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# Investigation the Substitution Capability of Oilseeds in Cropping Pattern

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**Abstract: Problem statement:** Farm activity is a risky activity special in less developed countries, so all decisions and activities are affected by this phenomenon. Consideration of risk either helps to elimination of deviations in result of model or preparing tools for evolution of some policies that the aim of them is reducing the risk for farmers. Oil seed are the second resource of food store in the world. Also, Iran is depending on oil import and going out of much exchange to provide oil and scum of that annually. Because of this matter, agriculture sector need plants that are adjust to climate of Iran and have a lot of oil, that canola is the best one. **Approach:** In this study, capability of substitution oilseeds in cropping pattern was considered; optimum cultivated pattern of important crops that have most cultivated area of canola in Khorasan Province is considered. Linear programming and risk-programming models such as MOTAD and quadratic programming were compared. **Results:** Models suggest increasing the cultivated area of oilseeds crop. **Conclusion:** Increasing the cultivated area of canola cause to the pattern cultivating of farmers improve and inputs will used in better way, too. Increasing the cultivated area, it is a movement toward self sufficient in oil seed production that will accompany with noticeable thrift in foreign exchange.

**Key words:** Cropping pattern, risk programming, linear programming, MOTAD, quadratic programming, oilseeds

## INTRODUCTION

Farm activity is risky activities special in less developed countries, so all decisions and activities are affected by this phenomenon. Farmers prefer plans that have more confident earning even if they have less income. Achieving to agricultural development goals is possible in condition to be proper policies and programs in agricultural sector and natural resources. It depends on the knowledge of manager about reaction of farmers. Due to the result of agricultural plans determine in future and it faces to uncertainty so, the programs have to consider this condition. Ignoring of risk and risky manner of farmers cause to the result of models has less conformity to reality. In such models, supply of risky crops and price of productive resources are[3]. Therefore, considering the risk, help to elimination of deviations in result of model or preparing tools for evolution of some policies that the aim of them is reducing the[10].

Ignoring of risk and the impact of it on farmers income causes to farm programming models have an unacceptable or sometimes offer policies that are in contrast to reality. Scientist presents several models to solve this problem including: Minimization of Total Absolute Deviation (MOTAD) which total of negative deviations of gross margin of farm activities minimize from the mean of several years and quadratic programming that variance-covariance of activities gross margin is minimized[11,13-15].

Oil seed such as canola is the second resource of food store. According to FAO reports, canola is third resource of production of edible oil such, 14.7% of produced oil is extracted from it [16]. Our country is depend on oil import and going out of much exchange to provide oil and scum of that, annually. Because of this matter, agriculture sector need a plant that be adjust to climate of Iran and have a lot of oil, canola is the best one and has all of these attributes and it is special phenomenon in agriculture of Iran in recent decade.

Type and amount of risk that farmers face on them are related to kind of farmers, climatic and structural combination and the type of products. Although, agricultural risk is in all part of the world, but intensity

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of that in developing countries is more than industrial countries[9] and it is hard for farmers in there to tolerate it[8].

There are many studies about applying of risk in agriculture sector including[1,2,4,56,12].

## MATERIALS AND METHODS

Set of efficient E and V can be obtained by quadratic programming. $X_j$ Is jth farm activity and $\sigma_{jk}$, is covariance between j and kth activity, (when j = k, $\sigma_{jk}$ is variance of farm.) so total covariance of gross margin is equal to:

$$V = \sum_j \sum_k X_j X_k \sigma_{jk} \quad (1)$$

The Eq. 1 show that total variance of gross margin, is aggregate of income variation of each activity and covariance between them.

To obtain set of efficient E and V, whereas possibility with due attention to constraint of resources is considered, V will be minimized for every possible level of expected revenue. Programming model of it is as following:

$$\text{Min}V = \sum_j \sum_k X_j X_k \sigma_{jk} \quad (2)$$

As:

$$\sum_j \overline{c}_j X_j = \lambda \quad (3)$$

$$\sum_j a_{ij} X_j \le b_i \quad (4)$$

$$X_j \ge 0 \quad (5)$$

In these equations $\overline{c}_j$ is expected gross margin of jth activity and $\lambda$ is vectorial scale. In Eq. 1 X's are quadratic, so the model should be solve in quadratic framework.

