



# Analysis of Factors Affecting Canola Plantation Development in Tabriz and Marand Counties, Iran

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## Abstract

This study identifies and analyzes factors influencing canola plantation development in Tabriz and Marand Counties. The Censored Model was used to analyze cross-sectional data collected from 372 farmers using a questionnaire. Due to the weakness of the Tobit model in separating factors affecting the adoption decision of farmers and factors affecting the rate of adoption, the Heckman Model was employed to separate the contributions made by these factors. The results of estimated Probit model in the first stage of the Heckman Approach showed that machinery ownership had an important effect on canola adoption, as a 1% increase in machinery ownership had led to 0.158% increase in canola adoption probability. Contact with extension agents, farm income proportion, education, and farmers' experience influenced canola plantation probability positively, and the age and number of fragmentations had a negative impact on it. The significance of inverse Mill's ratio indicates that the factors affecting the decision to start planting and the amount of canola plantation are not the same. The Heckman's second step estimation results indicated that the loan amount, canola relative benefit, and family labor had a positive effect, and that machinery cost and farm distance from the road had a negative effect on canola acreage. Relative benefit was the most effective element, as 1% increase in relative benefit results in a 0.342% increase in canola plantation.

**Keywords:**

*Canola Adoption, Censored Model, Heckman two step procedure*

## INTRODUCTION

Canola is the third most important source of vegetable oil in the world after soybean and palm. Rapeseed contains about 48% oil and has an appropriate fatty acid composition (Taheri et al., 2010). Per capita consumption of oil and fat is 17.4 kg in Iran and 90% of Iran's population oil need (2610 thousand tones) is imported from Brazil, Canada and Swiss (Mostofi, 2008; Youssefi et al., 2010). Given that domestic production of edible oils is insufficient to meet increasing demands due to population growth, the policy approach to Iran's agriculture has been increasing strategic agricultural products (especially oilseeds) to meet domestic consumption and to reduce dependence on food imports. In this regard, area expansion and yield improvement have been envisaged as the most significant solutions (Abyar, 2002).

Canola contains a high percent of oil. Characteristics and compatibility of canola with different climate conditions have increased its importance as hopes for the supply of edible oil in Iran. Meanwhile, despite the attempt made to increase canola production, East Azerbaijan Province has experienced considerable variation in canola cultivation to the extent that the number of canola cultivars has dropped from 1957 in 2007 to approximately 867 in 2010; it means 55% of canola cultivators during these years were decreased. Tabriz and Marand counties have an important role in whole province canola acreage determination. About one-third of province's canola cultivated area was assigned to these two counties.

Study of trend of canola plantation shows farmers' primary interest in canola plantation and in their turning away from this product. Farmers' attitudes toward canola are not stable; they may plant canola one year and give it up next year. Therefore, it must be investigated why farmers adopt different behaviors toward canola (cultivation continuity, or stop or deciding to start plantation for the first time).

Canola adoption and its plantation development can be a solution for oil import dependence problems. Whereas canola is an almost new crop in Iran, adoption models can be employed

for this study. Studies of adoption of new crops by farmers have been often framed within the traditional adoption-diffusion model of innovation. Rogers (1962) developed a model of diffusion, which has become widely established in the marketing literature. The diffusion process consists of four key elements: an innovation, the social system on which the innovation impacts, the communication channels of that social system, and time (Wright & Charlet, 1995). Notwithstanding, this model has some weaknesses, because it ignores individual farmer characteristics, social relations in decision-making and noneconomic goals. The other model is a farm structure model. This model looks at the economic constraints imposed by farm size and generally argues that larger and more economically viable farms are more capable of assuming the risks of new behaviors. Finally, researchers combined two theoretical explanations of farmer adoption behavior, the diffusion-innovation model and farm structure model (Lubell, 2004).

