An Analysis of the Determinants of Wheat Production Risk in Gorgan County

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ABSTRACT

Agriculture has always been a risky activity, and the first step in developing plans to face and overcome the risk is gleaning insight into the different types of risks and the risk factors. One of the risks faced in today's agriculture sector is the production risk incurred by the inputs. The overarching goal of this research was to study the wheat production risk in Gorgan County, Iran, using the method proposed by using J-P (Just and Pope) approach. Data and information required for this research were obtained through stratified random sampling from 80 questionnaires completed in the 2015-2016 crop year. The estimation results suggested that with an increase in labor and farmers' age, the production risk diminished, whereas the production risk escalated with an increase in the use of chemical fertilizers. Therefore, it is recommended to modify the usage pattern of this input to set the scene for the mitigation of the production risk of this crop in the region.

Keywords: Chemical fertilizers, Just and Pope approach, Production function, Output risk.

INTRODUCTION

Agriculture is a risky and unreliable profession, especially in developing countries. Risk is a French word. In Webster, risk is defined as the probability of financial and lethal losses (Torkamani, 1998). Almost all human efforts run a degree of risk, but some of them entail higher levels of risk. In financial literature, risk is defined as a series of unexpected incidents that normally change the values of assets or liabilities.

Terms such as risk and uncertainty bear different meanings in their actual sense. However, unspecialized people use these two terms interchangeably. Certainty refers to the likelihood of occurrence of incidents with unknown probability distributions. Therefore, uncertainty is perhaps about the occurrence or non-occurrence of an incident (Lawson *et al.*, 1998). The uncertainty about the prices and the productions of various products are among the causes of agricultural risks. One of the most important factors influencing the fluctuations

of crops is the use of different inputs, especially the new inputs. For example, when a farmer uses a new seed variety, a new pesticide, or new machinery, he would be exposed to some new risks because he does not know how and to what extent these new inputs affect the farm performance.

Based on the risk theory, producers try to minimize risk through different institutional and managerial tools. For example, they may change the level of different inputs used for optimal production. Empirical studies show that risk-averse producers tend to optimally use inputs with less risk during uncertain situations than they would under certainty. These inputs might be used to either increase the level of output or reduce the variability in the output, and thus any possible changes in their level of utilization might have different implications regarding the variability in the output. Output risk can be present in many different productions and industries, such as the agriculture, mining, medical and health, sectors. However, the level of output risk may differ for production types, industries, and

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location, as well as over time (Tveteras *et al.*, 2011).

In general, the type of prevailing risks varies from one agricultural system to another. However, farmers in the developing countries are exposed to more risks, and the low-income farmers, especially farmers in the arid and semi-arid regions, are more vulnerable (Yacoobi *et al.*, 2007). Moreover, most natural agricultural risks cannot be eliminated fully. For instance, a farmer can never prevent hail from falling or the wind from blowing. However, it is possible to reduce the losses caused by these risks through proper management and crop insurance. Making substantial comprehensive changes to the existing agricultural structure like the increasing level of mechanization, more effective extension services, and training farmers for agri-business management and skills are the requisites for agricultural growth and development. For example, one of the factors affecting production risk is overuse of inputs. Based on the production theory, by increasing the level of inputs, their Marginal Productivity (MP) will increase first, then, decrease and, finally, become negative. Many farmers have insufficient management skills or knowledge and may overuse the inputs and then cause negative productivity. It will result in more production risk. (Yazdani *et al.*, 2008). Hence, the first step in developing accurate plans and policies to properly manage the production risk is gaining insight into the production conditions and resources of this sector. Farmers who are seeking to gain profit must accept the risks because no profitable management strategy is risk-free. Farmers must employ the management strategies to establish a balance between the losses caused by the weather conditions and the potential profit. In such a system, farm management is stressed more than ever.

The common methods, which are based on certainty, lead to the emergence of unreal estimators in the analysis of factors such as the Area Under Cultivation (AUC), total production, and net income from the riskier products (Geravandi and Ali Beygi, 2010). Risk is determined by factors including price, market phenomena, weather conditions,

government policies, and new inputs (Naghshinehfard *et al.*, 2006).