$\sum \overline{c}_j X_j$ is total expected gross margin and is equal to $\lambda$. If $\lambda$ change, range of total gross margin obtain with regard to constraint of resources. Maximum value is corresponded to linear programming problems about of maximization of total expected gross margin with due attention to constraints in Eq. 3-5.

**MOTAD model:** One of linear programming model to analyze E, V was developed by Hazell. When variance of farm income be estimated by time series data. In this state, income variance criterion that use in quadratic programming, is a statistic estimation of real variance. Hazel suggested the applying of variance estimations based on Mean Absolute Deviations (MAD) of sample.

If the information of sample and classic model uses to estimate the variance and covariance of sample, variance of estimated income in quadratic programming is written as following:

$$\hat{V} = \sum_j \sum_k X_j X_k \left[ (1/T-1) \sum_{t=1}^{T} \left[ c_{jt} - \overline{c}_j \right] \left[ c_{kt} - \overline{c}_k \right] \right] \quad (6)$$

In Eq. 6 t = 1, 2,…,T, represent T observation of sample and $c_{jt}$ is gross margin of jth activity in ith year and average of gross margin is equal to $\overline{c}_j$.

Summing in term of t and factoring the variance of estimation would be equal to:

$$\begin{aligned} \hat{V} &= (1/T-1) \sum_t \left[ \sum_j c_{jt} X_j - \sum_j \overline{c}_{jt} X_j \right]^2 \\ &= (1/T-1) \sum_t \left[ Y_{1\_} \overline{Y} \right]^2 \end{aligned} \quad (7)$$

It means, variance of farm income for a production plan can be written in aggregation form of variance and covariance of each activity (Eq. 6) or by calculating the farm income correspond to each observation about gross margin of activities and estimation of the variance of stochastic variable, so MAD estimator of variance Y is used. MAD estimator is:

$$\begin{aligned} \hat{V} &= F \left\{ (1/T) \sum_t \left| \sum_j c_{jt} X_j - \sum_j \overline{c}_j X_j \right| \right\}^2 \\ &= F \left\{ (1/T) \sum_t \left| Y1 - \overline{Y} \right| \right\}^2 \end{aligned} \quad (8)$$

In this equation, the phrase that is put on bracket is MAD of sample and F is a fix coefficient that connects the MAD of sample to variance of society. $F = T\pi/2*(T-1)$ that $\pi$ in this equation is fixed mathematical coefficient. About of MAD estimator, if in quadratic programming, relation (8) is substituted in relation (2), therefore a linear programming model would be obtained.

Deviation of farm income from its mean is sowed by $Z_t^+$, if it were positive and by $Z_t^-$, if it were negative.

So:

$$Z_t^+ - Z_t^- = \sum_j c_{jt} X_j - \sum_j \overline{c}_j X_j \quad (9)$$

In this formula, $Z_t^+$ and $Z_t^-$ are nonnegative and measure the absolute deviation of income. In addition to, one of them can be zero in a year because deviation cant be negative and positive, simultaneously.

Now:

$$\sum_t \left[ Z_t^+ + Z_t^- \right] \quad (10)$$

It measure absolute deviation values of income for a farm plan, so, MAD estimator of variance would be equal to:

$$\tilde{V} = F\left\{ (1/T) \sum_t \left[ Z_t^+ + Z_t^- \right] \right\}^2 \quad (11)$$

Because $F/T^2$ is a fixed number for a special farm plan, $F/T^2$ can be divided to $\tilde{V}$ :

$$W = (T^2/F)\tilde{V} = \left\{ \sum_t \left[ Z_t^+ + Z_t^- \right] \right\}^2 \quad (12)$$

Whereas grading of farm program based on $W^{0.5}$ is like to that on based on W, the root of W is calculable. The linear programming model instead of quadratic programming is such this:

$$\text{Min} W^{\frac{1}{2}} = \sum_t \left[ Z_t^+ + Z_t^- \right] \quad (13)$$

$$\sum_j \left[ c_{jt} - \bar{c}_j \right] X_j - Z_t^+ + Z_t^- = 0 \quad (14)$$

$$\sum_j \bar{c}_j X_j = \lambda \quad (15)$$

$$\sum_j a_{ij} X_j \le b_i \quad (16)$$

$$X_j, Z_t^-, Z_t^+ \ge 0 \quad (17)$$

Hazel named this model MOTAD, because of minimization of total absolute deviation in objective function.

