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CALCULATION AND ASSESSMENT THE RISK OF FIELD CROP BY USING OF MATHEMATICAL PROGRAMMING (CASE STUDY: SEMNAN PROVINCE)

Mehri Alijani[1], Reza Rostamian[2], Mostafa Goudarzi[3]
1. Department of Agricultural Economics, Qaemshahr Branch, Islamic Azad University, Qaemshahr, Iran.
2,3. Department of Economics, Assistant Professor, Qaemshahr Branch, Islamic Azad University, Qaemshahr, Iran.

ABSTRACT
In this paper, to the use of stochastic programming models, which are able to involve risk conditions and uncertainty in the issue final results, determined the best pattern to optimize crops cultivation, including wheat, barley, maize, sugar beet, potatoes and sunflower in Semnan province by using data from the period 2006 to 2011, and finally, the obtained results from these techniques are compared. Techniques used in this research are linear programming, nonlinear programming, and Motad programming. The results show that the irrigated corn, sugar beets and potatoes are the most risky agricultural products in province, and irrigated sunflower, rainfed sunflower, irrigated barley and rainfed barley are the lower-risk products and irrigated wheat and rainfed wheat do not show a reaction to risk. In other words, it must be said that this product is a product with the degree of risk neutral. The software used in this article is win QSB.

KEY WORDS: Risk, Linear Programming, Nonlinear Programming, Motad Programming, Semnan.

1. INTRODUCTION

Agriculture is a risky activity, so that farmers are facing a variety of risks of weather, pests, disease, market risk and raw materials. Each year, farmers due to an uncertain income are worried about the loan payments, the cost of living. (Skess & et al. 1999). The existence of a variety of natural and unnatural hazards in agricultural activities, making agricultural producers is faced with uncertainty, and as a result, their income from agricultural production with instability. (Ray, 1969). A wide range of risks is impressive in the income from agricultural production. Farmers in developing countries (such as Iran), compared to their counterparts in developed countries, because of the lack of full and proper use of equipment and production technologies, lack of proper pricing system of products, shortages and processing industries, equipped and suitable packing and refrigeration for storage of agricultural products, lack of convenient transport system to move goods from production centers to consumption centers and many other factors and conditions are facing more risk and uncertainty. (Hassanshahi, 2006). Determine the optimal cropping pattern, according to available resources and taking into account the conditions of risk and uncertainty in agriculture can help farmers, managers and economic planners in the choose of the kind of the products and the level of their cultivation, and thus, the maximum use of available resources can be helped to a large extent to reduce potential damage to the agricultural sector. (Hazell, 1982). In the meantime, mathematical programming models (such as linear programming) could be a useful tool for selecting suitable cropping pattern (Kopahi, 1986), but ignore this risk impact on farmers' incomes in the agricultural sector planning models, often has creating an unacceptable result, and it is difficult the policy-making based on the obtained results.

One of the most important decisions facing farmers was to determine the optimal cropping pattern. Using this model, they can determine the most revenue from the consumption of a certain amount of inputs, or at least, the cost of developing a particular combination of products. Production and operation of agricultural products are always influenced by numerous conditions and factors that are not under the control of agriculture, therefore, always these two indicators in line with changing conditions is volatility on the production and affect the stability of farmers' income. (Di falko & et al., 2007). Also, in addition to production and performance, the market of agricultural products and trading volume as well as the indirect is affected by uncontrollable factors, such as climate change and thermal and moisture stresses. However, only agricultural implements at the time of the decision, is how to allocate land to the cultivation and production of various products, which are produced few months later and at harvest time influenced by climatic shocks. The implication of this is that, the farmers in cultivation time, there is no control over the performance of their product, as well as on the surplus or deficit that must be taken to market or purchased from the market. (Berg and