In agriculture, the sources of risks are classified into the following five categories: production risks, marketing risks, financial risks, institutional risks, and human risks. The present research addresses the production risk, which originates from factors that influence the quantity and quality of the crops. In this regard, Golestan Province is among the most successful Iranian provinces in the production of crops, especially wheat. This province has third place in the production of wheat in Iran. Farmers are motivated to increase the area under cultivation of wheat in this province by the soil fertility, weather conditions, purchases by the government at satisfactory prices, the decreased area under cultivation of cotton, autumn cultivation, the reduced need for water due to the rainfalls in autumn and winter, and the ease of planting, grazing, and harvesting.

Gorgan is a northern city in Iran. This city is located in the southwest of Golestan Province, and according to the statistics published by the Agriculture Jihad Organization of Golestan Province, approximately 400,000 ha of farmlands in this province are under the cultivation of wheat every year. Moreover, approximately one million tons are harvested yearly, while 250,000 tons of wheat is consumed locally (Statistics and Information Center of Ministry of Agriculture Jihad, 2016). Therefore, it is substantially important to analyze the risk factors involved in wheat production.

Various studies have been carried out to examine the determinants of agricultural risks using various methods. Just and Pope (1978) studied the effect of the inputs on the production risk using the generalized stochastic production function. After estimating the production function, they used the resulting error term to examine the effect of each input through the regression of the error term on the production inputs. They found that the chemical fertilizer, as an input, increased the production risk of corn and oat. Moghadasi and Yazdani (1996) studied the effect of the inputs on the production risk of potato in Fereydoun County, Isfahan Province. They concluded that fertilizer and seed did not have an increasing effect on the production

1154

risk, and the only input that increased the production risk was labor. Their findings also suggested that the farmer's age played a substantial role in their tendency to take risks and use risk management strategies. Torkamani and Qorbani (1997) used the generalized stochastic production function to examine the effect of the use of inputs on the wheat production risk in Saari County. After interpreting the research results, they concluded that seed and labor had a positive significant effect on the production risk, while an increase in the area under cultivation diminished the production risk. Falco and Perringsm (2005) investigated the effect of subsidies on the production of crops under uncertainty conditions in the south of Italy using the method proposed by Just and Pope (1978). Their investigations indicated that increasing subsidies, increasing the land surface area, and reducing the substitute crops were the measures taken for risk mitigation. Naghshinehfard *et al.* (2006) also studied the effect of inputs on the production risk of beet using the generalized stochastic production function in Fars Province. Their investigations unraveled the significant effect of the inputs, viz. pesticide, manure, seed, and water, on the production variations, whereas other inputs, namely, labor, chemical fertilizer, and machinery had no significant effect on the risk. Tahamipour (2008) examined the factors determining the production risk of pistachio in Zarand County using Just and Pope's method. Their findings indicated that inputs such as labor, the area under cultivation, machine work, and pesticides had positive effects on the production risk, but solely the effect of labor was significant. Other inputs, namely, chemical fertilizer, water, and manure also affected the production risk adversely. Koohpayi *et al.* (2009) studied the effect of the inputs on the production risk of rice in Gilan Province using a quadratic production function and the method proposed by Just and Pope. They reported that labor, chemical pesticides, and machinery were the inputs that reduced the production risk, whereas land, chemical fertilizer, and seed were the inputs that increased the production risk of rice. Tiedemann and Lohmann (2012) studied the significance of the production risk and technical efficiency in the organic farmlands in Germany and concluded that the area under cultivation and labor raised the production risk, whereas the land soil quality,

seed costs, and increased investments cut the production risks on these lands. Roll and Gothermsen (2006) discussed the production risk of subsistence agriculture to the farmers in Kilimanjaro, Tanzania, using the method proposed by Just and Pope (1979). Their findings implied that seed reduced the production risk, whereas the area under cultivation, chemical fertilizers, poisons, and availability of irrigation systems increased the production risk. Faraji *et al.* (2015) analyzed the effect of the inputs on the production risk of rice in Falavarjan County using a quadratic production function. The production risk function showed that an increase in the area under cultivation and the use of chemical fertilizers heightened the production risk of rice in the province. Lemessa *et al.* (2017) investigated the production risk of maize farmers in major maize producing regions of Ethiopia. Their findings of the Just and Pope model indicated that fertilizer and ox plow days reduce output risk while labor and improved seed increase output risk. Jannat Sadeghi *et al.* (2018) used the Just and Pope model to investigate the determinants of production risk for crops of wheat and barley in Khorasan Razavi Province, Iran. The results showed that some climate factors including temperature and rainfall were determinants of production risk for these crops. Saei *et al.* (2019) examined the effect of climate variables on the yield average and variability of major grain crops (rice, maize, and wheat) in Iran. The results of Just and Pope Model showed that temperature and rainfall could affect the production risk of crops.

