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Using Probabilistic-Risky Programming Models in Identifying Optimized Pattern of Cultivation under Risk Conditions (Case Study: Shoshtar Region)

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Abstract

Using Telser and Kataoka models of probabilistic-risky mathematical programming, the present research is to determine the optimized pattern of cultivating the agricultural products of Shoshtar region under risky conditions. In order to consider the risk in the mentioned models, time period of agricultural years 1996-1997 till 2004-2005 was taken into account. Results from Telser and Kataoka models showed that due to accepting the risk amounts, most of the optimized amounts suggest the tomato cultivation during the cultivation period of fall, and watermelon cultivation during the cultivation period of spring. On the basis of results, due to allocation of agricultural lands of Shoshtar to tomato and watermelon cultivation and specializing the farming activity in this province, gross profit of agricultural production system can be increased to 6116047000 and 727782272 thousand Rials, respectively. The results of understudy models were investigated under different income scenarios and probabilistic levels of risk acceptance. Correct policy making in order to offer the suitable equipments for adjusting the effects of lack of certainty and risks due to the climatic unwanted conditions in production process of agricultural products of Shoshtar region improve the life situation of farmers of the mentioned region.

Keywords:
Probabilistic-risky programming model, Cultivation pattern, Agricultural products, Shoshtar region

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INTRODUCTION

Although risk is common problem in agricultural activities amongst all parts of the world, its greatness in developing countries is more that that in other countries (Norak and et al. 1991). On the other hand, bearing the risk by small farmer is harder in comparison with great land owners (Irima and et al., 2004). In risky conditions, maximizing the profit of agricultural activities through maximizing the gross margin of agricultural risk from which the risk expense has been reduced is realized by considering the limitations due to production factors and risk (Hassan Shahi, 2006). With area about 3538 kilometer squares, Shoshtar region has been located at the center of Khuzestan province. Population of this province is 210108 people. The areas of aquatic and non irrigated lands of the mentioned province are 92047 and 49830 hectare, respectively. This region, with producing 2136229 tons aquatic agricultural products and 18409 tons non-irrigated agricultural product in agricultural year 2004-2005, has allocated a special position for itself in agriculture of Khuzestan province (Jahad-Keshavarzi, Khuzestan province, 2006). The main agricultural products of Shoshtar region include aquatic and non-irrigated wheat, aquatic and non-irrigated barley, paddy, aquatic cucumber, watermelon, grain maize and tomato. (Table 1)

Producing strategic products such as wheat and rice, in Shoshtar region makes it clear to make correct policies about stability of production system. On the other hand, unfavorable climatic conditions and limitations in availability to agricultural basic inputs cause frequent damages in agricultural lands of this region. In the event that only agricultural year 2004-2005, an area amounting 1142 hectares of aquatic lands of Shoshtar region has experienced damages and products have been destroyed. Regarding the mentioned problems, necessity for determining a suitable cultivation pattern that firstly creates stable and primary income for farmers of this city and then makes the ground ready for specializing the region's agriculture, is felt.

Linear programming models have frequent applications in agricultural decision makings (Nicholson and et al. 1994). On the other hand, together with development of programming models and compilation of multi-period decision making models the possibility for considering market risk and production was provided in agricultural decision makings. For example, dynamic algebraic linear programming model has been used in most studies about for determining the optimized pattern of water consuming regarding the previous agricultural periods (Backeberg, 1997; Haile and et al. 2003; Van Schalkwyk and Louw, 2004). Linear programming had been widely used in determining cultivation pattern under risky conditions. Peykani and et al. (2009) determined the best variety of rice for cultivation, using Kataoka and Telser programming methods. Results showed that at different levels of the gross margin of the aim, two varieties include Hashemi and Ali Kazemi were the best for achieving considered goals.

Intense dependence of Shoshtar region's farmers on income from production of these products as the only means for living causes these people to

Table 1: Acreages, production quantity and yield of major cultivation product of Shoshtar region in cultivation year of 2004-2005.