## RESULTS

In this study, optimum cultivated pattern of important crops of Sabzevar and Torbat Jaam that have most cultivated area of canola in Khorasan Province is considered. Linear programming and risk-programming models such as MOTAD and quadratic programming are compared. Farmers has been divided to 3 groups; farmers that have lees than 5 ha, between 5-10 ha and more than 10 ha. Decision variables are cultivated area of canola, wheat, barley, beetroot, caraway, cotton, melon, Lucerne and giant millet; received credits; self-consuming of wheat and barley and amount of sale of these products. In MOTAD model has been applied 6 variables from 2002-2007. In MOTAD model, object is minimizing the sum of deviation of total gross margin from expected revenue and in quadratic model is minimizing the total variance of gross margin. Constraints are including land, water, labor, machinery, capital and credits.

The results of determination of cultivating pattern by MOTAD and quadratic programming for Torbat Jaam and Sabzevar and are shown in Table 1 and 2.

In Table 1, the results of LP show cultivated areas of canola, barley, caraway in all groups of farmers increased in comparison to present state, for cotton, cultivated area increased for group 1 and 2, in other cases it decreased or had been zero.

The results of MOTAD model show, when $\lambda$ is equal to gross margin of LP pattern, cultivated areas of canola, barley, beetroot and caraway have been increased in all groups of farmers and it has been decreased for wheat and it has been zero for other crops. When $\lambda$ is equal to 90% of total gross margin of LP, as represented in Table 1, cultivated areas of canola, beetroot and caraway for group 1 and 3 have been increased and it has been decreased or has been zero in other situations. When $\lambda$ has assumed 80% of total gross margin of LP, the results are like the previous one, but in this state the cultivated area of caraway has increased for all groups.

The results of quadratic model show that, for canola in every three condition, when $\lambda$ = 100 or 90 and or 80% of total gross margin that have been gotten from LP, cultivated area increased in comparison to present state. For wheat, it decreased in all groups, for barely; it has decreased in most of the cases for all groups. For beetroot, it has decreased in all states and for caraway, most of the cases, it has increased or has been near to present state. For another crops including cotton, melon, Lucerne, except melon on group 3 and cotton on group 1 when $\lambda$ = 100%, it is zero.

In Table 2, the results of LP show cultivated areas of canola, barley and melon in all groups of farmers and giant millet, Lucerne and cotton for groups 1 and 2 and wheat in group 1, increased in comparison to present state, the cultivated area of beetroot, Lucerne and giant millet in group 3 became zero and other cases it decreased.