The decision to adopt a new crop or technology has been widely documented throughout the literature. Shapiro et al. (1992) used the Tobit Model to study the adoption of double cropping soybeans and wheat in the Midwest. The results showed that farmers start double cropping in an attempt to boost revenue and lower the risks. As Shapiro shows higher income encourages farmers to adopt new thing, so we can consider income and benefit as factors affecting canola cultivation adoption. Foster and Rosenzweig (1995) studied adoption and profitability of high-yielding seed varieties (HYV) associated with the Green Revolution of rural Indian households. They used a model incorporating learning by doing and learning spillovers. The estimates indicated that imperfect knowledge about the management of the new seeds was a significant barrier to adoption; this barrier diminished as farmers' experience with the new technologies increased. As they stated own experience and neighbors' experience with HYVs significantly increased HYV profitability, therefore experience and participation in extension classes could be an important factor influencing canola cultivation. Munshi (2004) studied technology diffusion in the Indian Green

revolution. As they stated, information flows are weaker in a heterogeneous population when the performance of a new technology is sensitive to unobserved individual characteristics, preventing individuals from learning from neighbors' experiences. This characterization of social learning is tested with wheat and rice. The rice-growing regions display greater heterogeneity in growing conditions and the new rice varieties were also sensitive to unobserved farm characteristics. Wheat growers respond strongly to neighbors' experiences, while rice growers do not. [Oladele \(2005\)](#) applied the Tobit Model to study the discontinued adoption of agricultural technology among farmers in southwestern Nigeria. The results indicated that the lack of extension visits and lack of input required were the most important factors on discontinuing adoption of improved maize. Accordingly, it could be deduced that inputs like machinery ownership, credits and so on, can influence canola cultivation. [Amao and Awoyemi \(2008\)](#) studied adoption of improved cassava varieties and its welfare effect on households in Osogbo. The results indicated that age, access to extension agents, crop yield, marital status, labor, production input, and education influenced the adoption positively, and family, size, had a negative effect, and that poverty was higher among the non-adopters. Their results show the importance of farmer characteristics on adoption. [Oyekale and Idjesa \(2009\)](#) studied adoption of improved maize seeds and production efficiency in Rivers state, Nigeria. The findings showed that education, farming experience, mono-cropping, minimum tillage, and use of fertilizer significantly influences adoption. It can be conclude that some characteristics could be very important on adoption and cultivation of new crops like canola. Using Tobit regression, [Kheil et al. \(2009\)](#) studied maize boom in the uplands of northern Vietnam and showed that the framers' area allocation to maize was mainly determined by education, wealth, sex, race, and distance to paved roads. [Scandizzo and Savastano \(2010\)](#) modeled adoption and diffusion decisions of farmers toward genetically modified crops under a real option framework. Both adoption and diffusion depend

on internal and external factors, such as information and prices. The results emphasize the role of profitability in expanding new crops. It is an important factor that encourages farmers to plant new crops. A number of studies have been conducted in Iran. [Salami and Einollahi Ahmad Abadi \(2001\)](#) applied Tobit and two-stage Heckman Models to specify factors affecting sugar beet production in Khorasan, Iran. The results showed that the factors influencing the farmers' decision to cultivate sugar beet are not the same as those affecting the area under cultivation. [Abyar \(2002\)](#) conducted a survey of factors influencing soybean area expansion in Golestan province of Iran. Using the Tobit method, the study found out that farm size, farmers experience, access to farm machinery, and the type of irrigation water source were the most effective factors in the soybean area expansion. [Shafiei \(2007\)](#) identified factors affecting olive plantation development in Kerman province, using Logit Model. The results showed that variables including education, children above 14 years old, contact with extension agents, and acreage of garden can affect olive adoption. As these studies indicate, some factors can influence adoption and other can influence cultivated area acreage. Those which can affect the adoption (first stage) are machinery ownership, income proportion, age, education, experience, fragments, and contact with extension agents. These variables are mostly characteristic variables. On the other hand, some variables can affect canola acreage like family labor, machinery cost, relative benefit, credit, and distance. These variables are mostly economic elements that can change farmers' profit.