Product	Acreages (ha)	Production quantity (ton)	Yield (kg per ha)
Aquatic Wheat	25967	117253	4515
Non-irrigated Wheat	15019	15417	1026
Paddy rice	13273	53971	4066
Aquatic Barely	3540	5982	1689
Non-irrigated Barely	4463	2992	674
Aquatic Cucumber	608	11031	18143
Watermelon	3532	104849	29685
Maize	3053	19502	64
Tomato	2412	73031	30278

Resource: Jahad-Keshavarzi of Khuzestan province.

take safety-first conditions and price risk into account in selecting cultivation pattern. Using probabilistic-risky programming models makes it possible to consider safety-first conditions in order to realize the considered gross margin per hectare and taking the price risk into account in determining the cultivation pattern. More studies have been made to analyze the farmers' decisions regarding the risk effect (Rudel, 2000; Tauer, 1983). On the other hand, using the safety-first models in most studies has been useful in explaining the farmers' behaviors (Patrik and et al., 1985; Roy, 1952). Lack of ability in exactly foreseeing the price of products, price of production inputs, and amount of production harvest from one hand and atmospheric and climatic conditions on the other, have caused instability in incomes of Shoshtar region's farmers. Taking this point into account that this region's farmers, considering the risk, want to gain maximum amount of profit, the questions are: 'From among the cultivation options of agricultural products, which of them and with what amount of risk should they select in order to gain maximum profit?', 'which combination of the production factors should they select to reduce the production costs down to the minimum level and cause the productions to reach the desired level?'. Answering the aforesaid questions requires applying an exact programming. Using Telser and Kataoka probabilistic-risky mathematical programming models, the present research is to determine the optimized pattern of agricultural products cultivation in Shoshtar region under the risky conditions. In order to consider the risk in aforesaid models, time period of the agricultural years 1996-1997 till 2004-2005 was regarded.

MATERIALS AND METHODS

Safety-first models have been used as standards for a long time to make decisions under uncertainty conditions. Using the two models of Telser and Kataoka, this research introduces the most suitable agricultural activities to realize the pre-determined goals. In this research, selection of sequence of optimized agricultural activities has taken place regarding the risk rows that include gross margin per hectare of each understudy products during the agricultural years 1996-1997 till 2004-2005, realizing the income goals of the farmer (under the first-safety conditions) and limitation of Shoshtar region's agricultural resources. In Telser's model, expected gross profit regarding the risk rows of the gross profit per hectare of each one of agricultural products during the understudy years, limitation of safety-first conditions and limitation of agricultural resources is maximized. In Kataoka's model, gross profit level per optimized hectare has been determined a goal such as T in which the probability of gross profit's falling down per hectare to the level lower than the amount of T, is less than the amount of probabilities that have previously been determined in the model. Both models of Kataoka and Telser include probabilistic limitations for considering the safety-first conditions that is as follows: (1)

$$\Pr(Z \, \pi \, g) \leq 1/L^{*} \quad (1)$$

At the above equation, Pr (Z π g) is the probability of occurrence of Z π g . Z is random variable of gross margin per hectare and g is the goal gross margin per hectare. $1/L^{*}$ is upper limit for Pr (Z π g).

Different approaches are used to enter the safety-first conditions regarding the hypothesis of programming model. In constrained chance programming, a common approach is changing the probabilistic limitations into deterministic ones (Charles and Cooper, 1959). Another approach requires the multi-normality and ability to make effective E-V series of the answers. Pyle and Turnovsly have used this approach to compare the results from the two methods of optimized expected utility and safety-first (Pyle and Turnovsly, 1970). The third approach is imposing the probabilistic limitation using the probabilistic inequality. For the first time, Berk and Hin used the nonlinear form of the Lower Partial Moment Inequality (Berk and Hin, 1982). Creating the conservative confidence limits is one of the difficulties regarding the aforesaid non-linear form usage. Atwood offered a special form of Chebychev's linear inequalities that created less conservative confidence limits (Atwood, 1985). This inequality enjoys continuous distribution and obeyed the Lower Partial Moment Inequality principles. This probabilistic inequality has been applies in this research to consider the safety-first conditions in both Kataoka's and Telser's risky programming models. Lower partial moment is defined as (Atwood, 1985): (2)

