7.	[Wheat + lettuce (second crop)] + maize
8.	[Wheat + maize for silage (second crop)] + maize
9.	[Wheat + lettuce (second crop)] + sugar beet + dried bean
10.	[Wheat + maize for silage (second crop)] + sugar beet + dried bean
11.	[Wheat + lettuce (second crop)] + sugar beet + lentil
12.	[Wheat + maize for silage (second crop)] + sugar beet + lentil
13.	[Wheat + lettuce (second crop)] + sugar beet + chickpea
14.	[Wheat + silage for maize (second crop)] + sugar beet + chickpea
15.	[Wheat + lettuce (second crop)] + onion
16.	[Wheat + maize for silage (second crop)] + onion
17.	[Rape seed + lettuce (second crop)] + soybean
18.	[Wheat + lettuce (second crop)] + (vetch + sunflower) + dried bean
19.	[Wheat + maize for silage (second crop)] + (vetch + sunflower) + dried bean
20.	Wheat + tomatoes
21.	Rape seed + tomatoes

Kızılırmak River basin and on plains along the Kızılırmak River. Six cities, Ankara, Kırıkkale, Yozgat, Çorum, Çankırı and Kırşehir, stand in this area. Çorum was selected to represent the research area since the cropping pattern along the Kızılırmak River in Çorum reflects all the characteristics of investigated area; 5200 holdings in this area constituted the target population.

The bulk of the data used in the study were collected from 216 sample farmers, selected by means of random sampling. The farmers were interviewed to obtain input-output data. Farmers' subjective beliefs regarding crop yields and prices were also ascertained. Time series data covering 10 years on yields and prices of different crops cultivated in the research area were gathered from regional production statistics and from the Research Station of the Ministry of Agriculture records in the region.

Cluster analysis (Hair et al., 1998) was applied to form homogeneous groups of sample farms. The sample farms were separated into 3 different size classes. The model farm for each group was constructed by using the average values of each group and was used as a representative farm. The 3 representative farms were small (1.1 ha), medium- size (5.063 ha) and large (8 ha).

Both farmers' subjective judgments and historical data on crop yields and prices were used as a basis for the probability distributions used in the model. In order to preserve aspects of the stochastic dependency in the historical data, the procedure suggested by Torkamani and Hardaker (1996) was adapted by appropriate statistical procedures. First, the effects of inflation and technological change in historical data were eliminated. Second, the triangular distribution method was used to obtain the marginal subjective probability distributions of crop yields and prices for the sample farms. Finally the subjectively adjusted time series data were used as alternative states of nature in programming models for the representative farms.

Table 2. Initial matrix for small farms*.

	Unit	Rotations																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Obj. func.	mil TL	366.43	363.33	360.15	411.11	377.87	136.24	126	92.75	204.99	171.75	201.89	168.65	198.71	165.47	121.5	88.26	127.05	165.73
Land	ha	0.5	0.5	0.5	0.5	0.5	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.3
Labor 1	hour	3.05	3.05	3.05	17.82	0.42	17.82	17.82	0.42	17.82	2.57	17.82	2.57	17.82	2.57	17.82	2.57	17.82	17.82
Labor 2	hour	54.74	54.74	54.74	72.46	22.47	72.46	11.66	0.65	72.46	35.02	72.46	35.02	72.46	35.02	72.46	57.42	22.47	35.02
Labor 3	hour	21.72	16.71	13.83	0.7	0.7	0.7	16.13	32.53	49.66	49.66	49.66	49.66	49.66	49.66			49.66	49.66
Labor 4	hour	22.28	22.28	22.28	54.43	42.27	1.06	1.17	1.19	1.26	1.26	1.26	1.26	1.26	1.26	42.27	42.27	42.27	1.26
Straw	kg				-320	-320		-320	-320	-320	-320	-320	-320	-320	-320	-320	-320		-320
Hay	kg	-400	-400	-400					-2000		-2000		-2000		-2000		-2000		-400
Feed	kg								-2000		-2000		-2000		-2000		-2000		
Stable	m^2																		
Sheepfold	m^2																		
Capital	mil TL	170.23	167.13	163.95	215.33	181.67	136.65	126.41	88.27	205.41	209.23	202.31	175.33	208.61	181.67	299.27	183.36	211.07	165.73
Year 1	mil TL	-32.1	-32.89	-26.30	-51.2	-41.42	-20.14	-19.75	-10.13	20.11	29.57	8.17	17.63	14.77	21.8	-26.97	-19.67	-20.06	-5.16
Year 2	mil TL	1.7	13.03	7.82	-3.59	-9.71	-4.8	-3.39	-9.14	-1.7	-8.14	-1.52	-7.96	-6.72	-6.61	25.79	25.19	-8.12	7.74
Year 3	mil TL	76.25	23.64	27.17	46.59	43.88	12.58	12.31	8.53	-4.75	-7.75	-5.59	-8.62	-2.05	-7.51	10.22	5.03	18.51	7.71
Year 4	mil TL	39.21	70.64	60.78	86.63	91.86	20.16	15.11	23.99	-14.97	-6.06	5.21	14.12	-4.54	1.94	36.53	-29.78	15.15	-19.27
Year 5	mil TL	-107.16	-80.27	-85.51	-71.41	-75.36	9.48	9.48	5.19	-19.5	-23.77	-3.76	-8.03	-8.99	-15.69	3.63	-10.06	5.78	-15.75
Probab.																			

