

Impact of Technological Change on Wheat Production Risk in Northwest of Iran

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Abstract:

There have been many previous studies about technical efficiency in wheat production in different areas in Iran, but attention was paid to impact of input utilization on production Risk and none has focused on impact of technological change on production risk. Thus in this study we tried to determine whether technology has a positive or negative effect on production variation. To achieve this aim, a stochastic frontier production function with a heteroskedastic error structure has been used. A 10-year panel dataset from 8 province (Azarbayjan-e-sharghi, azarbayjan-e-gharbi, Ardebil, Kurdistan, Kermanshah, Lorestan, Zanjan, Eilam) in northwest of Iran was used to estimate different functional specifications. The results indicated that Potash fertilizer and technological change have positive and significant impact on wheat production risk; as well land and labour have a positive effect on wheat production risk but these coefficients are not statically significant. Plus, using phosphate and nitrogen fertilizer and seed have negative and significant impact on wheat production risk.

Keywords

Heteroskedastic Error Structure; Northwest of Iran; Stochastic Frontier Production Function; Technological Change

Introduction

Producing a product is a risky activity and inherent uncertainties which result in variation in production have been indicated in literature especially in agricultural sector (Ogundari and Akinbogun 2010). Farmers face risk from a variety of sources, including price risk, input risk, and production risk, all of which cause uncertainty in profit and thus input choice decisions (Picazo-Tadeo and Wall, 2011). Production risks are dependent on weather, input utilization and other external factors (Läänemets et al, 2011). However, variation in production can be investigated by inputs. This method has been known as a production risk in input (Bokusheva and Hockmann, 2006; Villano and Fleming, 2006). Since technological change can be very risky action especially in developing countries, risk-

averse producers will be concerned about risk properties when they consider the adoption of new technologies; so, they may not choose the technology with the highest mean output (Ogundari and Akinbogun 2010).

Wheat is the most important agricultural production in the world and it plays an important role in food security and nourishment in developing countries. The wheat seed storage proteins are a major source of protein in the human diet, and responsible for the properties of wheat dough that allows a wide range of food products (Claudia et al, 2007). Hence, many people in developing countries especially the urban and rural poor are largely dependent on the performance of wheat economy (Ahmad et al, 2002).

In recent years, wheat has occupied a dominant position in agricultural policies of Iran and governments have been trying to achieve self-sufficiency in wheat production, because of this goal, most of production factors have been given to the farmers with subsidy; however, this program has not been successful because it imposed a great cost on government budget. In addition, due to this program, the producers are not able to use agricultural production factors at optimum level. Hence, this policy affects the yield and production volatility negatively (Semerci et al, 2012). Developing technology in wheat production can be a very important and useful measure to reach the self-sufficiency in Iran. However, as mentioned above, in developing country such as Iran, technological change can be a very risky decision for farmers and it may have a disastrous impact on production.

Northwest of Iran is the most important area in a wheat production and more than 70 percent of Iran's wheat production have been produced in these provinces (Azarbayjan-e-sharghi, azarbayjan-e-gharbi, Ardebil, Kurdistan, Kermanshah, Lorestan, Zanjan,

Eilam) in 2009 (Iran's agricultural censuses, 2009). So, the study of impact of technological change and other production factors on production risk has been investigated.

Because of the importance of production risk, a lot of researches have been done to investigate the impact of production input utilization on production risk (Abedullah and Pandey, 2004; Ligeon et al. 2008; Ogada et al. 2010; Lyman and Nalley, 2013).

Wanda (2009) investigated the effect of inputs and banana agronomic management practices on the mean yield and yield variability of bananas in Uganda. Just and Pope stochastic production function specification has been used to analyze the relationship between inputs and banana yield under production risk. The result showed that labour, mulch and manure had a negative effect on variability in banana yields while fertilizer, agronomic frequency and extension increased the variability in yields of bananas across the sample farmers.

Carew et al (2009) used Just-Pope production function to examine the relationship among fertilizer inputs, soil quality, biodiversity indicators, cultivars qualified for Plant Breeders' Rights (PBR), and climatic conditions on the mean and variance of spring wheat yields in Monitabo Canada, and the main result showed nitrogen fertilizer, temporal diversity, and PBR wheat cultivars were associated with increased yield variance.

Krishna et al (2009) used a Just-Pope approach to investigate the impact of Bt cotton technology and on-farm varietal diversity on production variation. The result showed that both of these factors enhance yield and reduce the production risk.