[1] Corresponding Author

Louviaks, 1997). The aim of this study is to find the most risky and lower-risk of field crop cultivation in the province, determine and provide an optimum cropping pattern by taking into consideration important indicators of production in the farm units, and provide the optimal pattern of resource use in farm units. Risk is a French word, which in Persian, translated into danger. Also, Webster Encyclopedia defines risk as the risk of loss and loss of life and property. (Torkamani, 1998). Risk is a time-dependent process and because the risk is related to an incident in the future, over time, the impact on our understanding of it, so that, during a job find a lot of things, which now appears to be a risk, there is no doubt that in the future the risk of production in the agricultural sector, consistently, will be unstable and difficult conditions. The high risk of these conditions, the production in the sector has made just work with risk. Hence, risks in agricultural activities are the unstable conditions that endanger agricultural production, which will cause property damage and insecurity in the spirit and the lives of farmers. (Bahrami and Agahi, 2005, p. 100).
A typical linear programming model is one of the simplest and most widely used mathematical programming models, but these models are not able to involve risk conditions and uncertainty in their final answers. Therefore, in recent years, has been proposed several models, which are their capable risk conditions and uncertainty in its final results. This class of mathematical programming models, so-called stochastic programming models. (Hazell & et al., 1986). Some foreign and domestic studies done on the effects of import risk conditions and uncertainty in the determine models of optimal cropping pattern are as follows:

- Akbari and Keyvan Zahedi (2010), by using ideal fuzzy programming model determined the farms optimal cropping pattern in Hamedan province. The results show that, given that the data and information used in this way (multi-objective planning) was as inaccurate and estimates (based on experience), and it was to include multiple targets, therefore, the obtained results in comparison to the classic planning are closer to real-world situations.
- Torkamani and Kalaiy (2008), revealed the impact of risk in the operation pattern of farming by using Motad programming and Target Motad. The results showed that with increasing risk, the risk planning model compared to the conventional linear programming is willing to replace products with higher yields rather than the other products.
- Oliveira & et al. (2007), with presentation techniques have to solve a range of multi-objective linear programming models and provided the possibility to the decision maker to be able to intervene to risk conditions, uncertainty and inaccurate data in mathematical programming models of decision-making. The results show that the solution method is more accurate than the existing solution methods and with this technique; the possibility of involvement of several goals is possible in uncertainty conditions.
- Takeshi & et al. (2003), in a study by using fuzzy parameters and random coefficients, presented techniques to determine the cultivation of agricultural crops. The results indicate that the studied model help ease many of the weaknesses of classical linear programming models and the results obtained were closer to real-world situations.

2. RESEARCH METHODOLOGY

Determine the optimal cropping pattern, according to available resources and taking into account the conditions of risk and uncertainty in agriculture can help farmers, managers and economic planners in the choose of the kind of the products and the level of their cultivation, and thus, the maximum use of available resources can be helped to a large extent to reduce potential damage to the agricultural sector. (Hazell, 1982). In the meantime, mathematical programming models (such as linear programming) could be a useful tool for selecting suitable cropping pattern (Kopahi, 1986), but ignore this risk impact on farmers' incomes in the agricultural sector planning models, often has creating an unacceptable result, and it is difficult the policy-making based on the obtained results.
Products evaluated in this study are irrigated wheat x1, rainfed wheat x2, rainfed barley x3, irrigated barley x4, corn x5, sugar beet x6, potatoes x7, rainfed sunflower x8, and irrigated sunflower x9. Programming techniques used in this study to determine the optimum cropping pattern of the elected crop of the province are as follows: linear programming model, random quadratic programming and Motad programming.

2.1 Linear programming model

Linear programming is called for short LP, the problem solving a system of linear inequalities, dates back to the time of February, which linear programming arose as a mathematical model and at the time of the Second World War, and then it turned out that, planning and coordinating various projects and the effective use of scarce resources is a necessity. Team (optimized applications scientific computing) United States Air Force began its serious work in June 1947. The implications have invented the simplex method by Jourje Ji dontezik, at the end of summer 1947. In general, any optimization model will be the following three items:

Objective function: It is a formula that says exactly what needs to be optimized. In commercial models, the objective function is usually a function of profit, which should be maximized it, or is a cost function to be minimized it. Models capable have a maximum of an objective function.
Variables: They are quantities that are under your control and you must decide what the best of them is.
Constraints: Some constraint will be limited to the values of the variables in a model of a source; these constraints are in the form of formulas, functions of the model, which is known as constraints such as time, materials and so on. (Moradinejad, 2009)

$$\mathbf{E}_{\max} = Z = \max \sum_{\mathbf{j}=1}^{\mathbf{n}} \bar{\mathbf{C}}_{\mathbf{j}} \mathbf{X}_{\mathbf{j}}$$

$$\mathbf{S.\ t:}$$

$$\sum_{\mathbf{j}=1}^{\mathbf{n}} \mathbf{a}_{\mathbf{ij}} \mathbf{X}_{\mathbf{j}} \le \mathbf{b}_{\mathbf{i}} \left(\mathbf{i} = 1, 2, \ldots, \mathbf{m}\right)$$

$$\mathbf{X}_{\mathbf{j}} \ge 0 \left(\mathbf{j} = 1, 2, \ldots, \mathbf{n}\right)$$