In Iran, due to the strategic importance of oilseed crops, identification and analysis of factors affecting canola plantation development can help economic specialists in the process of policy and strategy formulation to achieve canola growth. In recent years, special attention has been paid to canola in East Azerbaijan province of Iran. Despite support programs such as guarantees and providing bank credits for canola cultivars, considerable success has not been achieved in canola area development. The results

of this study can provide useful information that could help planners and public officials to make decisions and policies more rational and effective. Analysis of factors affecting canola plantation development can provide valuable information for policymakers with insight into how proposed agricultural policies might affect canola producers. The policy planners face the challenge of formulating suitable agricultural policy by which the desired growth rate in canola output may be achieved. But intervention and incentives are not constant across farmers and groups of farmers have different responses to these policies. For this reason, policymakers should examine the source of the change in farmers' behavior in addition to the aggregate change. The evaluation of a policy with censored data reveals that farmers react to interventions and incentives by changing their behavior with a move to / from the limit or by changing their behavior away from the limit. Such reactions are distinct and researchers should isolate the separate effects. Understanding the separate effects provides a more precise perception of the effects of a given policy. Understanding this effect can provide a significant contribution to the assessment of a policy designed to change participation rates among farmers. For instance, if the analysis of a policy demonstrates that the majority of the change in non-adopter behavior was attributable to prior participants rather than an increase in the adoption rate, such analysis could conceivably result in the search for a policy that has a stronger effect on farmers' participation rates.

## MATERIALS AND METHODS

### Methods of data analysis

Generally, there are two main methods to study the behavior of farmers: parametric and nonparametric approaches. In the frame of parametric methods, single equation estimations are widely used for agricultural studies. In economic perspective, two types of errors could occur when such a model is used for agricultural product's acreage response. The first error is sample selection bias, Sample selection bias means the sample includes only those farmers

who plant canola, and those farmers who do not plant canola are eliminated which could be potentially canola cultivators. The second error is to consider equal factors influencing on canola adoption decisions and factors affecting acreage of canola cultivation. While these two groups of factors can be different. [Tobin \(1958\)](#) introduced truncated or censored models to eliminate first error ([Salami & Einollahi Ahmad Abadi, 2001](#)). In censored models it is assumed that the dependent variable has been clustered at a limiting value, usually zero. If we use only the observations above the limit value, then we'll face bias estimation. The Tobit Model was designed to deal with biases introduced by censoring. Hence it uses all observations, both those at the limit and those above the limit, the estimations provide more information than commonly realized ([McDonald & Moffit, 1982](#)). Although Tobin could eliminate the first error, but the other problem is not yet fixed.

We can think of the canola plantation as a two stage process. First, farmers have to decide whether to adopt canola or not. Then, if they decide to adopt, they have to choose how much to plant. Decisions of whether to adopt and how much to adopt, maybe considered as joint or separate decisions. When the decisions are considered to be joint decisions, the Tobit Model is appropriate for analyzing the factors affecting the decision ([Greene, 1990](#)). But when we consider the decision separated, the Heckman procedure is appropriate.

We consider two different models. The Tobit Model estimates the likelihood of adoption and the extent of adoption, which could be expressed in the following way:

$$\begin{cases} Y_i^* = \beta'X_i + U_i \\ Y_i = \beta'X_i + U_i & \text{if } Y_i^* > 0 \\ Y_i = 0 & \text{if } Y_i^* \leq 0 \end{cases} \quad (1)$$

where the  $Y_i^*$  is the latent variable,  $Y_i$  is observed variable,  $\beta$  is a  $(k \times 1)$  vector of parameters, and  $U_i$  is a random error term that is normally distributed with mean zero and variance  $\sigma^2$  ([Tobin, 1958](#)).

