THE IMPACT OF WATER PRODUCTIVITY ON PRODUCTION FUNCTION OF CANOLA IN IRAN

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Abstract

The resources scarcity have always been of the critical limitations in production process, hence to create a favorablelife, the human have no choice but to better use of existing facilities to produce more and with higher quality. The water is considered as most important factor in agricultural crops production. The aim of this research is to investigate the impact of water productivity on production function of canola in all Iran's provinces during 2005-2010 using panel data model. The results suggest that the water productivity has positive effecton production, that is, if the water productivity growths by 1 percent the production will increase by 65 percent. Also with growth of water intensity by 1 percent the production will increase by 64 percent. Thus,consideringthe effects ofwater productivityon the welfare of canola producers we can consider the policy of water productivity improvement as one of the appropriate economic policies for Iran's agricultural sector.

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1-Introduction

Due tolowrainfall andits inappropriate temporal and locative distribution, Iran is considered among the arid and semiarid countries. Iran, on the other hand, due to the population growth, health development and expansion ofagricultural andindustrial sectors and such these cases is faced with the increasing water demand and this will lead to creating the gap betweendemand and supply ofthis valuable factor in the future. Increasing this gap, make it inevitable to serious attention to fundamentals of economic planning of water resources and its optimal allocation.Studies and surveysshowthatcurrently from country's total renewablewaterresources about 89.5 billion cubicmeters is harvested for agriculture, industry, mining and household uses which of if amount the agricultural sector accounts for about 83 billion cubic meters (93 percent), thehousehold sector accounts for 5.5 billion cubic meters (6 percent) and the rest is belonged to industry sector and other miscellaneous needs. Despite the limitation of water resources and its inappropriate locative distribution, unfortunately, the productivity and efficiency of utilization of these resources is very low.Analysis ofindicatorsof water use inthe agricultural sectorrepresentsa highwaterlossesinthis sector which a part of it is negligible, but a large part of it can be corrected by adopting a correct and efficient strategies (Ehsani and Khaledi, 2003). The food security depends on increasing agricultural production against increasing the food demand due to population growth. Increasing the agricultural production, on the other hand, is facing with serious constraints on water supply. The only way torespondto theincreasing demand forfood is optimal utilization ofextracted waterresources for agriculture and more production in exchange forless waterconsumption. Of course, controlling the losses in the production process and consumption of agricultural products should also be considered (Ommani and KhaliliEsnaki, 2011).

Humaneconomicefforthas alwaysbeentogetthemaximum resultsfromminimumattempts, thistendencycan beconsidered as achievetohigher productivity. The water is known as a key parameter in agriculture, so, its productivity whether in micro level or macro level is interest of economic experts in terms of economic and policymaking logic.

Today,due topopulation growth, resources scarcityandexpansion of competition inglobal markets,the optimaland efficientuseofresources and, infact,increasing the productivityof resourceshave great importance. Since the agricultural sector is one of the important sectors in every country's economics accounting for a large amounts of water usage, and, given that the growthinproduction ofthe agricultural sectorcouldhave asignificant roleineconomic growth, thusimprovingwater productivityis importantinthis sector.

2-Literature Review

MajdeSalimi et al. (2006) studied the impact of various periods of sprinkler irrigation on water productivity and qualitative characteristics of tea plant and also itseconomic assessmentover a three years period (2002 to 2004) in tea research station of Fooman (Guilan province). The results of economic assessment indicated that the mean of income to cost ratio for treatments of irrigation period of 4 to 16 days and control is equal to 2, 1.64, 1.74, 1.43 and 1.5, respectively.

Sepahvand (2009) compared the water demand, water productivityandeconomic productivityforwheatand canola in the west of Iran during 2001-2002 (rainy year) in research station of SarabChangaei (Lorestan province). The results of his study suggested that the difference of mean total water consumption, water productivity and water economic productivity of two plants is significant at 1 percent significant level.