Table 2. Initial matrix for small farms (continued)

	Unit	Rotations			Dairy	Sheep	Straw making	Straw buying	Hay buying	Labor hiring	Credit	1	2	3	4	5	Resources	
		19	20	21														
Obj func	mil TL	132.49	74.82	85.48	110.72	29.98	-30	-80	-250	-0.09	0						=	max
Land	Ha	0.3	0.2	0.2													<	1.1
Labor 1	hour	2.57	17.82	17.82	49.64	3.24				-1							<	1581
Labor 2	hour	35.02	12.61	65.75	50.56	3.30	5.15			-1							<	1439
Labor 3	hour	49.66	16.13	15.70	49.64	3.24				-1							<	1581
Labor 4	hour	1.26	1.23	1.26	38.61	2.52				-1							<	1139
Straw	Kg	-320	-320				1000										<	0
Hay	Kg	-2000			816				-1500								<	0
Feed	Kg	-2000			2720	1010	-1930	-1930	-1500								<	0
Stable	m^2				9.55												<	57.43
Sheepfold	m^2					1.32											<	9.80
Capital	mil TL	163.69	185.95	185.95	100.72	22.48	30	80	250	0.09	-1						<	5441
Year 1	mil TL	4.3	-16.92	-17.27	-15.57	-4.22						-1					<	0
Year 2	mil TL	1.3	11.58	10.21	3.29	0.89							-1				<	0
Year 3	mil TL	4.68	7.01	7.32	11.08	3								-1			<	0
Year 4	mil TL	-10.36	-17.15	-12.06	12.36	3.35									-1		<	0
Year 5	mil TL	-20.02	3.68	3.3	-13.11	-3.55										-1	<	0
Probab.												0.25	0.27	0.3	0.08	0.1	<	221.17

*After analysis, all values were transformed from Turkish Lira to US $ according to the exchange rate.

Table 3. Initial matrix for medium-size farms*.