Gardebreek et al (2010) compared the production technology and production risk of organic and conventional arable farms in the Netherlands. Just-Pope production functions have been estimated for Dutch organic and conventional farms. The result showed that organic farms face more output variation than conventional farms. Manure and fertilizers are risk-increasing inputs on organic farms and risk-reducing inputs on conventional farms. Labour is risk increasing on both farm types; capital and land are risk-reducing inputs.

Picazo-Tadeo and Wall (2010) in part of their study used a Just-Pope approach and it was indicated that land, labor, and fitosanitary products are risk-reducing inputs, whereas capital, seeds, and fertilizer all

increase risk in rice production in Spain.

Also, in Iran some studies have focused on different agricultural production inefficiency and use of inputs on risk production in different areas of Iran (Torkamani and Ghorbani, 1997; Mousavi et al, 2007) but none of these studies made the emphasis on impact of technological change on production variation. So, the main purpose of this study was to investigate the impact of technological change and other inputs on production risk in wheat production in northwest of Iran.

Materials and Method

In order to determine the effects of input factors on the level of yield and its variability, the stochastic production function approach pioneered by Just and Pope (1978, 1979) is applied. The fundamental concept underpinning this approach is that the production function can be decomposed into two sections: the first part is linked to the mean output level while the second segment is associated with the variability of that output (Cabas et al., 2010; Kim & Pang, 2009).

The general form of the Just and Pope production function is (Just and Pope 1978):

$$y = f(X) + g(X)\epsilon, \quad (1)$$

where y is yield and X is a set of explanatory variables. The parameter estimation of $f(X)$ shows the average impact of the explanatory variables on yield and $g(X)$ offers their effect on the variability of yield (Chen & Chang, 2005). According to different studies production function of the following form, it has been estimated:

$$y = (x) + u = f(X, \beta) + g(X, \alpha)\epsilon, \quad (2)$$

where y is wheat yield, X is a set of explanatory variables (land, labour, seed, Potash, phosphate and nitrogen fertilizer and time period as an index of technological change) and ϵ is an exogenous production shock with $E(\epsilon) = 0$ and $\text{Var}(\epsilon) = \delta_\epsilon^2$ as it has been shown that the explanatory variables affect both the mean and variability of wheat yield, because $E(y) = f(x)$ and $\text{Var}(y) = \text{Var}(u) = g(\cdot)$. The parameter estimation of $g(\cdot)$ gives the average effects of the explanatory variables on yield, whilst $g(\cdot)$ reveals the impacts of the covariates on the variability of yield. It is noteworthy that a positive sign on any parameter of $g(\cdot)$ implies that a rise in that variable indicates an increase of the variability of yield. On the other hand, negative sign on the same variable indicates decrease of the variability production.

Three functional forms of production functions: Cobb-Douglas, quadratic and translog are used for the Just

and Pope Production function (Kim and Pang, 2009). Because of the multiplicative interaction between the mean and variance, a translog functional form would violate the Just and Pope assumption (Sarker et al, 2012) and for liner quadratic provided poor estimate. In addition, cobb-Douglas production function has been the best functional form in different studies (Kebedeand Adenew, 2011; Hassan et al 2010; Khanal et al 2010). Therefore, we selected Cobb-Douglas form for the mean yield function estimation. This functional form is consistent with the Just and Pope assumption (Kim & Pang, 2009).

Mean function:

The mean function is specified as:

$$y = \alpha_0 + \alpha_t T + \prod_i x_i^{\alpha_i} \tag{3}$$

Where x_i is explanatory variables and T represents time trend, which can capture the technological change and α_i implies coefficients to be estimated.

Variance function:

Linear functional (Cobb-Douglas) form has been considered for the variability function because the variance function has a non-linear form. Following Just and Pope (1978 & 1979), the variability function $g(.)$ is modelled in a Cobb-Douglas form as follows:

$$g(x) = \beta_0 T \prod_i x_i^{\beta_i} \tag{4}$$

Where β_i is parameters to be estimated.

Fixed effect and random effect models are usually used for a panel model (Baltagi, 2005). In this study, fixed effect model has been used (McCarl et al., 2008; Barnwal and Kotani, 2010; and Cabas et al., 2010).

Panel unit root test and stationarity of variables:

It is essential to investigate the presence of unit roots for each variable before estimating the model. One important assumption of the Just and Pope model is that the variables under estimation are stationary (Chen et al., 2004). As using a non-stationary data set might yield bias results (Chen and Chang, 2005). However, the time series properties of one variable comprising many regions/areas in a panel data setting are hard to characterize (Chen et al., 2004). This study used the LLC (Levin, Lin, Chu) to investigate the stationary of variables.