In order to check the impact of plantingdistance and irrigation managementonwater productivityin theGilan province, Amiri et al. (2011) performed an experiment in the framework of split plots based on randomized complete blockplan in three replications during two crop years of 2001 and 2002 atthe Rice Research Institute (in Rasht). According to their results, they selected 75 percent of evaporation from the level of evaporation washbasin and plantingdistance of 20*20 cm as the best irrigationmanagement and plantingdistance.

In order to examine the effect of deficit irrigation on water yield and productivity of sevencultivars of soybean,Aminifar (2011) conducted an experiment as split plots ina randomized completeblock designwiththree replications at the Research Farm ofFacultyof Agriculture of Universityof Guilan. The results showed that with decreasing irrigation the grain yield significantly decreases, so that maximum grain yield intreatment increases by 13 and 33 percent, respectively.

Shah and Dalwadi (2010)criticallyevaluatetheirrigation command and water productivity based on satellite remote sensing. Their study showed that theremote sensingis based on estimation of water consumption and waterstressalong withsecondary dataforproduction andprofit.

Abdul- Ganiy et al. (2012) evaluated the usage and productivity of agronomic water for production of bell peppersin thenorthernregionof Ghana. Their results showed that the pepper needs 545.5 cubic mm water to growth and maturation. On average,the yield of fresh pepper was 7.3 tons per hectare while the water productivity was 1.33 kg. They suggest that use of effective water with appropriate irrigation program would be appropriate for improving irrigation performance.

3-Model introduction and results description

1-3-Solow residual model

The Solow residual is nothing but subtracting the weighted average of factors growth from output growth. This can be restated mathematicaly as

$$LNTFP = \ln r - \alpha \ln k - \beta \ln l$$

In other words, that part of output growth which cannot be explained by quantitative growth of labor and capital isattributable to total factorproductivity growth.

2-3-Solow model

In this model, a production function is defined.Tocalculatetotal factorproductivity growth, Solow suggests functions of the form of Cobb-Douglas that its general form is as follow:

$$V = A K^{\beta} L^{\alpha}$$

Where, A is the technology parameter. With regard to existence of constant returns to scale and satisfying the condition$\alpha + \beta = 1$, then theproduction functionhasonly oneparameter.By dividingboth sides oftheCobb–Douglas function on L (number of employees) andperform a series ofmathematicaloperations, the following equation is obtained of which we can calculate the LNA that is the technology growth or, in other words, the growth of total factor productivity growth.

$$LNP_l = LNA + Blnk$$

Where, P_l indicates the average laborproductivity growth,LNA is total factor productivity growth, LNK is capital intensitygrowth. The capital intensity is obtained from value of fixed capital inventory divided by the number of employees, K/L. If thetwo sides of Cobb-Douglasfunction is divided into k (the value of capital inventory), after performing themathematicaloperations we will achieve tofollowing equation

$$LNP_K = LNA + (\beta - 1) * LNK$$

As can be seen we can calculate total productivity growth (LNA) using labor productivitygrowthorcapital productivitygrowthandcapitalintensitygrowth and the coefficient of production elasticity with respect to labor factor (β)

3-3-Contribution of TFP growth to output growth

Inthe fourth development planthe contribution of TFPgrowth to value added growth has been determined for each economic sector andthe whole country using theSolowresidual model. In this research the total factor productivity is considered as the resultant of changes in labor and capital productivity. This mathematically is as follows:

$$LNTFP = \alpha\ LNAP_K + \beta\ LNAP_L$$

That is, total factor productivity growth (LNTFP) is equal to the weighted average of capital productivity growth rate ($LNAP_K$) and laborproductivity growth rate ($LNAP_L$). In other words, that part of output growth which cannot be explained by growth of labor and capital isattributable to total factorproductivity growth,namely:

$$LNTFP = LNY - \alpha LNK - BLNL$$

If the first equationis substituted in the second relation, given that the production elasticity of capital and labor is αandβ, respectively, the following equation is obtained:

$$Lny = \alpha lnk + \beta lnl + \alpha lnAP_K + LNAP_L$$

This relationship separates the output growth into two parts: the two first terms in the right hand side of equation represent theshare of increased use ofmanpower and capital in the output growth, and the latter two terms is related tocontribution oftotal factorproductivity to output growth. Thisrelationshipcanbe extendedtomore thantwoinputs(National Productivity Centre, 2006).

