Production risks in Bulgarian peanut production

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Abstract

As farmers in a transition economy search for new crop enterprises with a potential for income enhancement they are faced with increased risks in the process of resource allocation. It has been noted that biased estimation of production function estimates results from the lack of accountability of risks. Since peanut production in Bulgaria has increased at a varying rate since 1989 it is important that we examine the risks associated with input use. The data for this study were collected from farmers from 18 villages in the southern part of Bulgaria. A total of 205 farmers were surveyed for this study. Peanut yield in Bulgaria is positively related to the quantity of seed used, fungicide, manual labor, investment level and mechanized labor used. Peanut yield is negatively influenced by investment levels but positively by the increase of manual labor. The response of yield to quantity of seed used is elastic, and an addition of a kg of peanut seeds may increase yield by 32kg. However, as the quantity of seeds used per ha increases the risk is expected to increase, hence farmers may be cautious in increasing the quantity of seeds used. Investment capital, manual labor and mechanized labor are positively related to yield and there will be a reduction in yield if the optimal levels of those inputs are surpassed. Thus farmers may increase yield and production by augmenting the seeding rate, other factors remaining constant.

Introduction

The Bulgarian economy, like most other Central Eastern European (CEE), is heavily dependent on subsistence agriculture (Totev and Shahollari 2001). About 84% of all farms are less than 0.5 ha, and about 70% of the output is generated from subsistence agriculture (Kostov and Lingard 2002). Agriculture is responsible for about 26% of the GDP and employs about 18% of the work force (Totev and Shahollari 2001). Since 1992, the agricultural sector has experienced significant changes as farmers adjusted to the new economic climate and increased output and yield per ha in order to generate marketable surplus and additional farm revenue. However, production of most crops has been at a decline and varied widely over the period. Peanut is one of the only crops that experienced significant increases in output over the years.

Bulgaria is the most important producer of peanuts in Europe. In 2001-2002 it contributed 97% of all peanuts produced in Europe (Bencheva, 2002). Production of area

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planted in peanuts increased by 45% from 1990 to 2001. In spite of the increases in area planted in peanuts, peanut yields are less than that of other European countries. Increases in output have been achieved through the expansion of area planted. As farmers search for new crop enterprises with a potential for income enhancement they are faced with increased risks in the employment and reallocation of factors of production. Yet very little is known about the risks associated with structural changes at the farm level during a transitional period. Since peanut production has increased at a varying rate during the period of transition it is important that we examine the risks associated with input use in peanut production.

It has been noted that biased parameter estimation results from the lack of accountability of risks in decision making. According to Koundouri and Nauges (2004) incorrect inferences may result from risk and selection bias**.** Risk considerations are important in the evaluation of crop production functions. In the past, functional forms were chosen for such studies but they were limited in allowing for accountability of output variance due to input risks (Just and Pope 1979). The Just-Pope specification, which has popularized as the J-P production function, allows risk-increasing as well as risk-reducing inputs. Examples of studies that have used the J-P model are Eggert and Tveteras, (2004), Griffith and Anderson (1982), Hallam et al. (1989), Hassan and Hallam (1990), Kumbhakar (1993), Love and Buccola (1991), McCarl and Rettig (1983), Shankar and Nelson (1999), Traxler et al. (1995), Wan and Anderson (1985). Traditional production functions, such as the Cobb-Douglas, Translog, and others have been noted to have a risk increasing effect on all inputs according to Just and Pope (1979). Therefore, in this paper, the Just-Pope stochastic production function (will be called the J-P model from here on) was formulated because it allows inputs that have a positive effect on mean production to impact positively or negatively the variance of yields (Di Falco and Chavas 2004). And hence, the J-P model allows the effects of the production factors to be different for the deterministic as well as for the stochastic components of a production function. In Bulgaria it is expected that as farmers allocate resources to peanuts, and away from other crops, and at the same time increasing the amount of inputs used, they are likely to experience variance in yields.