In this model, Cj and bi and aij are constant values and Xj called the decision variables (activities). Cj's are called coefficient of cost or profitability, and bi's are called the right numbers. aij call the technical coefficients and if bi is denoting source, in this case, aij is indicated how much of the source i, which is used to perform a unit of work j. Z function is called the objective function, which is indicative asked to the decision maker as to maximize profits or minimize costs.
We have 9 x variables, include: irrigated wheat x1, rainfed wheat x2, rainfed barley x3, irrigated barley x4, corn x5, sugar beet x6, potatoes x7, rainfed sunflower x8, irrigated sunflower x9.

2.2 Quadratic programming model (QP)

In mathematics, quadratic programming is the process of solving a system of equalities and inequalities on the set of real unknown variables in an objective function, which should be minimum or maximum and part of its limitations is nonlinear.

$$\mathbf{MinV} = \sum_{\mathbf{j}=1}^{\mathbf{n}} \sum_{\mathbf{k}=1}^{\mathbf{n}} \mathbf{X}_{\mathbf{j}} \mathbf{X}_{\mathbf{k}} \boldsymbol{\sigma}^{\mathbf{jk}}$$

$$\mathbf{S.\ t:}$$

$$\sum_{j=1}^{n} \bar{\mathbf{C}}_{\mathbf{j}} \mathbf{X}_{\mathbf{j}} = \boldsymbol{\lambda}$$

$$\sum_{\mathbf{j}=1}^{\mathbf{n}} \mathbf{a}_{\mathbf{ij}} \mathbf{X}_{\mathbf{j}} \le \mathbf{b}_{\mathbf{i}} \left(\mathbf{i} = 1, 2, \ldots, \mathbf{m}\right)$$

$$\mathbf{X}_{\mathbf{j}} \ge 0 \left(\mathbf{j} = 1, 2, \ldots, \mathbf{n}\right)$$

In this model $\boldsymbol{\sigma}_{\mathbf{jk}}$ represents the covariance is between profits from acquisition from cultivation one hectare of product j to product k. If that is j=k, the covariance becomes to the variance.

$\bar{\mathbf{C}}_{\mathbf{j}}$, is represents the average profit of the product j in the period under review, and λ, is a constant parameter and represents the maximum attainable expected income from the firm. aij is represents the technical coefficients, and bi is the all source I, available to the firm. The total represents the average expected profit E, and is an equal set of parameters λ. Value of the parameter λ, changing from zero to EMAX and is acceptable.

2.3 Motad programming model

The Motad programming method is linear approximation programming with the risk from the second degree (QRP). Hazell to deal with problems, estimate of required variance-covariance matrix QRP, presented the proposed use of absolute deviation yields of the average return (MAD) them. So in Motad model, risk measurement, takes place on the basis MAD. These criteria could simply mean that in the linear programming model and performed it with common software to solve this kind of problem. Since the objective function this model has been to minimize the total value of deviations, Hazell called it Motad model.

$$\min \sum_{t} Z_t$$

S. t:

$$\sum_{t} \left(C_{jt}\ \bar{C}_j \right) X_j + Z_t \geq 0$$

$$\sum_{j} \sum_{j} \bar{C}_j X_j = \lambda$$

$$\sum_{+} a_{ij} X_j \leq b_i$$

$$X_j, Z_t^{-} \geq 0$$

In this regard, $\sum_t Z_t$ is being introduced to the sum of negative deviations below average incomes. The Motad programming model makes a minimum total negative deviation farm income from the expected income (average income). In fact, Motad programming is an approximate linear programming to solve quadratic programming.

3. RESULTS AND DISCUSSION

3.1 The results of solving the model Motad programming

According to the results presented in table1, about the risk, we can say the irrigated corn, sugar beets and potatoes are the most risky agricultural products in province, and irrigated sunflower, rainfed sunflower, irrigated barley and rainfed barley are the most low-risk products and irrigated wheat and rainfed wheat do not show a reaction to risk. In other words, it must be said that this product is a product with the degree of risk neutral.