As previous studies show, and as mentioned in the introduction section, using some inputs may have negative or positive effects on the farm production risk. Knowing and identifying them could help farmers to control and manage them better and more efficiently. It can finally result in more efficiency and profitability on the farm.

In Iran, there is not enough research about factors affecting crops production risk as one of the most important types of farming risks. There are insufficient studies about analyzing production risk both in Golestan for wheat. Thus, the present research goal was to identify the determining factors of wheat production risk in Gorgan County and the type of effects of the inputs on the production risk level.

MATERIALS AND METHODS

Theoretical Framework

Risk can be measured using the range, average standard deviation (average absolute deviation), variance (average squared deviation), standard deviation, half-standard deviation, beta, and Value At Risk (VAR) indices. The results from the agricultural models rarely comply with reality due to the farmers' attempts at neglecting the risks and their risk aversion behavior. Understanding of the risks and their consequences and the farmers' behavior in the risky conditions not only provide a deeper insight into the production conditions of the farming units but also allow for the assessment of the effects of the risk mitigation policies on the supply of crops and farmers' income. Risk awareness also enables the planners to have a better and more precise image of the farmers' decision-making process, predict their behavior, and select and implement proper plans for the attainment of the agricultural development goals (Torkamani, 1998).

In the studies devoted to risk management in agriculture, the most popular approach is based on the conditional moment of production output. This is mainly because the way inputs could modify the level of expected output or production risk is directly estimated from observations on inputs and output (Just and Pope, 1978).

In the present study, the determining factors of the wheat production risk were analyzed in two steps using Just and Pope's method (1978). In phase one, the production function was estimated and its error term was obtained. In phase two, the production risk resulted from the production inputs was investigated through the regression of the error term on the inputs identified in phase one.

In this section, the effects of various inputs on the production risk are examined using the model introduced by Just and Pope (1978). If the commonly used functions such as the Cobb-Douglas production function and the transcendental production function are used, the effect of input on the production variance is the same as its effect on the average production. There are many limitations on these functions,

proving that an increase in one input heightens the production risk. Therefore, these functions are often misleading in the analyses of the inputs that lessen the production risk (Tehrani and Bidgoli, 2008). In order to study the effects of the production input risks, each production function must be composed of two parts: one component shows the input effect on the average production, whereas the other represents the input effect on the production variance. A proper production function is the one that secures the additivity of the residual term (Antle and Crissman, 1990).

One of these functions is expressed as follows:

$$Y = f(x) + h^{\frac{1}{2}}(x)\varepsilon \quad E(\varepsilon) = 0 \quad V(\varepsilon) = 1 \tag{1}$$

Where, Y denotes the total production, f(x) is the average production, x shows the inputs vector, h(x) stands for the production variance and ε represents the residual with a mean of zero and a variance of one. Hence, the stochastic production function consists of a fixed and a stochastic component. f(x) and h(x) can have the Cobb–Douglas, Transcendental, or Translog forms. In order to use these functions, the necessary condition (the additivity of the error term) must be satisfied. Just and Pope (1976) used a two-stage estimation method to explore the effect of risk on the use of inputs and thereby estimate the production function and obtain consistent estimators with suitable properties. As stated, in this relation, h(x) represents the dependent variable of variance. This is because

$$Var(Y) = E[Y - E(Y)]^2$$
$$= E\left[f(x) + h^{\frac{1}{2}}(x)\varepsilon - f(x)\right]^2$$
$$= E\left[h^{\frac{1}{2}}(x)\varepsilon\right]^2$$
$$= h(x)E(\varepsilon^2)$$
$$= h(x)V(\varepsilon) = h(x) \tag{2}$$

Where, V means Variance. The effect of the i*th* input on the production variance is calculated as follows.