$$R(a,t) = \sum (t-z_i)^{a.f_i} \quad (2)$$

In the above relation, $R(a,t)$ is lower partial moment in which t is the amount of gross margin per hectare below which deviations are measured and zi shows the amount of z (expected gross margin) when the ith case occurs. a, (a>0) is the force that, taking it into account, deviations that are below t are created and fi is the amount of probability that, taking it into account, the ith case is occurred. In order to enter the probabilistic inequality in linear programming model the following relation can be used (Atwood and et al., 1988): (3)

$$\Pr (Z \leq t - pQ (a,t)) \leq (1/P)^a \quad (3)$$

In which $Q (a,t) = [R(a,t)]^{1/a}$ and its amount is always greater than zero. p is fixed amount and greater than zero. If p is defined as $P = (t-g)/Q(a,t)$, and if t>g, equation 3 can be expressed as (Atwood and et al., 1988): (4)

$$\Pr(Z \leq g) = \Pr (Z \leq t - pQ(a,t))[Q(a,t)/(t-g)]^a \quad (4)$$

In order to use the aforesaid probabilistic inequality in linear programming model, the amount of should be assumed as 1, therefore in the above relation Q (t) can be replaced with Q(1,t) or R (1,t): (5)

$$\Pr(Z \leq g) = \Pr(Z \leq t - pQ(t)) \leq Q (t)/(t-g) \quad (5)$$

Finally, in order to consider the probabilistic limitation of safety-first condition Pr (Zπ g) ≤ $1/L^*$ in considered risky programming models, inequality t- LQ (t) ≥ g is used.

Regarding the risk rows of gross margin per hectare of each one of agricultural activities during understudy years, limitations in safety-first conditions, and limitations in resources of agricultural production, expected gross margin in Telser's model is optimized. Specialty of the

$$\begin{aligned} &\text{Max } E (Z) = E' \pi_{ri} X_i \\ &\text{Subject to:} \\ &\Sigma_i a_{ij} X_i \leq b_j && j = 1,\dots, m \\ &\Sigma_i \pi_{ri} X_i - t + Z_r \geq O && r = 1,\dots, s \\ &r' Z_r - Q (t) = O \\ &t - LQ (t) \geq T \\ &X_i, b_j, Z_r \geq O && i = 1,\dots, n \end{aligned} \quad (6)$$

mentioned model is using the probabilistic limitation in order to consider the safety-first conditions. Taking the safety-first conditions into account, probabilistic-risky programming model can be defined as follows (Atwood and et al., 1988): (6)

In the above model a_{ij} is technical coefficient of the under use input j in the i^{th} activity, X_i is the i^{th} activity level, b_j is the existent amount of the jth input, π_{ri} the gross margin per hectare of i activity in the year r, T is the amount of goal income, E (z) is expected accumulative gross margin, $E' \pi_{ri}$ is the transpose vector of expected gross margin for each activity, and is the vector of activity levels. t is the resource level for gross margin, X_i is the transpose vector of probabilistic levels and $r' Z_r$ is equivalent with Q (t) . t- LQ (t) ≥ T is Atwood relation that after determining the amounts of goal income T and L, expected accumulative gross margin reaches to its maximum amount with considering this limitation, risk rows and limitations in resources.

In probabilistic-risky programming system of Kataoka's, taking the safety-first conditions into account, the goal is to realize ideal of maximizing the amounts of goal gross margin of the (T). Considered limitations in this model is identical with those of Telser's system, and only the probability limitation related to considering safety-first conditions is changed into t- LQ (t) - T ≥ O. Results from Kataoka's system show the maximum amounts of the goal gross margin regarding the limitation in resources, limitation in price risk or matrix of gross margin amounts of each activity

$$\begin{aligned} &\text{Max} T \\ &\text{Subject to:} \\ &\Sigma_i a_{ij} X_i \leq b_j && j = 1,\dots, m \\ &\Sigma_i \pi_{ri} X_i - t + Z_r \geq O && r = 1,\dots, s \\ &r' Z_r - Q (t) = O \\ &t - LQ (t) \geq T \\ &X_i, b_j, Z_r \geq O && i = 1,\dots, n \end{aligned} \quad (7)$$

during the understudy years and limitations in safety-first conditions. Considering the Kataoka's safety-first conditions, the probabilistic-risky programming model can be defined as (Atwood and et al., 1988): (7)