Table1. The results of the Motad programming model to elected farm crops of province

Optimum pattern of cultivation (hectares)	Optimal solution	Opportunity cost (million rials)	Constraints	Shadow price (million rials)
Irrigated wheat	0	79.9265		
Rainfed wheat	112635.5	0	Seed	0.2434
Rainfed barley	0	17.0095	Water	0
Irrigated barley	0	146.0361	Land	149.8096
Irrigated corn	14688.81	0	Poison	0
Sugar beet	0	309.8317	Fertilizer	0.9276
Irrigated potatoes	0	605.7121	work force	0
Rainfed sunflower	0	124.27	Tractor	0
Irrigated sunflower	11309. 44	0		0
Expected revenue (λ) (million rials)	49852560			

The results of Motad programming model for the agricultural sector of the province showed that is the most optimum cropping pattern, in order to achieve the highest level of profits, given the provisions and constraints facing the cultivation, 112635.5 hectares of rainfed wheat, 14688.81 hectares of irrigated corn and 11309.44 hectares of irrigated sunflower, that this crop pattern makes a profit of about 49,852,560 million rials increased agricultural sector of the province.

3.2 The results of solving the maximize linear programming model

The objective function in a linear programming model was to maximize profits of cultivation of crops in the region. Solve results of the linear programming model is presented as follows.

Table2. The results of linear programming model for maximizing elected farm crops of the province

Product Year	Irrigated wheat	Rainfed wheat	Rainfed barley	Irrigated barley	Irrigated corn	Sugar beet	Irrigated potatoes	Rainfed sunflower	Irrigated sunflower	Gross profit
2006-2007	-	-	-	-	914.9153	-	-	-	-	2583947
2007-2008	-	-	-	-	291.0679	-	-	-	-	1.358684
2008-2009	-	-	-	-	-	-	47.2716	-	-	9.183079
2009-2010	-	-	-	-	1673.0320	-	-	-	-	2391523
2010-2011	-	-	-	-	-	-	-	-	4197.35	4.660268

According to the results presented in the above table, the main product in terms of being profitable in the years 2006 to 2011, can be named irrigated corn. Also, in 2008-2009, due to lack of cultivation of this product, the product that is most profitable for the province is potatoes. On the other hand, in 2010-2011, despite the lack of cultivation of sugar beet and irrigated potatoes, the irrigated sunflower product selected as profitable product. Therefore, according to the linear programming model, products of irrigated corn, irrigated potatoes and sunflower, can be called as the elected farm crop of the province, in products generate profit in the province, respectively.

Table3. The results of linear programming model to lower the cost of elected farm products of province

Product Year	Irrigated wheat	Rainfed wheat	Rainfed barley	Irrigated barley	Irrigated corn	Sugar beet	Irrigated potatoes	Rainfed sunflower	Irrigated sunflower
2006-2007	-705756.6	-199433	-489282.6	-44723.27	-	-65941.99	-12006.7	-97752.5	-
2007-2008	-96634.41	-22721.48	-8449.473	-41611.65	-	-3743.558	-11531.75	-9265.424	-1672.665
2008-2009	-40066.93	-10065.20	-4963.604	-29720.49	-	-2872.218	-	-5306.933	-
2009-2010	-771747.1	-154609.3	-112228.8	-378157.4	-	-53083.57	-105870.9	-94877.98	-12854.77
2010-2011	-122709.6	-20905.14	-8992.147	-77026.27	-381.7961	-	-	-14292.34	-

According to table3, we can see that for the linear model, reducing the cost of agricultural production based on the optimum model products of the province is the form above. For example, reduce the cost of planting one hectare of irrigated wheat in the agricultural sector of the province is equal to 705756.6 million rials, and means that, if reducing the cultivation at a rate of one hectare of this product within the framework of the optimum cultivation pattern section agricultural of province will reduce the cost to the size of 705756.6 million rials. Similarly, for other products can be described as this pattern.

Shadow price, based on linear programming for constraint is shown in table4. Accordingly, the above table can be interpreted as follows. According to the table, in this model the shadow price for land constraints in the agricultural years 2006-2007, is the amount of 23.9343 million rials. In other words, we can say that in the linear programming model, the land constraints have a very important role in the structure of the model and cultivation of crops in this province. For the rest of the year, also shadow price is to land constraints that the amount of it, you can see in table4.