	Unit	Rotations																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Obj. func.	Mil TL	366.43	363.33	360.15	411.11	377.87	136.24	126	92.75	204.99	171.75	201.89	168.65	198.71	165.47	121.5	88.26	127.05	165.73
Land	ha	0.5	0.5	0.5	0.5	0.5	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.3
Labor 1	hour	3.05	3.05	3.05	17.82	0.42	17.82	17.82	0.42	17.82	2.57	17.82	2.57	17.82	2.57	17.82	2.57	17.82	17.82
Labor 2	hour	54.74	54.74	54.74	72.46	22.47	72.46	11.66	0.65	72.46	35.02	72.46	35.02	72.46	35.02	72.46	57.42	22.47	35.02
Labor 3	hour	21.72	16.71	13.83	0.7	0.7	0.7	16.13	32.53	49.66	49.66	49.66	49.66	49.66	49.66			49.66	49.66
Labor 4	hour	22.28	22.28	22.28	54.43	42.27	1.06	1.17	1.19	1.26	1.26	1.26	1.26	1.26	1.26	42.27	42.27	42.27	1.26
Straw	kg				-320	-320		-320	-320	-320	-320	-320	-320	-320	-320	-320	-320		-320
Hay	kg	-400	-400	-400					-2000		-2000		-2000		-2000		-2000		-400
Feed	kg								-2000		-2000		-2000		-2000		-2000		
Stable	M^2																		
Sheepfold	M^2																		
Capital	mil TL	170.23	167.13	163.95	215.33	181.67	136.65	126.41	88.27	205.41	209.23	202.31	175.33	208.61	181.67	299.27	183.36	211.07	165.73
Year 1	mil TL	-32.1	-32.89	-26.30	-51.2	-41.42	-20.14	-19.75	-10.13	20.11	29.57	8.17	17.63	14.77	21.8	-26.97	-19.67	-20.06	-5.16
Year 2	mil TL	1.7	13.03	7.82	-3.59	-9.71	-4.8	-3.39	-9.14	-1.7	-8.14	-1.52	-7.96	-6.72	-6.61	25.79	25.19	-8.12	7.74
Year 3	mil TL	76.25	23.64	27.17	46.59	43.88	12.58	12.31	8.53	-4.75	-7.75	-5.59	-8.62	-2.05	-7.51	10.22	5.03	18.51	7.71
Year 4	mil TL	39.21	70.64	60.78	86.63	91.86	20.16	15.11	23.99	-14.97	-6.06	5.21	14.12	-4.54	1.94	36.53	-29.78	15.15	-19.27
Year 5	mil TL	-107.16	-80.27	-85.51	-71.41	-75.36	9.48	9.48	5.19	-19.5	-23.77	-3.76	-8.03	-8.99	-15.69	3.63	-10.06	5.78	-15.75
Probab.																			

Table 3. Initial matrix for medium-size farms (continued)

	Unit	Rotations			Dairy	Sheep	Straw making	Straw buying	Hay buying	Labor hiring	Credit	1	2	3	4	5		Resources
		19	20	21														
Obj. Func.	mil TL	132.49	74.82	85.48	110.72	29.98	-30	-80	-250	-0.09	0						=	max
Land	ha	0.3	0.2	0.2													<	5.063
Labor 1	hour	2.57	17.82	17.82	49.64	3.24				-1							<	1718
Labor 2	hour	35.02	12.61	65.75	50.56	3.30	5.15			-1							<	1776
Labor 3	hour	49.66	16.13	15.70	49.64	3.24				-1							<	1718
Labor 4	hour	1.26	1.23	1.26	38.61	2.52				-1							<	1340
Straw	kg	-320	-320				1000										<	0
Hay	kg	-2000			816				-1500								<	0
Feed	kg	-2000			2720	1010	-1930	-1930	-1500								<	0
Stable	m^2				10.85												<	60.57
Sheepfold	m^2					1.32											<	11.39
Capital	mil TL	163.69	185.95	185.95	100.72	22.48	30	80	250	0.09	-1						<	6040
Year 1	mil TL	4.3	-16.92	-17.27	-15.57	-4.22						-1					<	0
Year 2	mil TL	1.3	11.58	10.21	3.29	0.89							-1				<	0
Year 3	mil TL	4.68	7.01	7.32	11.08	3								-1			<	0
Year 4	mil TL	-10.36	-17.15	-12.06	12.36	3.35									-1		<	0
Year 5	mil TL	-20.02	3.68	3.3	-13.11	-3.55										-1	<	0
Probab.												0.25	0.27	0.3	0.08	0.1	<	221.17

*After analysis, all values were transformed from Turkish Lira to US $ according to the exchange rate.

Table 4. Initial matrix for large farms*.