Methods

Theoretical Model

A J-P production function is used to estimate the risk effects of a production function, since it relaxes the second moment of the production restrictions (Traxler et al, 1995). The J-P function used in this study is given by:

$$Y_i = f(X_i, \beta) + g(X_i, \alpha)\varepsilon_i \quad (1)$$

Where Y_i is the yield or mean response output, and X_i is a vector of explanatory variables, β and α are parameter vectors, and ε_i is a random variable with zero mean. The mean output of production is a function of the explanatory variables and is given by the function $f(X_i, \beta)$. The variance of output is related to the explanatory variables by the function $g(X_i, \alpha)\varepsilon_i$. The J-P production function is based on the principle that the variance of the production function error may be related to some or all explanatory variables, implying that it is a multiplicative heteroskedastic model (Judge et al., 1985; Harvey 1976). Therefore, the three stage estimation method described by Judge et al. (1985)

is used in this study. The J-P production function in this paper is developed along the lines of the study done by Traxler et al. (1995). When the variance is an exponential function of K explanatory variables, the heteroskedastic error of the general model can be expressed as:

$$Y_i = X'_i \beta + e_i, \text{ where } i = 1, 2, ... N \quad (2)$$

$$E(e_i^2) = \sigma_i^2 = \exp[Z'_i \alpha] \quad (3)$$

Where $Z'_i = (z_{1i}, z_{2i}, ...z_{ki})$ is a vector of observations for K explanatory variables, $\alpha = (\alpha_1\ \alpha_1\ \alpha_1\ .....\alpha_k)$ is a (K x 1) vector of unknown coefficients, and $E(e_i) = 0$, $E(e_i e_s) = 0$ for $i \neq s$.

Using the natural log transformation, equation (3) can be rewritten as $\ln \sigma_i^2 = Z'_i\ \alpha$. Since σ_i^2 is unknown, the least square residuals from equation (2) can be used to replace σ_i^2 in equation (3) which then becomes

$$\ln e^{*2}_i = Z'_i\ \alpha^* + u_i \quad (4)$$

where $u_i = \ln(e^{*2}_i / \sigma_i^2)$

According to Harvey (1976) the u_i will be asymptotically independent with a mean of $E[u_i] = -1.2704$, and with an asymptotic covariance matrix $\Gamma = 4.9348\ (Z'Z)^{-1}$. This result is asymptotically valid in hypothesis tests for the risk effects. To obtain efficient coefficients the predicted values of equation (4) are used as weights for equation (1).

Model Specification

Quadratic functional forms are used for both the mean and the variance of the peanut yield, and are given in equation (5) and (6). The explanatory variables for these two models were the same for both models and were, quantity of seed (X_1), quantity of seed squared $(X_1)^2$, quantity of phosphate (X_2), quantity of phosphate squared $(X_2)^{2,}$ quantity of nitrogen (X_3), quantity of nitrogen squared $(X_3)^2$, quantity of fungicide (X_4), quantity of fungicide squared $(X_4)^2$, amount of investment capital (X_5), amount of investment capital squared $(X_5)^2$, amount of manual labor (X_6), amount of manual labor squared $(X_6)^2$, amount of mechanized labor (X_7) and amount of mechanized labor squared $(X_7)^2$.

The functional form for the mean yield is given as:

$$Y_i = \beta_1 X_1 + \beta_2 X_1^2 + \beta_3 X_2 + \beta_4 X_2^2 + \beta_5 X_3 + \beta_6 X_3^2 + \beta_7 X_4 + \beta_8 X_4^2 + \beta_9 X_5 + \beta_{10} X_5^2 + \beta_{11} X_6 + \beta_{12} X_6^2 + \beta_{13} X_7 + \beta_{14} X_7^2 \quad (5)$$

While the functional form for the variance of the yield is given as:

$$\ln e_i^2 = \alpha_1 X_1 + \alpha_2 X_1^2 + \alpha_3 X_2 + \alpha_4 X_2^2 + \alpha_5 X_3 + \alpha_6 X_3^2 + \alpha_7 X_4 + \alpha_8 X_4^2 + \alpha_9 X_5 + \alpha_{10} X_5^2 + \alpha_{11} X_6 + \alpha_{12} X_6^2 + \alpha_{13} X_7 + \alpha_{14} X_7^2 \quad (6)$$

Data

The data for this study were collected from farmers from 18 villages in the southern part of Bulgaria and are summarized in table 1 and 2. A total of 205 farmers were sur-