The estimator described in (1) does not alone indicate the effect of a change in  $X$  on  $Y$ . Fol-

lowing Tobin (1958) it can be shown that:

$$E(y) = x\beta F(z) + \sigma f(z) \tag{2}$$

Where  $z = X\beta/\sigma$ ,  $\sigma f(z)$  is the unit normal density and  $F(z)$  is the cumulative normal distribution function. Furthermore, the expected value of  $Y$  for observations above the limit represented by  $Y_i^*$  is given by?:

$$E(Y^*) = x\beta + \sigma f(z)/F(z) \tag{3}$$

Hence, the basic relationship between the expected of all observations,  $E(Y)$ , the expected value conditional upon being above the limit,  $(Y^*)$  and the probability of being above the limit,  $F(z)$ , is:

$$E(Y) = F(z)E(Y^*) \tag{4}$$

The effect of a change in explanatory variable,  $X$  on the dependent variable,  $Y$ , can be disaggregated into: (i) the change in  $Y$  if it is above zero (adopters) weighted by the probability of being above zero [ $F(z)$ ]; and (ii) the change in the probability of being above the limit weighted by the expected value of  $Y$  if above zero. That is (Gebremedhin et al., 2003):

$$\frac{\partial E(Y)}{\partial X_i} = F(z) \left( \frac{\partial E(Y^*)}{\partial X_i} \right) + E(Y^*) \left( \frac{\partial F(z)}{\partial X_i} \right) \tag{5}$$

Whereas the Tobit Model was designed to deal with estimation bias associated with censoring, the Heckman Model is a response to sample selection bias (Sigleman & Zeng, 1999). The choice to participate or be selected to participate in any program may not necessarily be random. Consequently, selection bias may exist (Kinuthia et al., 2011).

The extent of canola adoption is conditional on first adopting canola, and therefore, there is need to control for the factors that affect adoption before assessing determinants of extent of adoption. Single-equation approaches to these types of problems fail to capture the logical two-step decision process that potential participants undertake (Lohr & Park, 1995; Ngwira et al., 2014). The decision of the farmer will be formulated based

on two interrelated choices. The first choice is whether to adopt or not. If the decision to adopt is positive, then the second choice is how many acres will be allocated to canola.

A farmer decision to adopt or not is guided by the perceived utility that will be derived out of engagement in that activity rather than in any another activity (Kinuthia et al., 2011). It is assumed that the farmers adopt new technologies only when the perceived utility or net benefits from using such a technology is significantly greater than that of the existing technology. Although the utility that is derived from the agricultural choices is not directly observable, differences among farmers in the non-observable underlying utility function can be modeled through socio-economic and agronomic variables. The  $i$ th farmer will choose to plant canola if the utility of canola cultivation,  $U_{iA}$ , is greater than utility of other crop cultivation,  $U_{iB}$ , i.e.  $U_{iA} > U_{iB}$ . Otherwise, the farmer will not adopt canola plantation (Adesina & Zinnah, 1993; Caviglia & Khan, 2001; Ngwira et al., 2014). The index function used to estimate the adoption of canola can be expressed as (Ibrahim et al., 2012):

$$\begin{cases} i=1,2,\dots,N \\ Z_i=1 & \text{if } \gamma'W_i + V_i Z_i^* = Z_i^* > 0 \\ Z_i=0 & \text{if } Z_i^* \leq 0 \end{cases} \tag{6}$$

where  $Z_i^*$  is a latent variable denoting the difference between utility from planting canola  $U_{iA}$  and the utility from not planting canola  $U_{iB}$ . The farmer will cultivate canola if  $Z_i^* = U_{iA} - U_{iB} > 0$ . The term  $\gamma' W_i$  provides an estimate of the difference in utility from adopting canola ( $U_{iA} - U_{iB}$ ), using socio-economic and agronomic characteristics,  $W_i$ , as explanatory variables, while  $V_i$  is an error term (Ibrahim et al., 2012).