$$\frac{\delta Var(Y)}{\delta x_i} = h_i(x) \tag{3}$$

Where, δ is a symbol of the derivative. Hence, the effect of the i*th* input on the

1156

production variance may be positive, negative, or neutral. Since h(x) denotes the variance of Y, it must be included as $h^{1/2}(x)$ in the function (Tahamipour, 2008). In addition, given that h(x) is a function of the explanatory variables, it has the heteroscedasticity problem and it is taken into account in the function estimates. To satisfy the above function and obtain consistent estimators with the suitable properties, Just and Pope (1978) adopted a two-stage estimation method for assessing the effect of risk on the use of the inputs. In stage one, the function was defined as Equation (4) and the alpha parameters were estimated.

$$Y = f(x_i, \alpha) + \varepsilon^*$$

$$\varepsilon^* = h^{\frac{1}{2}}(x, \beta)$$

$$\quad (4)$$

$$Y = \alpha_0 x_1^{\alpha_1} x_2^{\alpha_2} \dots x_n^{\alpha_{n1}} + \varepsilon^*$$

In stage two, the error terms were obtained via equation (5) and then equation (6) is estimated as follows.

$$\varepsilon^* = Y - f(x_i, \alpha) \quad (5)$$

$$\varepsilon^* = g(x_1, \dots, x_n) \quad (6)$$

In the above relation, ε^* is the error term of the production function and the coefficients represent the type of effect of the inputs on the production risk.

Empirical Model and Data

In order to estimate the production function, various forms of the function were examined for the significance of the variables and the violation of the classic regression hypotheses. Finally, the best function form was selected. The general forms of the most important functions are presented in Table (1).

Research Statistics and Information

This study was based on field research. Because the main aim was to estimate a wheat production function, a questionnaire was designed to determine both quantity of wheat production and all inputs used. Data and information required for this research

Table 1. The general form of the production functions. [a]

Function	Function form
Cobb–Douglas	$Y = \alpha \prod_{i=1}^{n} x_i^{\beta_i}$
Transcendental	$Y = \alpha \prod_{i=1}^{n} x_i^{\beta_i} e^{r_i * x_i}$
Translog	$\ln(Y) = \alpha + \sum_{i=1}^{n} \beta_i \ln(x_i) + \frac{1}{2} \sum_{i=1}^{n} \gamma_{ii} (\ln x_i)^2 + \sum_{i=1}^{n} \sum_{j=2}^{n} \gamma_{ij} (\ln x_i)(\ln x_j)$
Generalized Leontief	$Y = \alpha + \sum_{i=1}^{n} \beta_i (x_i)^{1/2} + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} (x_i)^{1/2}(x_j)^{1/2}$
Generalized quadratic	$Y = \alpha + \sum_{i=1}^{n} \beta_i x_i + \frac{1}{2} \sum_{i=1}^{n} \gamma_{ii} (x_i)^2 + \sum_{i=1}^{n} \sum_{j=2}^{n} \gamma_{ij} (x_i)(x_j)$
Constant elasticity of substitution (CES)	$Y = \left[\alpha + \sum_{i=1}^{n} \beta_i X_i^{-\rho} \right]^{-v/\rho}$

[a] Source: Husseinzadeh and Salami (2004).

including variables such as the Area Under Cultivation (AUC), total production, and input use in the planting, grazing, and harvesting phases as well as the farmers' personal information such as age, education, experience, and marital status were collected through stratified random sampling by designing the questionnaires and asking the wheat farmers of Gorgan County to complete them.

After defining the aim and the needed variables, it was necessary to determine the sampling method and also sample size. The statistical population for this research included the irrigated and rain fed wheat farmers of Gorgan County, who totaled 6996 according to the last census conducted by the Ministry of Agriculture Jihad (2013-2014 crop year). Gorgan County is divided into five different service centers, viz. Roshan Abad, South Ester Abad, Qoroq, Anjirab, and North Ester Abad. Therefore, a stratified random sampling method was used and the sampling and stratification were carried out based on this classification. Population shares of the farmers in these five regions (w_i in equation 7) were 22, 21, 20, 15, and 22%, respectively. After determining the sample size, the size of each stratum (n_i) was found by multiplying these shares by total sample size as follows.