Table 1. Number of farms and peanut area for the different villages in Bulgaria

Village	*Number of Peanut Farms*	*Peanut Area (hectares)*	*Peanut Area (%)*	*Average size of Peanut Farm (hec-tares)*
Asenovgrad	21	49.50	8.70	2.4
P. Evtimovo	12	11.25	2.00	0.9
Kozanovo	11	41.25	7.30	3.8
Muldava	10	9.00	1.60	0.9
D.Voden	10	112.88	19.90	11.3
Zlatovrah	10	10.50	1.80	1.1
Konush	11	63.50	11.20	5.8
Izbegli	15	32.00	5.60	2.1
Karadzhovo	11	41.50	7.30	3.8
Hr. Milevo	10	8.75	1.50	0.9
Katunitsa	2	8.00	1.40	4.0
Kochevo	10	19.50	3.40	2.0
Popovitsa	10	19.50	3.40	2.0
Mominsko	14	32.25	5.70	2.3
Boljrtsi	10	36.75	6.50	3.7
D. Izvor	14	43.75	7.70	3.1
Debar	10	12.50	2.20	1.3
Gradina	14	15.50	2.70	1.1
Total	205	567.88	100.00	

Table 2. Descriptive statistics for the factors used in the production functions

Variable	*Mean*	*Min*	*Max*	*CV (%)*
Yield (Kg/Hae)	2349.12	1358.02	4172.42	17.73
Seed (Kg/Ha)	112.4	79.01	189.63	9.26
Qty. Phosphate (Kg/Ha)	87.75	0.00	493.83	136.10
Qty. Nitrogen (Kg/Ha)	419.15	118.52	987.65	25.07
Qty. Fungicide (Kg/Ha)	27.58	0.00	395.06	171.85
Investment capital ($/Ha)	20.69	0.00	268.38	265.69
Manual Labor (Hours/Ha)	132.89	9.88	829.61	31.77
Mechanized Labor (Hours/Ha)	187.18	23.70	21728.43	30.57
Peanut Acreage(Ha)	1.27	0101	40.5	262.77

veyed for this study. Information regarding yield, production, expenditures on variable and fixed inputs was collected. Examples of variable and fixed inputs included quantity of seed, quantity of phosphate, quantity of nitrogen, quantity of fungicide, amount of investment capital, amount of manual labor used, and the amount of mechanized labor. Prices received by farmers during the last planting season were noted.

Variability in selection of inputs and output levels were obtained from spatial variability in soils, micro-climate and varieties planted. Observations were made on type of ownership, crop combination and marketing decisions. The average size of the peanut farms ranges from 0.10 to 40.5 ha. The peanut yield for the Bulgarian farmers ranges from 1358 to 4172 Kg/ha, with an average yield of 2349 Kg/ha.

Results

Mean Output Response

The estimated results for the mean response function for peanut production (average yield) in Bulgaria are giving in table 3. All the estimated coefficients had the expected

Table 3. Estimated coefficients for the mean and the variance of the peanut yield

Variable	*Mean of Yield*	*Variance of Yield*
Seed	32.04*** (8.35)	0.25*** (2.92)
Seed Squared	-0.294*** (-6.45)	-0.003*** (-2.52)
Quantity Phosphate	0.128 (0.24)	-0.002 (-0.24)
Quantity Phosphate Squared	0.0042 (1.95)**	0.00008 (1.09)
Quantity Nitrogen	-1.47 (-1.00)	0.038 (1.31)
Quantity Nitrogen Squared	0.0019 (0.39)	-0.00015 (-1.56)
Quantity Fungicide	261.22* (1.63)	1.936 (0.62)
Quantity Fungicide Squared	-664.79*** (-3.81)	-2.041 (-0.60)
Investment capital	-2.49* (-1.72)	-0.014 (-0.53)
Investment capital Squared	0.033* (1.72)	0.00022 (0.62)
Manual Labor	14.77*** (3.73)	-0.068 (-0.90)
Manual Labor Squared	-0.114*** (-2.54)	-0.001 (1.19)
Mechanized Labor	-15.93*** (-3.34)	-0.017 (0.18)
Mechanized Labor Squared	0.35*** (4.76)	0.0004 (0.28)
R^2	0.98	0.93
N	203	203

Values between brackets represent t-statistics

* Statistically different from zero at 10% level of significance ** Statistically different from zero at 5% level of significance *** Statistically different from zero at 1% level of significance

signs, and the R^2 for this model was 0.98, indicating that the variation of the dependent variable is adequately explained by the variation of the independent variables. The factors affecting yield are quantity of seeds, quantity of seeds squared, quantity of phosphate squared, quantity of fungicide squared, investment capital, investment capital squared, mechanized labor and mechanized labor squared. Farmers can increase yield by increasing the quantity of seeds used to a given level. However, there is a point at which the optimum level is attained. Farmers can also increase yield by increasing the amounts of fungicide and manual labor, whereas increasing the investment level may have a decreasing effect on yield.