Table 1: Estimation results of cultivating pattern in Torbat Jaam

| Variable | Land (ha) | Present state (ha) | Linear programming | MOTAD λ = 100% | MOTAD λ = 90% | MOTAD λ = 80% | Quadratic λ = 100% | Quadratic λ = 90% | Quadratic λ = 80% |
|---|---|---|---|---|---|---|---|---|---|
| Canola | Less* than 5 | 40 | 116.19 | 493.87 | 493.870 | 493.870 | 106.37 | 493.87 | 493.87 |
| | 5-10** | 100 | 463.49 | 463.49 | 463.490 | 463.490 | 463.49 | 463.49 | 463.48 |
| | More*** than 10 | 210 | 1112.84 | 1112.85 | 1112.850 | 1112.850 | 1112.85 | 1112.85 | 1112.85 |
| Wheat | Less than 5 | 3600 | 4225.11 | 2053.70 | 1922.260 | 1254.560 | 2454.61 | 1628.44 | 945.79 |
| | 5-10 | 7200 | 7361.03 | 7964.37 | 9408.210 | 5328.600 | 3964.37 | 2605.11 | 6938.19 |
| | More than 10 | 15000 | 5649.37 | 5415.09 | 5525.410 | 3042.290 | 3261.51 | 3210.43 | 2914.15 |
| Barley | Less than 5 | 1000 | 4630.12 | 1559.83 | 1428.400 | 760.700 | 2348.24 | 1134.57 | 451.93 |
| | 5-10 | 2000 | 5476.27 | 4081.29 | 1081.320 | 950.190 | 1105.61 | 1025.61 | 4056.14 |
| | More than 10 | 4200 | 3929.27 | 4381.64 | 2194.312 | 3031.110 | 2271.36 | 2097.58 | 1801.30 |
| Beetroot | Less than 5 | 400 | 0.00 | 5000.00 | 5000.000 | 5000.000 | 4909.23 | 5000.00 | 5000.00 |
| | 5-10 | 930 | 0.00 | 462.91 | 1594.460 | 2215.160 | 3718.41 | 4899.23 | 452.87 |
| | More than 10 | 1800 | 0.00 | 1282.06 | 2822.560 | 4247.850 | 3192.83 | 4006.86 | 4926.24 |
| Caraway | Less than 5 | 220 | 293.18 | 892.60 | 287.810 | 254.934 | 0.00 | 601.17 | 584.23 |
| | 5-10 | 500 | 467.60 | 903.54 | 266.270 | 903.850 | 1598.84 | 447.36 | 642.68 |
| | More than 10 | 960 | 1594.17 | 3355.27 | 2273.690 | 627.210 | 3658.66 | 2289.43 | 775.47 |
| Lucerne | Less than 5 | 100 | 1028.58 | 0.00 | 0.000 | 0.000 | 0.00 | 0.00 | 0.00 |
| | 5-10 | 230 | 0.00 | 0.00 | 0.000 | 0.000 | 0.00 | 0.00 | 0.00 |
| | More than 10 | 440 | 0.00 | 0.00 | 0.000 | 0.000 | 0.00 | 0.00 | 0.00 |
| Melon | Less than 5 | 1370 | 521.20 | 0.00 | 0.000 | 0.000 | 0.00 | 0.00 | 0.00 |
| | 5-10 | 3160 | 0.00 | 0.00 | 0.000 | 0.000 | 0.00 | 0.00 | 0.00 |
| | More than 10 | 6000 | 509.94 | 0.00 | 0.000 | 0.000 | 122.70 | 0.00 | 0.00 |
| Cotton | Less than 5 | 170 | 214.20 | 0.00 | 0.000 | 0.000 | 181.55 | 0.00 | 0.00 |
| | 5-10 | 400 | 116.48 | 0.00 | 0.000 | 0.000 | 0.00 | 0.00 | 0.00 |
| | More than 10 | 750 | 892.23 | 0.00 | 0.000 | 0.000 | 0.00 | 0.00 | 0.00 |