When a farmer adopts canola, he has self-selected to participate instead of a random assignment. After this stage decides about how many acres that allocates to canola. We state the determinants of the canola cultivated area as a linear function of the vector of explanatory variables ( $W_i$ ) and an adoption dummy variable ( $Z_i$ ). The linear regression can be specified as (Greene, 1990):

$$Y_i = \beta'W_i + \delta Z_i + e_i \quad (7)$$

Where  $Y_i$  is the land area devoted to canola,  $W_i$  is a vector of independent variables with coefficients  $\beta'$ ,  $e_i$  is the error term (normally distributed with zero-mean) and  $Z_i$  is a dummy variable;  $Z_i=1$  if the farmer plant canola and  $Z_i=0$  otherwise.

In estimating equations (6) and (7), it needs to be noted that the relationship between canola adoption and acreage could be interdependent, thus estimating equation (7) using the ordinary least squares (OLS) will lead to biased estimates. To address this problem, a two-step Heckman's procedure was employed to analyze factors affecting canola plantation. The model is appropriate because it addresses simultaneity problems (Kinuthia et al., 2011; Ibrahim et al., 2012; Ngwira et al., 2014).

According to Heckman (1979), for the estimated parameters of equation (7) to be efficient, there should be no correlation between the two error terms ( $e_i$  and  $V_i$ ). However, sample selection bias results in a nonzero correlation between the two errors. To correct for this selection bias, the Heckman Model first estimates the first stage (6) to obtain a sample selection indicator called Inverse Mills Ratio (IMR). The IMR measures the covariance between the two errors and is an indicator of whether there is significant sample selection bias or not. The predicted errors and the IMR in the first stage are there entered into the second stage together with the  $W_i$  vector of regressors (Ngwira et al., 2014).

The Mackinnon non nest test can be applied for choosing a functional form of second stage. First the next equation must be estimated

$$\text{Log } y_i = b_0 + \sum b_i \log X_{it} + \theta v_i + e_i$$

Then the coefficient of  $v_i$  must be tested with Wald test. The model is linear if the coefficient was the significant model and logarithmic vice versa.

From the Probit equation the inverse of the Mill's ratio, LAMBDA ( $\lambda$ ), which is the ratio of the ordinate of a standard normal to the tail area of the distribution, can be computed. The IMR reflects the probability that an observation belongs to the selected sample and is obtained

as follows (Ben-Houassa, 2011):

$$\lambda_i = \frac{\phi\left(\frac{\gamma'W_i}{\sigma}\right)}{\Phi\left(\frac{\gamma'W_i}{\sigma}\right)} \quad (8)$$

This variable can remove the heteroscedasticity of the model, and as indicated earlier, the IMR parameter estimate is used to test for sample selection bias. The null hypothesis for sample selection bias is that the coefficient of IMR is zero, i.e., the IMR collapses to zero hence there is no sample selection bias. Therefore, when the IMR is significant, the null hypothesis is rejected (i.e. there is a significant sample selection bias). On the other hand, when the IMR is not significant, the null hypothesis of sample selection bias is not rejected implying that a single-equation ordinary least squares (OLS) estimation of the equation (7) would yield efficient estimates (Ngwira et al., 2014).

#### Source of data

The study was carried out in Tabriz and Marand counties, which are situated in the northwest of Iran. Tabriz is the capital of East Azerbaijan province which is situated in an area of about 1780km<sup>2</sup>. Marand is a city in East Azerbaijan province, northwest of Tabriz. Marand has an area about 3340km<sup>2</sup>.

East Azerbaijan has experienced considerable volatility in canola cultivation. Tabriz and Marand counties have an important role in whole province canola acreage determination. In 2008 approximately half of province's canola production was devoted to these two counties. Table 1 presents canola statistics in Iran.