The quantity of seed used had a significant and positive effect on yield. An increase in the quantity of seed by 1% would increase yield by 1.53%. The elasticities of the other variables were inelastic, though that of investment capital was negative which suggests that peanut producing farms in Bulgaria may be overcapitalized.

Output Variance Response

The results of the variance response function estimation are given in table 3. The R^2 for this model was 0.93. The joint F-test was used to test the hypothesis that each production factor did not affect the variance (see Table 4). This was done by testing to determine whether the coefficients of each production factor in equation (6) was equal to zero. The F-test that the coefficients of quantity of seed and quantity of seed squared were equal to zero shows that ($\beta_1 = \beta_2 = 0$) was rejected with a F-value of 4.43, indicating that quantity of seeds affected the variance of peanut yield. This means that quantity of seeds used increases the risk of the peanut farmers in Bulgaria. The F-test that the coefficients of quantity of phosphate and quantity of phosphate squared were equal to zero ($\beta_3 = \beta_4 = 0$) was rejected with a F-value of 2.27, this implies increasing phosphate use increases the risk of peanut yield in Bulgaria. The F-tests for the other production factors were not rejected implying that they were not affecting the variance of the peanut yield and the risk of producing peanuts in Bulgaria. The results indicate yield variability may be seriously impacted by variability in quantity of seeds used.

Table 4. The F-test results

Null Hypothesis (H_o)	***Parameter Restriction***	***Test Statistics***	***Conclusion***
Variance is not influenced by seed	$\beta_1 = \beta_2 = 0$	F = 4.43	Reject H_o^{***}
Variance is not influenced by phosphate	$B_3 = \beta_4 = 0$	F = 2.27	Reject H_o^{*}
Variance is not influenced by nitrogen	$B_5 = \beta_6 = 0$	F = 2.06	Fail to Reject H_o
Variance is not influenced by fungicide	$B_7 = \beta_8 = 0$	F = 0.20	Fail to Reject H_o
Variance is not influenced by investment capital	$B_9 = \beta_{10} = 0$	F = 0.23	Fail to Reject H_o
Variance is not influenced by manual labor	$B_{11} = \beta_{12} = 0$	F = 1.26	Fail to Reject H_o
Variance is not influenced by mechanized labor	$B_{13} = \beta_{14} = 0$	F = 2.10	Fail to Reject H_o

* Statistically different from zero at 10% level of significance, ** Statistically different from zero at 5% level of significance, *** Statistically different from zero at 1% level of significance

Conclusion

Peanut yield in Bulgaria is positively related to the quantity of seed used, fungicide, manual labor, investment level and mechanized labor used. Peanut yield is negatively influenced by investment levels but positively by the increase of manual labor. The response of yield to quantity of seed used is elastic and an increment of a kg of peanut seeds may increase yield by 32kg. For example, in the U.S. the average quantity of seeds recommended per ha is about 100 kg for irrigated and non-irrigated lands and the costs of seeds make up about 15 to 22% of variable costs (University of Georgia 200). The yield per ha in the U.S for irrigated and non-irrigated peanuts averaged about 2492 and 2923 kg per ha. The average amount of seeds used in Bulgaria is about 112 kg per ha and seed cost makes up about 19.8% of variable costs and the yield per ha is 2349 Kg/ha. Therefore, there may be room for improving peanut yield by increasing the seeding rate. However, as the quantity of seeds used per ha increases the risk is expected to increase, and even if the seed cost share may be relatively small it may be a significant amount for limited resource Bulgarian farmers. Hence farmers may be cautious in increasing the quantity of seeds used.

The effect of investment on yield may indicate that farms may increase yield holding capital constant while increasing the quantity of labor. This may not be possible since the present tendency is for labor to exit farms in search of more lucrative sources of income. However, one must be cautious in the interpretation of the results since a decision to increase or decrease capital employment can not be taken in isolation since the quantity of seed interaction should also be considered. Capital use may be increased if the new capital introduced is labor saving.

Investment capital, manual labor and mechanized labor are positively related to yield and there will be a reduction in yield if the optimal levels of those inputs are surpassed. It should be noted that nitrogen has no apparent effect on peanut yields. This is expected since Bulgarian farmers apply on the average 406kg/ha of fertilizers.

Changes in production of peanut and other crops may be altered without any major policy engagement at the administrative level. What is needed is the diffusion of scientific information about the relationship between seeding rate and yields and the accompanying risks and yield. However, one must be careful since much information was not available as to whether farmers adopted mono-cropping or intercropping which could alter recommendations for farm improvement.

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