In the present research the sequence of understudy activities is cultivation of aquatic and non-irrigated wheat, aquatic and non-irrigated barley, paddy, aquatic cucumber, watermelon, grain maize, and tomato in Shoshtar region. In order to determine the optimized pattern of cultivation using the Telser's and Kataoka's approaches, the limitations in production resources – including labor, land, chemical fertilizers of nitrogen, phosphor, potassium, fungicide chemical poisons, herbicide, pesticide and water– were considered in programming models. In order to consider the production and yield risk in the processes of determining the optimized pattern of cultivation, gross margin of each one of the sequence of understudy activities during the agricultural years 1996-1997 till 2004-2005 was regarded. Data needed for doing the present research was gathered from Jahad-Keshavarzi of Shoshtar region, Khuzestan province's agricultural supportive services company, Khuzestan province's regional water company, Khuzestan province's coordination office and economical affairs and central bank of Islamic Republic of Iran.

CONCLUSIONS AND DISCUSSION

In the present research, in order to estimate Telser's and Kataoka's programming models, Lingo software packages were used. After calculating the amounts of gross margin for each one of agricultural activities of aquatic wheat, aquatic barley, paddy, non-irrigated wheat, non-irrigated barley, cucumber, aquatic maize, tomato and watermelon during the agricultural years 1996-1997 till 2004-2005, the aforesaid amounts were changed into 2005 basic year with the use of suitable price index. Consequently, besides enjoying homogeneous risk rows in programming models, all of the results can be interpreted on the basis of prices relating to the year 2005. In order to consider the capacity of the region's lands and take the most important advantages of agricultural production resources, three programming groups were taken into account for non-irrigated lands, agricultural products relating to the cultivation period of fall and agricultural products relating to the cultivation period of spring.

Applying Telser model which includes probabilistic inequality for considering safety-first conditions has provided the possibility that taking the living conditions of farmers into account and measuring the probabilistic limitations, the most suitable sequence of agricultural activities for cultivation

Table 2: Telser's model Results for fall cultivation period.

Goal gross margin per hectar[1]	Probability limitation	Expected gross margin[2]	Acreage of optimized enterprises (ha)	
			Tomato	cucumber
6347	0.1	6116047	416766.5	0
	0.1	2349603*	10836.5*	262124.8*
	0.2	6116047	416766.5	0
	0.2	2349603*	10836.5*	262124.8*
8347	0.1	6116047	416766.5	0
	0.1	2349603*	10836.5*	262124.8*
	0.2	6116047	416766.5	0
	0.2	2349603*	10836.5*	262124.8*
10347	0.1	6116047	416766.5	0
	0.1	2349603*	10836.5*	262124.8*
	0.2	6116047	416766.5	0
	0.2	2349603*	10836.5*	262124.8*

1 in thousand rials.
2 in million rials.
* Scenario of keeping tomato's acreage at present region's level.
Resource: research findings.

Table 3: Telser's model Results for spring cultivation period

Goal gross margin per hectar[1]	Probability limitation	Expected gross margin[2]	Acreage of optimized enterprises (ha)	
			Paddy	watermelon
6106	0.1	727782272	0	90139
	0.1	587966528*	68070*	22069*
	0.2	727782272	0	90139
	0.2	587966528*	68070*	22069*
7106	0.1	727782272	0	90139
	0.1	587966528*	68070*	22069*
	0.2	727782272	0	90139
	0.2	587966528*	68070*	22069*

1 and 2 in thousands rials.
* Scenario of keeping watermelon's acreage at present region's level.
Resource: research findings.

be selected regarding the goal income. In Telser model, the optimized levels of activities are determined by selecting the amount of goal income and lower partial moment amounts. In this direction, after selecting the amounts of goal income, basic probabilistic levels are considered for each amount of the goal income. Aforesaid probabilistic amounts are expressive of littleness of expected accumulative gross margin in comparison with the level of goal income. Results from Telser's model have been reported in the following tables. (Table 2)