	Unit	Rotations																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Obj func	mil TL	366.43	363.33	360.15	411.11	377.87	136.24	126	92.75	204.99	171.75	201.89	168.65	198.71	165.47	121.5	88.26	127.05	165.73
Land	ha	0.5	0.5	0.5	0.5	0.5	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.3
Labor 1	hour	3.05	3.05	3.05	17.82	0.42	17.82	17.82	0.42	17.82	2.57	17.82	2.57	17.82	2.57	17.82	2.57	17.82	17.82
Labor 2	hour	54.74	54.74	54.74	72.46	22.47	72.46	11.66	0.65	72.46	35.02	72.46	35.02	72.46	35.02	72.46	57.42	22.47	35.02
Labor 3	hour	21.72	16.71	13.83	0.7	0.7	0.7	16.13	32.53	49.66	49.66	49.66	49.66	49.66	49.66			49.66	49.66
Labor 4	hour	22.28	22.28	22.28	54.43	42.27	1.06	1.17	1.19	1.26	1.26	1.26	1.26	1.26	1.26	42.27	42.27	42.27	1.26
Straw	kg				-320	-320		-320	-320	-320	-320	-320	-320	-320	-320	-320	-320		-320
Hay	kg	-400	-400	-400					-2000		-2000		-2000		-2000		-2000		-400
Feed	kg								-2000		-2000		-2000		-2000		-2000		
Stable	m^2																		
Sheepfold	m^2																		
Capital	mil TL	170.23	167.13	163.95	215.33	181.67	136.65	126.41	88.27	205.41	209.23	202.31	175.33	208.61	181.67	299.27	183.36	211.07	165.73
Year 1	mil TL	-32.1	-32.89	-26.30	-51.2	-41.42	-20.14	-19.75	-10.13	20.11	29.57	8.17	17.63	14.77	21.8	-26.97	-19.67	-20.06	-5.16
Year 2	mil TL	1.7	13.03	7.82	-3.59	-9.71	-4.8	-3.39	-9.14	-1.7	-8.14	-1.52	-7.96	-6.72	-6.61	25.79	25.19	-8.12	7.74
Year 3	mil TL	76.25	23.64	27.17	46.59	43.88	12.58	12.31	8.53	-4.75	-7.75	-5.59	-8.62	-2.05	-7.51	10.22	5.03	18.51	7.71
Year 4	mil TL	39.21	70.64	60.78	86.63	91.86	20.16	15.11	23.99	-14.97	-6.06	5.21	14.12	-4.54	1.94	36.53	-29.78	15.15	-19.27
Year 5	mil TL	-107.16	-80.27	-85.51	-71.41	-75.36	9.48	9.48	5.19	-19.5	-23.77	-3.76	-8.03	-8.99	-15.69	3.63	-10.06	5.78	-15.75
Probab.																			

Table 4. Initial matrix for large farms (continued).

	Unit	Rotations			Dairy	Sheep	Straw making	Straw buying	Hay buying	Labor hiring	Credit	1	2	3	4	5	Resources	
		19	20	21														
Obj func	mil TL	132.49	74.82	85.48	110.72	29.98	-30	-80	-250	-0.09	0						=	max
Land	ha	0.3	0.2	0.2													<	8
Labor 1	hour	2.57	17.82	17.82	49.64	3.24				-1							<	1890
Labor 2	hour	35.02	12.61	65.75	50.56	3.30	5.15			-1							<	2309
Labor 3	hour	49.66	16.13	15.70	49.64	3.24				-1							<	1890
Labor 4	hour	1.26	1.23	1.26	38.61	2.52				-1							<	1742
Straw	kg	-320	-320				1000										<	0
Hay	kg	-2000			816				-1500								<	0
Feed	kg	-2000			2720	1010	-1930	-1930	-1500								<	0
Stable	m^2				14.70												<	82.10
Sheepfold	m^2					1.58											<	13.67
Capital	mil TL	163.69	185.95	185.95	100.72	22.48	30	80	250	0.09	-1						<	7429
Year 1	mil TL	4.3	-16.92	-17.27	-15.57	-4.22						-1					<	0
Year 2	mil TL	1.3	11.58	10.21	3.29	0.89							-1				<	0
Year 3	mil TL	4.68	7.01	7.32	11.08	3								-1			<	0
Year 4	mil TL	-10.36	-17.15	-12.06	12.36	3.35									-1		<	0
Year 5	mil TL	-20.02	3.68	3.3	-13.11	-3.55										-1	<	0
Probab.												0.25	0.27	0.3	0.08	0.1	<	221.17

*After analysis, all values were transformed from Turkish Lira to US $ according to the exchange rate.