Comparing figures 1 and 2 shows the same trend of canola cultivars' behavior in East Azerbaijan Province and Marand and Tabriz counties. Farmers initially adopt canola plantation and then turn away from this product.

The cross-sectional data for the analysis were obtained from primary sources, a combination of a written questionnaire, and an oral face-to-face interview. Structured questionnaires were conducted to obtain data on the socio-economic and agronomic characteristics of the respondents such as age, family size, level of formal education,

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Table 1  
Canola Statistics of Iran

Year	Cultivated area (hectare)	Growth rate (percent)	Production (ton)	Growth rate (percent)	Yield (kg per hectare)	Growth rate (percent)	Price (IRR)	Growth rate (percent)
1999	5067	-37	5221	-21	1030	26	1200	14
2000	17852	252	13507	159	757	-26	1400	17
2001	26387	48	27591	104	1046	38	1710	21
2002	49000	86	69250	151	1413	35	2050	20
2003	72000	47	112164	62	1557	11	2500	22
2004	73521	2	105929	-5	1441	-7	2830	13
2005	127463	73	210199	98	1650	14	3110	10
2006	174500	37	296000	41	1696	28	3420	10
2007	140825	-19	219000	-26	1555	-8	3700	8
2008	120000	-15	150000	-31	1250	-20	3700	0
2009	105000	-12	160000	7	1500	20	4000	8
2010	110000	5	185000	16	1650	10	6200	55

East Azerbaijan Province Organization of Jihad-e-Agriculture (2010)

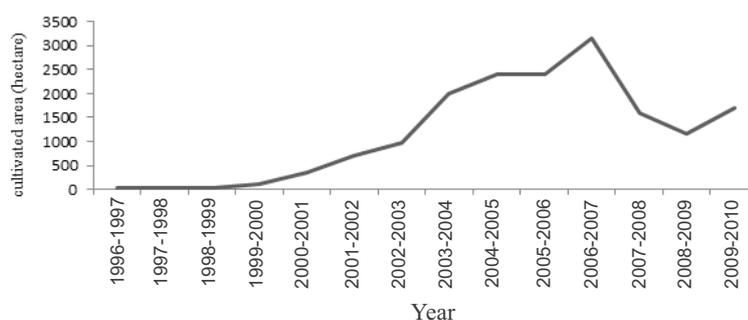


Figure 1. Changes in canola cultivated area in east Azerbaijan province  
Source: East Azerbaijan Province Organization of Jihad-e-Agriculture (2010)

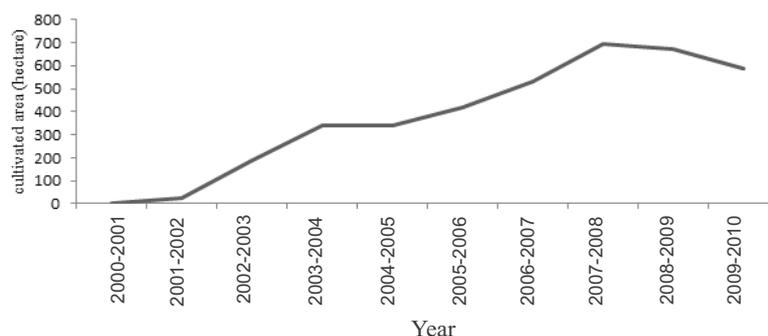


Figure 2. Changes in canola cultivated area in Tabriz and Marand counties  
Source: East Azerbaijan Province Organization of Agriculture (2010)

canola farming experience, farm size, input quantities, input costs, output incomes, farm distance from the main road and farmland patch number. Cochran formula was applied to determine the sample size, which resulted in  $n = 372$ . Then this sample size was devoted to each county proportionally (200 for Marand and 172 for Tabriz) and the socio-economic factors and

agronomic characters were gathered in 2010.