Table4. Results of linear programming model (shadow price)

Constraint	Seed	Water	Land	Poison	Fertilizer	work force	Tractor	Capital
2006-2007	-	-	23.9343	-	-	-	-	-
2007-2008	-	-	2.8860	-	-	-	-	-
2008-2009	-	-	1.3485	-	-	-	-	-
2009-2010	-	-	24.8958	-	-	-	-	-
2010-2011	-	-	3.9327	-	-	-	-	-

3.3 The results of solving a quadratic mathematical programming model

Table5. The results of solving a quadratic programming model

Product Year	Irrigated wheat	Rainfed wheat	Rainfed barley	Irrigated barley	Irrigated corn	Sugar beet	Irrigated potatoes	Rainfed sunflower	Irrigated sunflower
2006-2011	-	-	-	-	21296118	9927215	-	-	-

According to the results from quadratic model, you can see in the above table shows that over the years, field crop cultivation of irrigated corn and sugar beet have been chosen as the selected product. Means cultivation of these two products in terms of cost for the agricultural sector has suffered a lower cost compared to other agricultural products of the province. Of course, the results of this model, like the previous model, irrigated corn crop has been selected again as a product that is optimal in terms of cost and in terms of profits, it can be concluded that the consistency of three models. Also in this model, the shadow price for water constraint in the second row is to the amount of 3132801792 rials. In other words, we can say that in the quadratic mathematical programming model, the water constraint has a significant share in the structure of the model and cultivation of crops in this province. According to procedures in the process of study, we have determined that the irrigated corn, sugar beets and potatoes are the most risky agricultural products in province, and irrigated sunflower, rainfed sunflower, irrigated barley and rainfed barley are the most low-risk products and irrigated wheat and rainfed wheat do not show a reaction to risk. In other words, it must be said that this product is a product with the degree of risk neutral.

According to the Motad model, also performed in this study, combined agricultural production of rainfed wheat, irrigated corn and irrigated sunflower are products that optimize the their cultivation and includes the lowest costs in the agricultural sector. On the other hand, the constraint of seeds, land and fertilizer has a very important role in determining the optimal cropping pattern.

According to the linear programming model, also in 2006 to 2011, can be regarded irrigated corn, as the most economical agricultural products of Semnan province, and after that, production of potatoes and irrigated sunflowers, economically are useful and a profit more than other crops in the agricultural sector in Semnan province. Also the results of the quadratic programming model, the agricultural production of irrigated corn and sugar beets has chosen as key products of the province. Also, for the constraint, according to the third model, the Motad model (seeds, land, and fertilizer) has the highest share, in the linear model the land has the highest share, and in the quadratic programming model the water has the greatest impact in the optimal cropping pattern of agricultural production.

According to the results, based on three models of Motad, linear and quadratic, it could be argued:

- The irrigated corn crop in all three models has been chosen as the economic product of the agricultural sector.
- Irrigated sunflower crops in the Motad and linear model has been chosen as the basic product.
- Also, products such as sugar beet in the quadratic programming model, potato in the linear model, and rainfed wheat in Motad model has been selected as basic products.
- The main constraints, according to three performed models, in order of priority: are land, water, fertilizer and seed.

According to the obtained results that have been achieved in this research is presented suggestions offered to reduce risk, and increase profitability, and reduce the cost of farmers in Semnan province, So we can present the following proposals, according to the results of this research, for the agricultural sector in Semnan province:

- ✓ Encourage by the use of low-risk pattern crops cultivation, such as sunflower and barley, in cases where, the farmers in the province are exposed to risk conditions and serious uncertainty in this section.
- ✓ Promote and encourage farmers to insure agricultural products, especially corn, sugar beet and potatoes in this province.
- ✓ Expanding the safety net of insurance, especially in the irrigated corn, sugar beet and potato, and decrease their insurance premiums.
- ✓ According to the optimized the irrigated corn crop in all three programming models in this study, it is suggested that the cultivation of this crop in the province, should be a priority, as well as to increase investment in this product.
- ✓ With respect to the find farming main constraints in the agricultural sector of Semnan province for this province is suggested that the government in the agricultural sector to increase productivity from agricultural produce of province reduce these constraints.
- ✓ It is suggested, according to the study objectives in the case of research facilities conducted more broadly and with larger samples and the results compared with the results of this research.

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