Goal income amounts have been determined on the basis of adjusted average gross margin of understudy agricultural activities in each time period, and continue up to the maximum average of the existent adjusted gross margin. In case of the cultivation period of fall, three goal incomes were selected as 6347, 8347, and 10347 thousand rials per hectare. Taking this goal into account that the amount of gross margin of farming on the basis of the price of the year 2005 with probability of 0.1 not to be less than 6347 thousand rials, the amount of under cultivation level of 416766/5 hectares tomato was selected as optimized activity. In this case the average amount of expected gross margin with optimized product cultivation is 6116047 million thousand rials. In this level of the goal income changing the probabilistic amounts into 0.2 or accepting more risk doesn't cause any changes in model results. Changing the goal income into 8347 thousand rials at probabilistic level 0.1 causes the optimized level of tomato cultivation activity to become 416766/5 hectare. Regarding the defined risk rows in Telser's model and fluctuations in gross margin of production system in understudy years in lieu of placing other amounts of goal income in basic probabilistic levels, optimized answers don't change by Telser model. In other words, in Telser model, the ideal of maximizing the expected accumulative gross margin in comparison with other probabilistic amounts and goal income, have priority. Beside each probabilistic and goal income limitation a scenario has been considered on the basis of retaining the under cultivation level of tomato at the present amount. Regarding the high consumed amounts of fertilizer and chemical poisons and labor intensify cultivation of tomato, compilation of retaining the under cultivation level of tomato at present amount of the region was considered. After exercising the aforesaid scenario the amount of expected accumulative gross margin was reduced from 6116047000 to 2349603000 thousand rials and the agricultural product of cucumber is also placed in optimized cultivation mode. (Table 3)

The ideal of Telser's model is to maximize the expected gross margin. Regarding the condition of gross margin of mentioned agricultural activities during understudy period, at first adjusted average of gross margin of mentioned activities (6106 thousand rials) was selected as goal income. Then two probabilistic levels of 10 and 20 percent for probability of expected gross margin reduction from the level of goal gross margin was taken into account. In case of goal income of 6106 thousand rials and probabilistic limitation of 10 percent, the offered optimized cultivation model by Telser's model is generally peculiar to watermelon cultivation. Under the aforesaid conditions, maximum amount of expected gross margin that farmers of the region gain is 727782272 thousand rials. Regarding the strategically of paddy cultivation, and emphasis of economical planners on retaining the under cultivation level of this product, scenario of retaining the present under cultivation level of watermelon was regarded. By exerting aforesaid scenario at probabilistic level of 10 percent and goal income 6106 thousand rials 68070 hectares were allocated to paddy cultivation. In this case expected gross margin amount of the region's agriculture is reduced by 23.8%. Ideal of Telser's model is such that changes in probabilistic amounts and goal income don't cause changes in model results and always maximizing the expected gross margin is taken into model's account. Regarding the negative expected gross margin amounts for non-irrigated products during the under study years, the ideal of Telser's model is not realized on the basis of maximizing the expected accumulative gross margin amounts and the model is not able to offer feasible results for non-irrigated products. (Table 4)

In Kataoka model no goal income is inspired into the model and the model is always to offer cultivation model that maximizes the goal gross margin level in the region. Means for accepting higher risk levels by farmers in Kataoka's model is probabilistic limitation. As results show, by accepting higher probabilistic amounts maximum goal gross margin level is also increased. Increase in probability level that expected gross margin being less than the goal gross margin from 0.2 to 0.3 causes 1% increase in maximum goal gross margin. This increase is in accordance with theoretical principles, because by accepting more risk levels, the farmer expects higher expected gross margin to be realized. Finally, when the probability of expected gross margin being less than the goal gross margin is increased to 40%, the offered model by Kataoka will be very similar to the results of Telser's model and this is an expressive of results not being conservative, in this case, maximum goal gross margin that can be expected on the basis of events of agricultural years 1996-1997 till 2004-2005 and limitations in production resources is 4172275 million rials. Regarding the labor intensify cultivation of tomato (162.6) and high amount of used chemical fertilizers (789.8 kilograms) and chemical poisons (10.7 liter) in the aforesaid agriculture and consequently, creating environmental risks in the region, optimized cultivation pattern has been offered by retaining the same probabilistic conditions and limiting under cultivation level of tomato in its present amount in the region.(Table 5)

Results from Kataoka's model showed that regarding the 10 percent probability of reduction in expected gross margin level from the goal income level, watermelon agricultural products with 82865.66

Table 4: Kataoka's model Results for fall cultivation period.