Results and Discussion

In the research area there have been important yield fluctuations and variations of product and input prices. Research results show that maize for silage, wheat, rice and soybean have the highest yield risk. Their coefficients of variation (CV's) are 67%, 29%, 26% and 22%, respectively. Onions (CV: 4%) and sugar beet (CV: 8%) have less yield risk compared to the others. On the other hand, onions (CV: 48%) and rice (CV: 38%) are higher risk crops compared to the others in terms of price, while the reverse is the case for wheat (CV: 14%) and sugar beet (CV: 16%). Input prices also have a wide range of variation. Fertilizer is the most discriminative input, and has a CV of 37%. Variations of feed and fuel prices follow at 26% and 25%, respectively. These variations in product and input prices and yield fluctuations have a considerable effect farm structures in the research area. However, many earlier studies neglect this and assume there is no price or yield risk. Risk efficient farm structures are estimated in this research.

Based on our results, farmers have grown higher risk cash crops with higher payoffs only if their risk aversion is low. Similarly, Özçelik (1988), Özkan and Akçaöz (2001) and Akçaöz and Akdemir (2001) pointed out that farmers preferred risky crops in farm structures if only they have low risk aversion. Although this type of behavior may be rational for the individual farmer, output levels and product combinations are inefficient from society's point of view (Anderson and Dillon, 1992). In addition, small farms prefer less risky activities in order to stabilize their net farm returns compared to others in the research area (Tables 5, 6 and 7).

The E, M efficient frontiers from the MOTAD formulation for different size farms are shown in Figures 1, 2 and 3. The typical result is that a significant reduction in mean annual deviations in net farm income is observed at the cost of relatively little expected income. However, later curves fall more steeply indicating that a greater sacrifice of expected income is needed to reduce

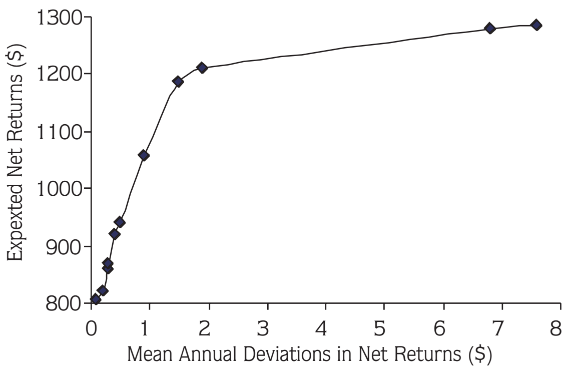

Figure 1. The E, M efficient frontier from the MOTAD formulation for small farms.

Table 5. Risk efficient farm structures for small farms.

E[TFNR] $ *	M $ *	Activity level (hectare nd head)**										
		Wheat	Lettuce (2nd crop)	Rape seed	Maize	Maize (Silage) (2nd crop)	Sugar beet	Dried bean	Lentil	Chick pea	Onion	Dairy
805.98	0.641	0.495	0.334	-	0.063	-	0.271	-	0.217	0.054	-	-
820.64	2.229	0.333	0.366	0.072	0.075	0.038	0.291	-	0.241	0.050	0.038	0.282
858.62	2.966	0.336	0.367	0.061	0.061	0.030	0.306	-	0.269	0.037	0.030	0.601
868.37	3.143	0.337	0.367	0.057	0.057	0.028	0.310	-	0.277	0.034	0.028	0.685
918.61	4.313	0.347	0.341	0.040	0.040	0.047	0.326	-	0.315	0.011	0.021	1.130
940.47	4.890	0.352	0.312	0.033	0.033	0.073	0.330	-	0.330	-	0.022	1.335
1057.72	9.139	0.378	0.158	-	-	0.221	0.343	0.001	0.342	-	0.036	2.484
1186.77	15.232	0.390	-	-	0.005	0.390	0.329	0.092	0.228	-	0.056	3.711
1211.55	19.256	0.412	-	-	0.073	0.412	0.276	0.276	-	-	0.063	3.967
1280.37	67.885	0.550	-	-	0.455	0.550	-	-	-	-	0.095	5.293
1286.18	76.094	0.550	-	-	0.550	0.550	-	-	-	-	-	5.293

* E and M are expected total net farm return and mean annual absolute deviation in net return, respectively.

** Straw making takes place in all the optimum plans with the exception of 3 plans whose risk is below $3. Straw making ranged from 0.538 to 1.76 with an average of 1.19 t.