*: Less than 5 ha; **: Between 5-10 ha; ***: More than 10 ha

Table 2: Estimation results of cultivating pattern in Sabzevar

| Variable | Land (ha) | Present state (ha) | Linear programming | MOTAD λ = 100% | MOTAD λ = 90% | MOTAD λ = 80% | Quadratic λ = 100% | Quadratic λ = 90% | Quadratic λ = 80% |
|---|---|---|---|---|---|---|---|---|---|
| Canola | Less* than 5 | 90 | 2410.26 | 2410.260 | 2410.26 | 2410.260 | 2410.26 | 2410.26 | 2410.26 |
| | 5-10** | 340 | 5767.63 | 5767.630 | 5767.63 | 5767.630 | Infeasible | Infeasible | Infeasible |
| | More*** than 10 | 220 | 2926.74 | 2926.740 | 2696.74 | 2926.740 | 2926.74 | 2926.74 | 2926.74 |
| Wheat | Less than 5 | 6200 | 6738.61 | 6738.610 | 4502.91 | 4465.400 | 4463.16 | 3716.53 | 4096.16 |
| | 5-10 | 21000 | 20428.63 | 11056.920 | 13027.91 | 16544.360 | Infeasible | Infeasible | Infeasible |
| | More than 10 | 15000 | 13172.82 | 8292.680 | 8407.16 | 12165.330 | 9566.34 | 14608.32 | 10122.65 |
| Barley | Less than 5 | 3500 | 4560.38 | 6671.240 | 6683.30 | 4475.790 | 8121.95 | 4781.07 | 4162.62 |
| | 5-10 | 13000 | 13760.38 | 33844.130 | 26477.85 | 18362.200 | Infeasible | Infeasible | Infeasible |
| | More than 10 | 84000 | 8736.71 | 11571.040 | 9134.43 | 6098.990 | 4963.27 | 8743.18 | 7207.65 |
| Beetroot | Less than 5 | 3500 | 0.00 | 0.000 | 5812.89 | 10227.920 | 1517.53 | 7994.94 | 10669.03 |
| | 5-10 | 12000 | 0.00 | 9776.480 | 24509.05 | 37858.750 | Infeasible | Infeasible | Infeasible |
| | More than 10 | 8000 | 0.00 | 2844.050 | 6962.80 | 9578.260 | 4656.09 | 4174.98 | 10138.84 |
| Giant millet | Less than 5 | 150 | 171.30 | 0.000 | 0.00 | 1087.120 | 0 | 0 | 1489.16 |
| | 5-10 | 500 | 675.19 | 0.000 | 0.00 | 0.000 | Infeasible | Infeasible | Infeasible |
| | More than 10 | 350 | 0.00 | 0.000 | 0.00 | 0.000 | 0 | 0 | 0 |
| Lucerne | Less than 5 | 250 | 308.37 | 439.230 | 3586.76 | 1123.530 | 2950.79 | 1002.08 | 0 |
| | 5-10 | 1000 | 1207.91 | 3363.360 | 1992.39 | 2815.430 | Infeasible | Infeasible | Infeasible |
| | More than 10 | 700 | 0.00 | 0.000 | 0.00 | 0.000 | 0 | 0 | 0 |
| Melon | Less than 5 | 30 | 1912.91 | 2342.890 | 4590.64 | 2420.640 | 6069.04 | 3474.79 | 2476.72 |
| | 5-10 | 100 | 14688.01 | 28554.840 | 19217.56 | 9026.267 | Infeasible | Infeasible | Infeasible |
| | More than 10 | 70 | 4588.74 | 6205.100 | 3654.01 | 1125.330 | 7129.1 | 3602.23 | 1002.17 |
| Cotton | Less than 5 | 1000 | 6696.95 | 5837.004 | 0.00 | 0.000 | 1418.065 | 1622.42 | 185.22 |
| | 5-10 | 3600 | 18766.75 | 0.000 | 0.00 | 0.000 | Infeasible | Infeasible | Infeasible |
| | More than 10 | 2300 | 2174.79 | 0.000 | 0.00 | 0.000 | 0 | 0 | 0 |