Probability limitation	maximum Goal gross margin	Acreage of optimized enterprises (ha)		
		Tomato	cucumber	Aquatic Wheat
	4025430	355726.4	61040.05	0
	987775.5*	10836.5*	74112.7*	294856*
	4025430	355726.4	61040.05	0
	1007539*	10836.5*	98716.39*	256270.5*
	4066941	386372.47	30394.02	0
	1128476*	10836.5*	262124.86*	0*
	4172275	416766.22	0.27	0
	1373593*	10836.5*	262124.6*	0*

1 in million rials.
* Scenario of keeping tomato's acreage at present region's level.
Resource: research findings.

Table 5: Kataoka's model Results for spring cultivation period.

Probability limitation	maximum Goal gross margin	Acreage of optimized enterprises (ha)		
		Paddy	Maize	Cucumber
	575325824	7273.33	0	82865.66
	418269216*	57603.9*	10466*	22069*
	575325824	7273.33	0	82865.66
	418269216*	57603.9*	10466*	22069*
	591480512	19326.87	0	70812.12
	426256928*	68070*	0*	22069*
	609046720	0	0	90139
	438237792	68070*	0*	22069*

1 in thousands rials.
* Scenario of keeping watermelon's acreage at present region's level.
Resource: research findings.

hectares and paddy with 7273 .33 hectares are offered as optimized cultivation pattern by Kataoka's model. By accepting more risk amounts (increasing the probabilistic levels) the amounts of maximum goal gross margin is increased and, on the other hand, watermelon allocates more under cultivation level to itself. Finally, in 40% probability, watermelon is introduced as the only optimized agricultural product by the model. Taking the probabilistic amounts into account, a scenario was offered to retain under cultivation level of watermelon at the present amount of the region. By exerting this scenario the amount of maximum goal gross margin, is reduced at the same probabilistic limitation. The mentioned scenario at probabilistic levels of 30 and 40 percent allocates the whole available under cultivation level to two products of paddy and watermelon.

Kataoka's model determined the amount of under cultivation level of non-irrigated products as 0 in all risk accepting levels. The mentioned results are due to the negative expected gross margin amounts of non-irrigated products in under study years.

CONCLUSION

As results from Telser's and Kataoka's models showed that by accepting more risk amounts (increasing the goal income and probabilistic levels in Telser's model and increasing probabilistic levels in Kataoka's model), the optimized amounts advise tomato cultivation during the cultivation period of fall and watermelon cultivation during the cultivation period of spring. On the basis of results, by allocating agricultural lands of Shoshtar region to tomato and watermelon cultivation and specializing the farming in this city, gross margin of agricultural production system can be increased to 6116047000 and 727782272 thousand rials, respectively. At the present conditions of Shoshtar region, because of unsuitable living conditions of the farmers, changing the cultivation model and leading the farmers towards the mentioned products cultivations besides increasing the productivity of productive units, are among the most suitable techniques. In this way, production stability can be guaranteed.

Accepting aforesaid risky levels by farmers of Shoshtar region depends on offering suitable equipments for adjusting the effects of uncertainty and risks due to unwanted climatic conditions in agricultural production process. Beside the equipments such as different kinds of agricultural insurances and cheap financial dept, on time performing of agricultural activities and reducing the variable expenses of production by mechanization development are among those cases that can be effective in realizing the above said things. Granting cheap financial dept in order for providing production inputs, strengthening productive structures, giving power to rural cooperatives in order to increase the power of bargaining of farmers and it effect on market, private sector's more participating and commercializing the production companies and developing distributive services to know about the methods of correct applying of production inputs are some of important techniques of risk reducing in production system and encouraging the farmers to change the cultivation model and specialize the farming.

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