Table 6. Risk efficient farm structures for medium-size farms.

E[TFNR] $ *	M $*	Activity level (hectare and head) Wheat	Lettuce (2nd crop)	Soybean	Paddy	Rape seed	Maize	Maize (Silage) (2nd crop)	Sugar beet	Dried bean	Lentil	Chick pea	Onion	Dairy	Sheep
3552.00	10.309	1.554	1.691	-	-	0.264	0.264	0.128	1.426	-	1.269	0.157	0.129	3.109	-
3779.99	14.478	1.597	1.573	-	-	0.186	0.186	0.209	1.498	-	1.442	0.056	0.098	5.127	-
4001.85	22.463	1.662	1.093	-	-	0.112	0.112	0.680	1.516	-	1.516	-	0.145	5.582	8.598
4203.96	37.165	1.637	0.947	0.149	0.443	-	-	0.691	1.346	0.547	0.800	-	0.142	5.582	8.629
4252.77	61.423	1.609	0.919	0.183	0.546	-	-	0.696	1.289	0.552	0.738	-	0.146	5.582	8.629
4362.23	69.857	1.561	0.857	0.256	0.771	-	-	1.011	1.156	1.156	0.001	-	0.162	5.582	8.629
4488.05	88.455	1.463	0.720	0.338	1.013	-	-	0.743	1.124	1.124	-	-	0.001	5.582	8.629
4713.75	118.470	1.327	0.542	0.542	1.624	-	-	0.785	0.785	0.785	-	-	-	5.582	8.629
4788.84	200.768	1.172	0.774	0.774	2.322	-	-	0.398	0.398	0.397	-	-	-	5.582	-
4822.81	279.347	1.239	0.862	0.862	2.585	-	0.375	0.377	0.001	0.001	-	-	-	5.582	-
4822.91	354.575	1.241	0.862	0.861	2.585	-	0.376	0.377	-	-	-	-	-	5.582	-

* E and M are expected total net farm return and mean annual absolute deviation in net return, respectively.

** Straw making takes place in all the optimum plans with the exception of 3 plans that whose risk is below $1.7. Straw making ranged from 3.05 to 5.43 with an average of 4.66 t.

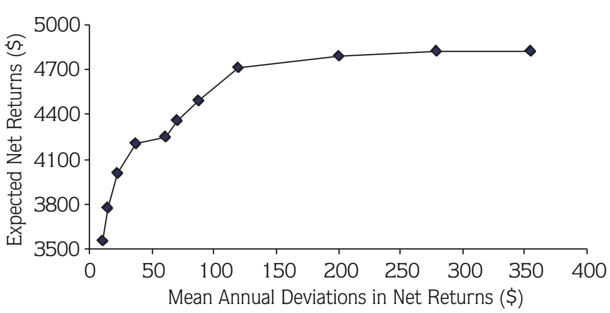

Figure 2. The E, M efficient frontier from the MOTAD formulation for medium-size farms.

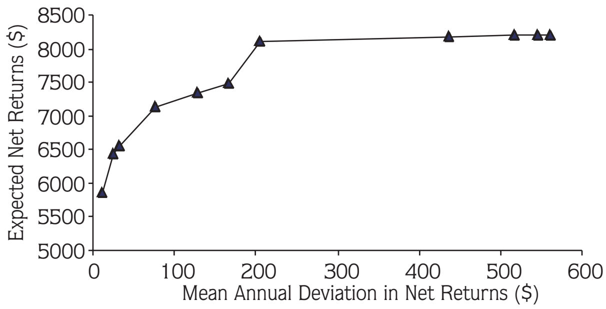

Figure 3. The E, M efficient frontier from the MOTAD formulation for large farms.

Table 7. Risk efficient farm structures for large farms.