*: Less than 5 ha; **: Between 5-10 ha; ***: More than 10 ha

Table 3: Results of comparison of different models

| | | Sabzevar | | Torbat Jaam | |
|---|---|---|---|---|---|
| Variable | Land (ha) | Present state (ha) | Selected pattern | Present state (ha) | Selected pattern |
| Canola | Less than 5 | 90 | 2410.26 | 40 | 493.87 |
| | 5-10 | 340 | 5767.63 | 100 | 463.49 |
| | More than 10 | 220 | 2696.74 | 210 | 1112.85 |
| Wheat | Less than 5 | 6200 | 4502.91 | 3600 | 2053.70 |
| | 5-10 | 21000 | 13027.91 | 7200 | 7964.37 |
| | More than 10 | 15000 | 8407.16 | 15000 | 5415.09 |
| Barley | Less than 5 | 3500 | 6683.30 | 1000 | 1559.83 |
| | 5-10 | 13000 | 26477.85 | 2000 | 4081.29 |
| | More than 10 | 84000 | 9134.43 | 4200 | 4381.64 |
| Beetroot | Less than 5 | 3500 | 5812.89 | 400 | 5000.00 |
| | 5-10 | 12000 | 24509.05 | 930 | 462.91 |
| | More than 10 | 8000 | 6962.80 | 1800 | 1282.06 |
| Caraway | Less than 5 | ___ | ___ | 220 | 892.60 |
| | 5-10 | ___ | ___ | 500 | 903.54 |
| | More than 10 | ___ | ___ | 960 | 3355.27 |
| Giant millet | Less than 5 | 150 | 0.00 | ___ | ___ |
| | 5-10 | 500 | 0.00 | ___ | ___ |
| | More than 10 | 350 | 0.00 | ___ | ___ |
| Lucerne | Less than 5 | 250 | 3586.76 | 100 | 0.00 |
| | 5-10 | 1000 | 1992.39 | 230 | 0.00 |
| | More than 10 | 700 | 0.00 | 440 | 0.00 |
| Melon | Less than 5 | 30 | 4590.64 | 1370 | 0.00 |
| | 5-10 | 100 | 19217.56 | 3160 | 0.00 |
| | More than 10 | 70 | 3654.01 | 6000 | 0.00 |
| Cotton | Less than 5 | 1000 | 0.00 | 170 | 0.00 |
| | 5-10 | 3600 | 0.00 | 400 | 0.00 |
| | More than 10 | 2300 | 0.00 | 750 | 0.00 |

## DISCUSSION

The results of MOTAD model show, when λ is equal to total gross margin of LP pattern, results of that for canola, wheat, barley, Lucerne and melon are similar to LP model. The cultivated area for cotton shows, it increased for group 1 and decreased for groups 2 and 3 in comparison to present one. It has had noticeable growth for beetroot on group 1 and 2. It became zero for giant millet. When λ is equal to 90% of total gross margin of LP, as represented in Table 1, situation of canola, barley, Lucerne and melon didn't have changed in relation to previous model (λ = 100%) and it has increased a lot for beetroot, it is zero for giant millet and cotton. When λ has assumed 80% of total gross margin of LP, the results for crops including canola, wheat, barley, beetroot, Lucerne and cotton is like to λ = 90% and it increased for giant millet on group 1 of farmers.

The results of quadratic model show that, the answers for group 2 of frames were infeasible for every λ, for canola on groups 1 and 2, results are like pervious models, for wheat, cultivated area is decreased for mentioned groups in relation to present condition, for barley it increased for all λ on group 1 and decreased for all λ group 3. when λ = 100, 90 and 80% of total gross margin that have been gotten from LP, cultivated area of beetroot increased in comparison to LP that were 0. It decreased when λ = 100% and increased when it is 80%. For giant millet, it's zero except when λ = 80% on group 1 that increased. For melon on all groups, cotton on group 1 in every three state of λ and Lucerne when λ = 100 and 90%, it increased and for remains, it's zero.

Among the estimated model, MOTAD model when its λ = 100% for Torbat Jaam and MOTAD model when its λ is equal to 90% for Sabzevar are selected based on minimum mean deviation of cultivated area from present condition. It is tried to choose the pattern is more similar to present state and be more acceptable for farmers (Table 3).

## CONCLUSION

On the basis of finding, selected model for risky situation advices to increase cultivated area of canola, barley, beetroot and Melon and decrease cultivated area of wheat, giant millet and in Sabzevar. For Torbat Jaam, increasing in cultivated area of canola, barley, beetroot, caraway and decreasing in wheat, Lucerne, melon and cotton is suggested.

Because the emphasis on present study is on cultivated area of canola, as you see in results, all models suggest increasing the cultivated area of this crop. Increasing the cultivated area of canola cause to the pattern cultivating of farmers improve and inputs will used in better way, too. Increasing the cultivated area, it is a movement toward self sufficient in oil seed production that will accompany with noticeable thrift in foreign exchange.

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