$$LNY = ALNK + LNL + \ldots + \mu LNE + ALNAPK + BLNAPL + \ldots + LNAP\mu$$

4-3-Data and model variables

The data used in analysis is collected from the information of 13 provinces during 2005 to 2010. The estimation method is therefore panel data model. The variables used in the model include the yield per hectare as dependent variable and independent variables include the water (in liters), labor force (in person- Labor Day) and fertilizersand pesticidesin kilograms.The data are collected from the site of ministry of agriculture and statistics related to thecensus of the costs of agricultural corps production.

5-3-Estimation oftheSolow residualgrowth modeland the interpretationof results

The function used in estimation of Solow residual model is the Cobb-Douglas function. The reason of application of this function instead of other functions is that: firstly, Solowhas recommendedthe Cobb-Douglas functiontocalculatetotalfactorproductivity. Secondly,studies conducted inside the country indicate that this function is suitable for estimating the total productivity and economic growth. Thirdly, due to its feature it is possible to substitute the factors in production flow and also its functional form is suitable. Before estimating the model, the two tests of F-Limer and Hausman is examined. The F-Limer test is applied to recognize whether the model estimated using OLS method (pooling data) or panel data model. The null hypothesis in this test is that the cross-sections are homogeneous (pooling data) and the alternative hypothesis is homogeneity amongcross-sections(panel data). The results of table 1 reveal that the panel data model is appropriate for estimation. In panel data method we are facedwithtwo fixed and random effects. The Hausman test is used to determine whether data have fixed or random effect. InHausman testthe null hypothesis is that the estimated error is random and the alternative hypothesis is that the effects are fixed. According to table 1 the nullhypothesis is not rejected and the random effects model must be used. But, since our study is on thepopulation, we estimate the model by fixed effect model.

Table 1: The results of F-Limer test and Hausman test for Solow growth model

Test	Test statistic	prob	Result
F-Limer	F=2.4483	.0215	Estimation with panel data method
Hausman	χ^2=2.3951	.9664	Estimation with random effects but since whole population has been considered, the model is estimated by fixed effects method.

Table 2: The results of the Solow residual growth model estimation

Variables	coefficients	Standard deviation	T	Significant level
C	1.992**	.0797	24.999	0.000
LNAPW	.656**	.0617	10.645	0.000
LNAPL	.076**	.0161	4.762	0.000
LNAPF	.236**	.0628	3.769	0.000
LNAPP	.019	.0174	1.060	0.297
LNW	.649**	.0626	10.371	0.000
LNL	.049**	.0098	5.059	0.000
LNF	.118**	.0355	3.322	0.002
LNP	.019*	.0099	1.938	0.0615
AR(1)	-.0839	.0824	-1.0198	0.3154
R^2=.99	N=54	DW=2.27	F=3327.57	

Source: research findings

* Significant level of 95%

** Significant level of 99%

According to table 2, it is seen that the sign of all estimated coefficients is positive exceptthe coefficient of AR (1) which are consistent with theoreticalexpectations. Also the estimated coefficients are statistically significant in significant levels of 95% and 99%. According to $R^2$and F statistics the explanatorypower ofthemodel is high and the amount of Durbin-Watson statistic indicate that there is no autocorrelation problem in the model.Consideringthat theSolowgrowth modelis estimatedinlogarithmicform,sum ofthe estimated coefficientscorrespondingto each of theinputs shows, in fact, the partialelasticityofproduction with respect to each of the production factors. In our model the sum of estimated coefficients is greater than unit and equal to 3.2256 indicates the increasing returns to scale.