E[TFNR] $ *	M $*	Activity level (hectare and head) Wheat	Lettuce (2nd crop)	Soybean	Paddy	Rape seed	Maize	Maize (Silage) (2nd crop)	Sugar beet	Dried bean	Lentil	Chick pea	Onion	Dairy	Sheep
5855.68	12.410	2.948	2.694	-	-	-	0.588	0.252	2.106	-	1.764	0.342	0.252	1.853	-
6447.44	24.130	2.824	2.596	-	-	-	0.334	0.228	2.352	-	2.236	0.116	0.138	5.582	6.733
6560.96	31.602	2.540	2.365	0.031	0.092	0.236	0.236	0.411	2.356	0.001	2.355	-	0.153	5.582	8.629
7133.60	79.637	2.439	1.997	0.419	1.257	-	-	0.442	1.866	1.578	0.288	-	0.153	5.582	8.629
7341.60	129.549	2.306	1.823	0.541	1.624	-	-	0.483	1.764	1.764	-	-	0.001	5.582	8.629
7472.08	165.992	2.232	1.727	0.651	1.953	-	-	0.506	1.582	1.582	-	-	-	5.582	8.629
8108.00	204.905	1.849	1.226	1.226	3.677	-	-	0.624	0.624	0.624	-	-	-	5.582	8.629
8182.96	437.435	1.695	1.458	1.458	4.375	-	-	0.236	0.236	0.236	-	-	-	5.582	0.002
8196.56	516.800	1.721	1.493	1.493	4.480	-	0.150	0.228	0.078	0.078	-	-	-	5.582	-
8202.64	546.365	1.737	1.508	1.508	4.526	-	0.228	0.228	0.001	0.001	-	-	-	5.582	0.096
8202.72	560.939	1.736	1.509	1.509	4.527	-	0.228	0.228	-	-	-	-	-	5.582	0.096

* E and M are expected total net farm return and mean annual absolute deviation in net return, respectively.

** Straw making takes place in all the optimum plans with the exception of 5 plans with a high level of risk. Straw making ranged from 4.49 to 9.04 t with an average of 7.48 t. In addition, labor hiring and credit are included. In all optimum plans, with the exception of 3 plans with a risk more than $3.16, labor hiring is necessary. Labor hiring ranged from 57 to 506 million TL and was, on average, 275 million TL. Farms have to obtain credit only in optimum plans with a risk below $31.

income deviations still further. If the decision makers' utility functions are known, the points of maximum expected utilities can be found by putting both curves together on the same graph. The points of tangencies give the maximum expected utilities for each farm.

In small farms, the expected net farm return ranged from $806 to $1286, ignoring the deviations (Table 5). The E, M curve for small farms falls more steeply below the level of mean annual deviations of $15. This means that a greater sacrifice in income is needed for a further decrease in income deviations.

In medium-size farms increasing risk led to the allocation of more farmed land to more risky activities such as rice and soybean with dramatic reduction in sugar beet, rapeseed, onion, and lentils. Sheep included in farm plans as a more revenue stabilizing activity (Table 6).

Table 7 shows that increasing risk caused the allocation of more farmed land to rice and soybean. In the research area, an additional $1 risk may provide more net farm return on small farms compared to others. Similar results were achieved in many earlier studies (Prevatt et al., 1992; Dunn and Williams, 2000; Held et al., 2002).

As expected, the total net farm return in the research area increases for all farm sizes as risk increases. This confirms the results of many earlier studies, which showed that risk might play important role in farm structures (Atwood et al., 1989; Rawlins and Bernardo, 1991; Prevatt et al., 1992; Goetz, 1993; Vieth and Suppapanya, 1996; Torkamani and Hardaker, 1996; Romero, 2000; Akçaöz and Akdemir, 2001; Özkan and Akçaöz, 2001; Held et al., 2002).

Modeling results indicate that net farm return per hectare is irrespective of the farm size at the high level of risk. However, there is a positive correlation between farm size and net farm return per hectare at the low level of risk. This finding confirms the results of some of the earlier studies (Torkamani and Hardaker, 1996; Özkan and Akçaöz, 2001), but not those of other previous studies (Dunn and Williams, 2000; Romero, 2000; Held et al., 2002). These studies suggested that increasing farm size had a negative relationship with net farm return per hectare.

In the light of the empirical evidence, farm plans are sensitive to the risk criteria and farmers' willingness to accept risk in the research area. Due to the presence of price inefficiency in the research area, farmers gain less net farm income under present conditions compared to the optimum conditions. A government policy aimed at improving the working of the markets could enable farmers to increase their efficiency, especially price efficiency. On the other hand, cultivating under risk should be made part of farmers' training and extension programs brought in to improve the efficiency of individual farms.

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