Data

In this study, a panel data for 8 province (Azarbayjan-e-sharghi, azarbayjan-e-gharbi, Ardebil, Kurdistan, Kermanshah, Lorestan, Zanjan, Eilam) in northwest of

Iran for ten years, since 2000 to 2009, has been used gathered from Iran’s agricultural census in these years.

Results and Discussion

Unit root test:

In table 1, results of panel unit root test have been represented. The null hypothesis of LLC test is that panels contain a unit roots and opposite hypothesis express that panel is stationary. As it has been shown that the null hypothesis of unit roots is rejected at the 1% level of significance for all variables in the model. So, all variables under the model are stationary.

TABLE1 RESULT OF STATIONARY TEST

Variable	LLC statistic (adjusted)	P-value
Wheat production	-3.65	0.0001
Land	-2.88	0.002
Labour	-1.32	0.09
Seed	-1.84	0.03
Nitrogen fertilizer	-3.74	0.0001
Phosphate fertilizer	-2.30	0.010
Potash Fertilizer	-1.88	0.029

TABLE 2 ESTIMATION RESULT FOR WHEAT PRODUCTION

Variable	Coefficient	Z-statistic	p-value
Mean Function			
Land	1.077	6.70	0.000
Labour	-0.11	-3.37	0.001
Seed	0.12	0.86	0.39
Nitrogen Fertilizer	0.034	1.11	0.26
Phosphate Fertilizer	0.026	1.15	0.25
Potash Fertilizer	-0.003	-1.94	0.05
Technological change	0.014	4.2	0.00
Constant	-1.56	-4.44	0.00
Variance Function			
Land	4.38	1.27	0.20
Labour	1.45	1.61	0.10
Seed	-5.59	-1.81	0.071
Nitrogen fertilizer	-1.54	-1.23	0.22
Phosphate fertilizer	-1.09	-1.73	0.083
Potash Fertilizer	0.19	2.27	0.023
Technological change	0.26	3.31	0.001
Log likelihood	Wald	Prob > chi2=	
=101.67832	chi2(7)=2463.09	0.0000	

Results for mean and variance function:

The result of Cobb-Douglas production function estimation is represented in table 2. The first part of this table represents coefficients of the mean function and the second part of this table represents coefficients of variance function. Coefficients of mean function represent the elasticities of the included variable inputs. The elasticity of 1.077, -0.117, 0.121, 0.0346, 0.026, -0.0037 and 0.014 are obtained for land, labour, seed, nitrogen fertilizer, Phosphate fertilizer, Potash Fertilizer and technological change. As it has been indicated that land has the greatest positive impact on

a wheat production and its coefficient is statically significant. Moreover, technology improvement has a positive and significant impact on wheat production in this area. The elasticities which have been estimated for seed, nitrogen fertilizer and Phosphate fertilizer have a positive effect on wheat production; however, these coefficients are not statically significant. Moreover, the elasticities which have been estimated for labour and Potash Fertilizer have a negative impact on the wheat production.

The coefficient of the production risk in inputs has been represented in table 2, and these coefficients of variance function also represent the elasticities of the included variable inputs for variance function. The elasticities of 4.38, 1.45, -5.59, -1.54, -1.09, 0.19 and 0.26 were obtained for land, labour, seed, nitrogen fertilizer, Phosphate fertilizer, Potash Fertilizer and technological change. These coefficients indicated that land is a risk increasing inputs, however, it is not statically significant. While labour, potash fertilizer and Technological change are risk increasing inputs and these coefficients are statically significant. Hence, the study assumption about the positive impact of technological change on production variability has been accepted. Further, risk-averse farmers in these provinces are expected to use less labour and potash fertilizer and not willing to adopt a new technology compare with risk-neutral farmers; because these actions can increase the production variability. On the other hand, seed, nitrogen and phosphate fertilizer have negative impact on production variability; among which seed is the greatest. So, risk-averse farmers might use these inputs in order to reduce the production risk and the revenue variability.

Conclusion

The main purpose of this study was to investigate the impact of technological change and other inputs on production risk in wheat production in northwest of Iran. To achieve this aim, a stochastic frontier production function with a heteroskedastic error structure has been used.

According to production function and variance function estimation, the study concluded that a better insurance policy should be adopted, which can provide a safer condition for wheat producer in these province, leading to optimum utilization of input; as some of these inputs, like seed, are overused in order to reduce the production risk.

Also, as it has been represented above, technological

change and improvement have a positive effect on wheat production and production risk; so, if Iran's agricultural insurance fund designs a insurance package to cover the Potential damage arising from changes in technology, it might cause a safer condition for wheat producers, and leading to increased production of this strategic production by using new technology.

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