6-3-Interpretation of the Solow growth model coefficients

According to table 2 the coefficient of water productivity growth (LNAPW) is positive and equal to 0.66 which has a significant role in output growth. Also, this coefficient implies that a one percent increase in water productivity growth leads to increase in output growth by 66 percent. The coefficient of labor productivity growth (LNAPL) is equal to 0.07 which is positive and statistically significant. This coefficient impliesthataone percentincrease inlabor productivitygrowth cause the output growth increase by 7 percent.

The coefficient of fertilizer productivity growth (LNAPF) is equal to 0.24 which is positive and has significant effect on output growth. This coefficient indicates that if the fertilizer productivity growth increase by one percent the output growth will increase by 24 percent. Also the coefficient of pesticideproductivity growth (LNAPP) is equal to 0.02 which is positive and statistically is not significant and has no significant effect on production. According to the results of previous estimations the marginal productivity of pesticide is negative and this is due to entry of this input into third region of production, which increases the cost of production. So, in order to increase the production the consumption of this input should be decreased and its positive and insignificant coefficient may be due to the same fact that it has been currently placed in third region of production.

The coefficient of water (LNW) is equal to 0.65 which is significant and indicates that a one percent increase in water used increase the output growth by 65 percent. The coefficient of labor force (LNL) is equal to 0.05 which is positive and statistically significant and indicates that one percent increase in the number of labor force will increase the output by 5 percent. The estimated coefficient offertilizer is equal to 0.12 which is positive and statistically significant and shows that a one percent increase in the amount of fertilizer will lead to 12 percent increase in the amount of output. The estimated coefficient of pesticide is equal to 0.02 which is positive and significant at level of 95%. This coefficient indicates that with one percent increase of the amount of pesticide the output will increase by 2 percent.

Apart from the main results, it is worth mentioning that the coefficient of first order auto-regressive term is equal to -0.08 and not statistically significant which indicates that the model do not need to autoregressive term.

4-Conclusions and Recommendations

Considering the increasing growth ofpopulation, the food securityis of importantissues of anycountry which thisrequiresgreater attention toagricultural sector.Although, thewater shortageis not newproblem, but it isbeing extendedand its effectshas beenmore destructive (Mendal, 2002). On the other hand,the available evidencesuggests acriticalsituation of theseresources in our country.Increasingthe water productivityhas been known asone of thesolutions to thischallenge.Therefore,understandingthe amount ofwaterproductivityinagronomicproductions is the first step in in planning and management for increasing the usage of this resource. According to the results of Solow growth model estimation, the effect of water productivity on production is positive, that is if the water productivity increase by one percent the output will increase by 66 percent. Also a one percent increase in water usage will increase the output by 65 percent.

The water is one of the most important factors of countries' growth and development and shortage of drinking water on the one hand, and increasing need for food on the other hand, has faced the available water resources with a serious crisis. Middle East is among the areas which are severely faced with the problem of freshwater resources limitation. Due tothe lowrainfalls andits inappropriate spatial and temporaldistribution,Iran is among the world's arid and semiarid countries.One of the goalsof this research has been to provideguidelines andpolicy recommendationsforimprovingwater productivity level inthe countrywhichaccording toresults,the following strategiescan beproposedinhope ofreducingwater consumption.

1. More researchis neededto examinethe effectwater consumptionon thedrainage.
2. Appropriate pricing policy of inputs is a positive step in preventing the indiscriminate use of these inputs and pushing farmers to make optimum use of these inputs.

3. Improving water productivity through better crop management methods in different areas can help more to reduce water consumption.
4. Identifying the areas in which there is a less of potential agricultural performance. By proving appropriate irrigation systems the water productivity can be increased in a stable way.

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