The samples were selected from the statistical population using the stratified random sampling method and the following formula (Scheaffer *et al.*, 1996).

$$n = \frac{\sum N_i^2 p_i q_{i/w_i}}{N^2 D + \sum N_i p_i q_i} \quad (7)$$

$$\beta = 0.05 \rightarrow n = 77$$

$$D = \frac{B^2}{4}$$

$$n_i = w_i \cdot n$$

Where, N shows the Number of farmers (who totaled 6996), n denotes the total sample size, N_i represents the total Number of the beneficiaries in the i-th stratum, p_i stands for the percentage of the farmers that use the risk mitigation strategies and were familiar with the risk factors, q_i denotes the percentage of the farmers who did not use the risk mitigation strategies and were not familiar with the risk factors (in this question, q_i and p_i are assumed to be 50%), w_i represents the share of farmers population in every center, D is the estimate

error boundary, and β represents the error level (which is set to 5%) (Scheaffer *et al.*, 2001).

Considering Equation (7), the sample size was set to 77. In order to increase reliability and present an equal number of questionnaires to the rainfed and irrigated farmers, a total of 80 questionnaires were completed by the farmers of Gorgan County. After determining the sample size (#80) based on the scientific and statistical approach, the size of the subsample for every center was determined based on the share of farmers population in every center. After that, the lists of farmers for each center were obtained. In those lists, each farmer had a unique number (code). Then, farmers of every subsample were selected "randomly" based on their codes. Afterward, the calculations, equation estimates, and production function and risk estimates were carried out in Eview 8.

RESULTS AND DISCUSSIONS

The main aim of the present research was to determine factors affecting the wheat production risk. Based on the Just and Pope (1978) approach, there is a two-stage analysis. In the first stage, the wheat production function for Gorgan County should be estimated. In the second stage, and using the resulting error terms as a dependent variable and production inputs as independent variables, the production risk model could be estimated to show the effect of each production input on the wheat production risk.

Farmers' Personal and Professional Characteristics

Table 2 presents the results of analyzing the farmers' personal and professional characteristics. As seen, the age of the wheat farmers in Gorgan County varied between 23 and 77 years, with an average age of 50 years. The frequency of the farmers' age groups indicates that most beneficiaries in this region were senior citizens. Furthermore, their education varied from illiterate to the bachelor's degree, with an average education duration of 4.65 years. In fact, most wheat

Table 2. Farmers' personal and professional characteristics. [a]

Variable	Average		Standard deviation		Minimum		Maximum	
	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated
Age (Year)	53.35	49.5	10.42	11.12	23	30	77	75
Education (Year)	3.67	5.4	4.5	5.36	0	0	16	16
experience (Year)	37.33	31.13	13.19	14.15	1	3	60	60
AUC (ha)	11.31	19.56	9.22	15.48	1	1	45	65
Yield (kg ha^{-1})	2254	4546.5	489.67	704.25	1500	3500	3500	7000

[a] Source: Research findings.

farmers only had elementary school education. The average wheat cultivation experience of the farmers was 32 years. Wheat showed a varying performance in the study sample and only two farmers harvested over 5,500 kg ha^{-1} of wheat. The average yield was 3,486 kg ha^{-1}, and the average Area Under Cultivation (AUC) of wheat was 15.75 ha among the farmers. These figures suggest that the wheat farmers of Gorgan County are elderly and highly experienced farmers on average, with low levels of education.

Based on the findings from the questionnaires, the maximum, minimum, and average use of the various wheat production inputs over one-hectare were calculated and presented in Table 3. The comparison between the average use of each production input over one hectare and the recommended usage by the experts from the Agriculture Jihad Organization (Some of the experts from the

Agriculture Jihad Organization of Gorgan were asked about the optimum use of the wheat production inputs. Afterwards, the average use was used as the reference for comparing the average inputs used by the wheat framers in this study.) revealed that although the farmers overuse the production inputs and exceed the optimum amount, their yields are extremely lower than the average yield declared by the experts (3,700 kg). The average use of seed, urea, phosphate, fungicides, and pesticides also exceeds the recommended levels, whereas the pesticides and potash are used less than recommended.

Estimating Wheat Production Function

The wheat production function was estimated using the relations discussed in the Table 1. After analyzing the different function

Table 3. The inputs used per hectare to produce wheat.