### RESULTS AND DISCUSSION

Required data derived from a sample of 372 farmers, of whom 255 (69%) planted canola and 117 (31%) planted other seeds. Whereas canola guaranteed price by Iran's government is the same for all farmers, we cannot use it as a variable, because it has insufficient variation to

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Table 2  
Results of estimating Tobit Model of Canola Plantation Acreage

Variable	Coefficient	t statistic	Elasticity of index	Elasticity of E(y)
Education	0.038***	4.399	0.159	0.252
Proportion	0.020***	7.560	0.488	0.771
Credit	0.035***	8.341	0.207	0.327
Real price	0.005***	4.173	1.411	2.230
Distance	-0.103***	-2.756	-0.133	-0.210
Relative benefit	0.339***	3.072	0.249	0.394
Fragment	-0.089*	-1.918	-0.123	-0.194
Machinery cost	-0.236***	-3.769	-0.297	-0.469
Intercept	-1.718***	-2.855	-	-

log likelihood=-182.12      Number of Obs.=372  
square correlation between observed and expected values=0.86  
wald chi-square statistic= 288.80      with 8 d.f.      p-value= 0.000

\*\*\*, \*\*, \* = significant at 10% , 5% and 1% levels respectively

enter the model. Therefore, we used another variable that demonstrates the real price received by farmers. For generating such a variable, we calculate the price of canola after reducing moisture drop. Product's moisture content (M.C.) can influence storage and may sometimes lead to spoilage. When the government buys the product, it determines the maximum moisture content level. If product's moisture exceeds that level, a penalty is charged. The amount of the penalty is determined by the amount of moisture content above the acceptable level. The government reduces the product price based on the canola moisture percent and then pays farmers. Now the researches can use real prices that have enough variance to be interpreted. Finally, the Tobit regression was estimated and the

results were summarized in Table 2.

Among the variables, real price and farm income proportion had the most impact on canola growing. Whereas a 10% increase in real price and farm income will result in an increase in canola cultivated acreage by 22.3% and 7.71%, respectively, and a 10% increase in real price and farm income will result in a canola adoption probability, by 14.11% and 4.48%, relative benefit of canola producing, compared with other crops, had a positive impact on the cultivated area under canola. It is logical that farmers would devote their limited land resources to that crop whose relative benefit tends to be favorable. The received credit and education had a positive impact and machinery costs per hectare had a negative impact on canola plantation.

Table 3  
Results of Estimating Probit Model

Variable	Coefficient	t statistic	Weighted aggregate elasticity	Marginal effect
Machinery ownership	0.772***	3.317	-	0.158
Farm income proportion	0.060***	5.144	0.403	0.012
Age	-0.026***	-2.867	-0.339	-0.005
Education	0.047*	1.796	0.057	0.009
Contact with extension agents	0.366**	1.994	-	0.075
Experience	0.410***	7.853	0.298	0.084
Fragment	-0.558***	-4.134	-0.268	-0.114
Intercept	-0.711	1.351	-0.191	-

Likelihood ratio =201.763      with 7 d.f.      P-value=0.000percentage of right predictions=0.85  
number of right predictions=318      Number of Obs.=372  
Estrella r-square= 0.512, Maddala r-square= 0.418, Cragg-Uhler r-square= 0.595, McFadden r-square= 0.447

\*\*\*, \*\*, \* = significant at 10% , 5% and 1% levels respectively

Table 4  
Results of Estimating OLS

Variable	Coefficient	t statistic	Elasticity at means
Inverse of Mill's ratio	-0.407***	-3.678	-
Credit	0.049***	11.610	0.266
Distance	-0.112***	-2.641	-0.098
Relative benefit	0.464***	3.635	0.342
Machinery cost	-0.185***	-2.549	-0.159
Family labour	0.064*	1.824	0.056
Intercept	1.149***	5.011	0.655

D.W=1.78, R<sup>2</sup>=0.57 F=6.49 P-value=0.01 Number of Obs.=255

\*\*\*, \*\*, \*= significant at 10% , 5% and 1% levels respectively

Number of fragments per farm also influenced canola cultivation negatively. Fragmentation of land implies that farmers have to transport inputs to several isolated plots in different locations. Moreover fragmentation can lead to decreasing plot size. Farmland distance from main road had a negative impact on canola plantation.