Inputs per hectare	Maximum	Minimum	Average	Recommended	Variation percentage[a]
Yield (kg)	7000	1500	3486	3700	-5
Machinery hours (Hour)	20	9.75	13.6	-	-
Seed (kg)	240	200	207.75	200	3
Urea (kg)	300	150	180	150	16
Phosphate (kg)	250	50	128.75	100	28
Potash (kg)	200	0	15.65	50	-68
Total fertilizer (kg)	750	200	108.13	100	0.08
Fungicide (L)	1.5	1	1	1	0
Herbicide (L)	2	1	1	2	-50
Pesticide (L)	1.5	0	0.08	0	-
Poison (L)	5	2	0.69	1	-0.31
Man hour	10.37	0.937	2.47	-	-

[a] The percentage of variation of the used inputs compared to the recommended amount. Source: Research findings.

forms and examining and solving the hypothesis violation problems (such as collinearity, autocorrelation, and heteroscedasticity), the Translog function was used as the regression model based on the number of the significant variables and the model coefficient of determination. Table 4 shows a brief comparison of some important results of different estimated functional forms.

The general form of the Translog function is as follows.

$$ln(Y) = \alpha + \sum_{i=1}^{n} \beta_i \, ln(x_i) +$$
$$\frac{1}{2} \sum_{i=1}^{n} \gamma_{ii} \, (lnx_i)^2 +$$
$$\sum_{i=1}^{n} \sum_{j=2}^{n} \gamma_{ij} \, (lnx_i) \, (lnx_j) \qquad (9)$$

Where, Y is the wheat production (kg) as dependent variable, and independent variables (x_i or x_j) are: area under cultivation or AUC (ha), yield (kg ha^{-1}), machinery hours (hour), seed (kg ha^{-1}), urea (kg ha^{-1}), phosphate (kg ha^{-1}), potash (kg ha^{-1}), fertilizer (kg ha^{-1}), while fungicide, herbicide, pesticide, and poison in (L ha^{-1}) and labor in (Man day: 8-Hour day).

The results of this estimation are presented in Table 5. As shown in the table, not all of the previously mentioned inputs or independent variables are included in the final estimated model. Of course, all of them were included in the first run but in the process of finding the best functional form and combination of independent variables, the following combination was selected.

The estimation results indicated that labor, the seed-labor interaction, the seed-machinery interaction, and seed were significant at the 1% level. The seed-fertilizer interaction and the machinery-labor interaction were also significant at the 5% level, and the poison-

fertilizer interaction and labor-AUC interaction were significant at the 10% level. Moreover, labor, the machinery-labor interaction, the labor-AUC interaction, the seed-fertilizer interaction, and the poison-seed interaction had positive effects on wheat production. On the other hand, the seed-labor interaction, the seed-machinery interaction, the fertilizer-AUC interaction, and the poison-fertilizer interaction had adverse effects on wheat production. The $\bar{R}$ results also showed that the model was capable of explaining 75% of the variations of the dependent variable. The F statistic was also significant at the 1% significant level, reflecting the significance of the model at the 1% significance level.

Following the estimation of the production function, a regression was run on the production inputs using the error term resulting from stage one in order to analyze the determining factors of the production risk in stage two by Just and Pope's method (1978). After analyzing the different functional forms and examining and solving the hypothesis violation problems (such as collinearity, autocorrelation, and heteroscedasticity), the Cobb-Douglas function was used as the regression model based on the number of the significant variables and the model coefficient of determination. In this model, the dependent variable is the error term of estimated production function (as logarithm of absolute value) and independent variables are the same as the production function model, i.e., area under cultivation or AUC (ha), yield (kg ha^{-1}), machinery hours (hour), seed, urea, phosphate, potash, and fertilizer in kg ha^{-1}, while fungicide, herbicide, pesticide, and poison in (

Table 4. Comparison of different estimated functional forms. [a]

Function form	No of significant coefficients	R^2	F stat	
			Value	Prob
Cobb–Douglas	2	0.20	1.53	0.19
Transcendental	2	0.74	15.85	0
Translog	8	0.78	22.67	0
Generalized Leontief	4	0.70	14.57	0
Generalized quadratic	6	0.76	14.44	0
CES [b]	1	0.54	1.16	0.37

[a] Source: Research findings. [b] Constant elasticity of substitution

Table 5. The results from the regression estimate of the wheat production function.

Variable	Coefficient	Standard error	t Statistic	Prob
Constant (C)	0.56	2.88	0.19	0.84
Labor	1.95***	0.19	10.03	0.00
Seed and labor interaction	-0.06***	0.01	-4.20	0.00
Seed and machinery interaction	-0.007***	0.002	-3.40	0.001
Poison and labor interaction	0.12	0.14	0.90	0.36
Machinery and labor interaction	0.13***	0.05	2.46	0.01
Seed	1.51***	0.55	2.71	0.008
Labor and AUC interaction	0.009*	0.005	1.85	0.06
AUC and fertilization interaction	-0.15	0.09	-1.59	0.11
Seed and fertilization interaction	0.08*	0.04	1.81	0.07
Poison and fertilizer interaction	-2.18*	1.21	-1.80	0.07
Seed and poison interaction	0.005	0.005	0.97	0.33
DW= 2.39	*n*= 80	*F*= 22.67	R^2= 0.78	
	df= 69	*Prob*= 0	$\bar{R}^2$= 0.75	

*, **, and ***: Denote significance at the 10, 5, and 1% levels, respectively. Source: Research findings.

L ha^{-1}) and labor (Man day: 8-Hour day). The results from these estimates are presented in Table 6. Like the production function estimation, after evaluating the different combinations of inputs, the following was selected as the best.

The results from these estimates revealed that, except for machinery and poison, all variables were significant at least at the 10% level. Variables age and urea had negative and phosphate, seed, and labor had positive effects on the production risk. Both R^2 and adj-R^2 values show that the estimated model can explain more than half of the variation of dependent variable, i.e. production risk.

As the results show, every one percent increase in the age of farmers and the use of the urea can decrease the production risk by 0.68 and 0.64%, respectively. On the other hand, the production risk increases by about 0.34% when the farmers use 1% more phosphate. Moreover, with a 1% increase in the seed and labor use, the production risk increase by 3.44 and 0.46%, respectively.

The significant positive effect of labor on the production risk in this study is compatible with the results of Koohpayi *et al.* (2009), but opposite to the results of Tahamipour (2008) and Tiedemann and Lohmann (2012). Also, the significant negative effect of urea on the production risk in this study is compatible with

the results of Just and Pope (1987), Koohpayi *et al.* (2009), Roll and Gothermsen (2006) and Faraji *et al.* (2015) but opposite to the results of Tahamipour (2008). As mentioned before, the theoretical basis of production risk implies that any change in inputs productivities could result in more (or less) variation and instability in production, which means more (or less) production risk. Comparing the results of different studies reveals that having a positive or negative effect of inputs on the production risk may depend on their levels of usage and productivities.

The machinery and poison were also the inputs that positively and negatively affected the production risk, respectively, but since they were not significant at the 10% significance level, it was not possible to assuredly discuss the effect of each of these inputs on the production risk.

In general, the somewhat small $\bar{R}$ value is commonly observed in such models. In other similar studies (e.g. Asche and Tveras, 1999; Naghshinehfard *et al.*, 2006; Yazdani and Sasooli, 2008; and Koohpayi *et al.*, 2009) it was found out that $\bar{R}$ is small in such studies. This is because other factors such as weather conditions, improper time management, and the use of incorrect inputs, and some economic factors like changing government policies may influence production and reduce or increase

Table 6. The results from the estimation of the production risk function.

Variable	Coefficient	Standard error	t Statistic	Prob
Constant (C)	-16.27040*	9.173074	-1.773713	0.0803
Age logarithm	-0.684184*	0.362103	-1.889476	0.0629
Urea logarithm	-0.641093*	0.344036	-1.863449	0.0665
Phosphate logarithm	0.341965**	0.140857	2.427752	0.0177
Machinery logarithm	1.033354	0.645630	1.600536	0.1139
Seed logarithm	3.439298**	1.657928	2.074456	0.0416
Poison logarithm	-0.720642	0.517811	-1.391709	0.1683
Labor logarithm	0.459427***	0.056995	8.060892	0.0000
DW= 1.72	$n = 80$	$F = 17.79$	$R^2 = 0.55$	
	$df = 74$	$Prob = 0.000$	$\bar{R}^2 = 0.51$	

*, **, and ***: Denote significance at the 10, 5, and 1% levels, respectively. Source: Research findings.

the production risk. It is certainly impossible to consider and model all of these factors. In addition, the F statistic in this study was significant at the 1% level, reflecting the significance of the whole model at the 1% level.