Although the results of the Tobit Model show the importance of the variables, it cannot separate the factors affecting the adoption decision and the factors affecting the amount of adoption. In this context, the Heckman Model was estimated, and Table 3 and 4 present the first and second step of Heckman Model estimation, respectively.

Probit regression was estimated using maximum likelihood. The model LM2 statistic is 7.8 which show that the null hypothesis of homoscedasticity could not be rejected. Variance inflation factor for all variables were less than 10 which shows that there is not collinearity. As Table 3 shows 1% increase in farm income proportion (farm income relative to total income, including employment earnings, other business activities and...) leads to 0.403% increase in canola adoption probability. Experience of canola production influences canola plantation positively. This experience will help the farmer assess the worthiness of the new crop in meeting the farmer's own objective, better than new entrants. Farmer's formal education had a positive effect on canola. Contact with extension agents, also increases canola adoption, whereas the adoption probability of canola will increase by 0.075%. Machinery ownership is the last factor has a positive impact on the adoption probability of canola by 0.158%. Obtaining machinery at the right time is a big

matter for farmers, if not results in untimely harvest of canola and increases risk of canola shattering and production loss. So owning machinery eliminates such a problem. Furthermore, increasing landowner's age decreases canola adoption probability of 0.339%, suggesting that older farmers are likely to adopt canola less than young farmers. Number of fragments per farm had a negative impact on canola adoption.

Results from the first stage of the Heckman method (Probit Model) expresses factors effective in probability of canola adoption, and results from the second stage of this method (OLS) show factors affecting the amount of canola acreage. The inverse Mill's ratio, which is calculated from the first stage enters the OLS estimation as an additional explanatory variable. The results are shown in Table 4. The significance of Mill's ratio shows that factors effective in decision making about canola adoption are not identical with factors determining the amount of land devoted to canola. Accordingly, using Heckman two-stage is appropriate for this study. Among all variables, the relative benefit of canola had the most impact on canola area. A 1% increase in relative benefit results in 0.342% increase on canola plantation. Farm machinery cost per hectare had a negative effect on canola acreage and farm distance from main road is another variable that influences canola plantation negatively. A 1% increase in the distance leads to 0.098% decrease in the canola cultivated area. Family labor numbers had a positive effect on canola plantation. With increasing 1 person in the family labor, the canola acreage will increase 0.064 hectares. Moreover, received credit

amount had a positive impact on canola area.

### CONCLUSION

Identification of factors affecting canola plantation development can provide insight into the decision-making process farmers engage in when deciding to adopt and/or retain the rapeseed cultivation. The Tobit and Heckman's two-stage Models were applied to analyze the cross-sectional data collected from a sample of 255 canola planters and 117 other farmers of Tabriz and Marand Counties of Iran.

This study found that the real price is an important factor motivating canola adoption. Accordingly, the government should have to increase certified price for canola and decrease production drop percent determined in purchasing time. Machinery ownership is an effective element on canola plantation acreage. The government can establish some machinery leasing companies rent farm equipment at lower rental rates or can help farmers obtain credits for equipment buyers. Fragmentation is a serious problem in adoption decisions. Overcoming this problem would be possible by organizing agricultural production cooperatives. Hence education and contact with extension agents had a positive impact on canola production; it is recommended that more extension classes be conducted by agents. These agents can increase farmers' knowledge and assist them in applying this information for on-farm use. It is noteworthy that none of the proposed solutions will work alone. Whereas the farmer's behavior is likely to be influenced by different factors, policy makers must consider all factors to design a policy package for canola plantation development.

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