CONCLUSIONS

In this study, the method proposed by Just and Pope (1978) was employed to study the effect of each production input on the wheat production risk in Gorgan County. The investigation results revealed that there was a positive and significant effect of the farmer's age on the mitigation of the production risks. This finding implies that with an increase in the farmers' age and their experience, their ability to reduce the production risk escalates significantly. Also, the farmers used fertilizer urea properly, both quantitatively and qualitatively, because it showed a negative effect on the production risk. However, in contrast, the phosphate is used more than the recommended rate and the overuse of this input may result in negative productivity and then raises the production risk as mentioned before. Of course, it may be because of bad quality of this kind of fertilizer. On the other hand, according to the findings, an increase in labor (as an input) can increase the production risk, reflecting the low productivity and low labor quality in this region. Similar to the phosphate, more use of the seed can result in more production risk, which indicates the overuse or low quality of this input. This study

had some limitations. First; it was a field study and because of time and budget limitation, it was not possible to cover a larger area and more crops. Second, there were not enough previous research studies on the topic for wheat in the study region to compare the results and draw a better and more comprehensive conclusion. Therefore, it is recommended that similar research be done for wheat and in some other regions and also for other crops in the study region. In brief, considering the effect of age, the authorities and planners are recommended to not only provide effective and suitable communication and information infrastructure but also offer training and promotional courses to facilitate the spread of the management experiences and findings and encourage the farmers to collaborate with the other farmers. Also, the government can offer more facilities (e.g. credits, subsidies, etc.) to the older farmers to encourage them more than the younger farmers to produce wheat in the region. Based on the resulting effects of the phosphate and seed, it is recommended that the government in addition to assessing the quality of these two inputs, offer some training courses to the farmers to use inputs at the proper level. Of course, some price policies like decreasing input subsidies can help to modify the usage pattern or assess the quality of these inputs to set the scene for the mitigation of the production risk of this crop in the region. Finally, the positive effect of labor on the production risk, like the seed and phosphate, maybe because of the low level of labors' skill and productivity in the region, or, overuse of

labors in the farms. For the policymakers, the first reason means that it is needed to train labors via extension services to have labors that are more skilled and then control the production risk. Also, the second reason is related to the farmers to learn the proper use of labor in their farms. Like the case of seed and phosphate, the government can offer some training courses and mitigate the production risk. The results of this study could be used by policymakers when planning for developing crops or providing and distributing inputs for wheat in the region. Also, the results of other researches (both about other crops and also other regions) in the field could be compared with the results of this study for a more comprehensive analysis of crops production risk.

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بررسی عوامل موثر بر ریسک تولید گندم در شهرستان گرگان

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چکیده

کشاورزی همواره فعالیت همراه با ریسک است و آگاهی از انواع و عوامل ایجاد کننده ریسک اولین گام برای برنامه‌ریزی در جهت مقابله و رهایی از آن به‌شمار می‌آید. یکی از ریسک‌هایی که در کشاورزی وجود دارد ریسک تولیدی است که در اثر نهاده‌های تولیدی به وجود می‌آید. پژوهش حاضر به‌منظور بررسی ریسک تولید گندم با استفاده از روش J-P (جاست و پوپ) در شهرستان گرگان صورت گرفت. آمار و اطلاعات مورد نیاز برای انجام پژوهش با تکمیل تعداد ۸۰ پرسشنامه در سال زراعی ۹۵- ۱۳۹۴ از طریق روش نمونه‌گیری طبقه‌ای تصادفی جمع‌آوری گردید. نتایج برآورد نشان داد که با افزایش نیروی کار و سن زارع، ریسک تولید کاهش و با افزایش مصرف کود شیمیایی، ریسک تولیدی افزایش می‌یابد. بنابراین، پیشنهاد می‌شود که به‌منظور کاهش ریسک تولید این محصول در این منطقه، الگوی مصرف این نهاده اصلاح گردد.