

MEASURING THE TECHNICAL EFFICIENCY OF POTATO PRDUCTION AND ITS DETERMINATS IN IRAQ (BAGHDAD PROVINCE AS CASE STUDY).

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ABSTRACT

This study aimed to estimate the stochastic frontier production function and the inefficiency function and technical efficiency of potato production by using cross-section data collected from 173 potato farms that were randomly selected in Baghdad province/ Yusifiyah for production season 2016. The results showed that 90.6% of inefficiency in production was due to technical inefficiency. Also, there was a significant relationship between the variables of inefficiency function and the inefficiency of farms. The values of the parameters of the stochastic frontier production function were positive and significant for both human work hours and the amount of seeds. However, the parameter of DAP fertilizer was negative and significant. The estimation of the technical inefficiency function showed that its parameters were significant for both the local seed provider and the agricultural season (fall), while the parameters experience in growing potatoes and the number of irrigations were significant and their impact was negative on the inefficiency. The results also showed that the technical efficiency of the study sample (50%) on average. The researchers recommended the necessity of providing imported seed tubers for the increased productivity in dunum to achieve technical efficiency.

Keywords: Productivity, Stochastic frontier analysis, Production economics.

الحجامي وآخرون

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قياس الكفاءة التقنية لإنتاج البطاطا ومحدداتها في العراق (بغداد حالة دراسية)

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المستخلص

تهدف الدراسة الى تقدير دالة الإنتاج الحدودية العشوائية و دالة عدم الكفاءة والكفاءة التقنية لإنتاج البطاطا باستخدام بيانات مقطعية تم جمعها من 173 مزرعة لإنتاج البطاطا تم اختيارهم عشوائياً في محافظة بغداد اليوسفية للموسم 2016، أظهرت النتائج (90.6 %) من إبتعاد الإنتاج عن الإنتاج الكفوء يعود سببه الى عدم الكفاءة التقنية، كذلك وجود علاقة معنوية بين متغيرات عدم الكفاءة وعدم كفاءة المزارع في الانتاج الحدوي وكانت قيم معاملات دالة الانتاج الحدودية العشوائية موجبة ومعنوية لكل من (ساعات العمل البشري وكمية التقاوي) في حين كانت قيمة معلمة (كمية سماد الداب) سالبة ومعنوية ، كذلك تم تقدير دالة عدم الكفاءة التقنية وكانت معالمها معنوية لكل من مصدر التقاوي (المحلية) والموسم الزراعي(العروة الخريفية) وأثرها في زيادة عدم الكفاءة في حين كانت معالم (الخبرة في زراعة البطاطا وعدد الريات) معنوية وأثرها السلبي في عدم الكفاءة ، وأظهرت النتائج الكفاءة التقنية لعينة الدراسة بمتوسط قدره (50%). أوصى الباحثين بضرورة توفير التقاوي المستوردة لما تحققة من زيادة في إنتاجية الدونم وبالتالي تحقيق كفاءة تقنية.

كلمات مفتاحية: الانتاجية، التحليل الحدوي العشوائي، إقتصاديات الإنتاج .

INTRODUCTION

Potato crop occupies the fourth place in terms of importance globally after wheat, rice and corn, and it is an important crop worldwide and a good source of vitamins, minerals and dietary fiber as well as phytochemicals (14). The consumption of fresh potatoes is preferred by many consumers in many countries around the world. Furthermore, it is essential in fast food industries, snacks and ready foods in order to meet the growing demand due to population growth in cities, increased incomes, diversification of meals, and the time required to prepare the fresh for consumption. China is the first producer of potatoes followed by India (18) and Russia with production levels of 991205600, 48605000, 29590000 tons respectively (12). Potato crop is grown in Iraq with an area of (24552) dunums and production (165589) tons and a yield of (6744.4) kg / dunums (9). These quantities are less than the actual need given the availability of sufficient resources to increase production and productivity and reach higher levels of potato crop production, through the continuous support of successive Iraq governments represented in supporting and subsidizing production inputs and scientific research efforts. The problem of low productivity of the potato crop is one of the most important challenges that is reflected in the profits and thus the sustainability of production and future expansion. The research aimed to measure the production efficiency of potato farms and study the factors affecting production by relying on field data for a random sample of 173 potato production farms in Baghdad province during the 2016 season by estimating the stochastic frontier production function and the function of productive inefficiency of the farms. The study assumes a significant relationship between potato production inputs as well as economic, social and qualitative variables and the inefficiency of potato farms.

MATERIALS AND METHODS Efficiency measurement is based on the determination of the production function which has been suggested by (Aigner *et al.*, 1977; Meeusen and Von den Broeck, 1977). The original specifications of the production function include specific cross-sectional data and up to the error there are two components, one for

calculating random effects and the other for calculating technical inefficiency. Thus, random estimates of technical efficiency include a measure of random error which is one of the components of the compound error term of random production limits. This model recognizes the fact that factors that fall outside the control of farmers can influence the level of production, so it has become possible to know whether deviations in production from the frontier product are due to specific factors of the farm or due to external random factors. The traditional school followed several methods to indicate success and failure in agricultural work through the function of production, cost, or profits and the use of regression techniques based on the least squares method (6). Deviations from the maximum output and profits and the minimum cost were because farmer operates under a state of uncertainty, mainly due to fluctuations in the use of inputs, technical inefficiency and random variables. The fluctuation is resulting from variation in the use of inputs can be obtained through the production function. In the result, due to technical inefficiency and random variables, they can be found and analyzed through the function of stochastic frontier inefficiency. The random curriculum is a parametric method that takes the random error test and requires a predetermination of the model used (8). The total error limit (ϵ_i) is divided into two parts. The first one is the random error limit (v_i), which reflects measurement errors that may be positive or negative. The second part is the efficiency limit (u_i), which is a one-sided error that reflects efficiency differences between farms. It comes from the negative deviation from the border efficiency curve. There are many social economic, demographic, institutional, environmental, and non-physical factors that affect efficiency (15). These factors include gender, age, educational level, family size, experience in agriculture, mixed seed, access to credit, off-farm work, membership of a farmer-based organization, single crop, land lease, etc. (17). Stochastic frontier analysis is an auxiliary method in comparing farms with similar productive activities (3). The random production function can be written as (7):

$$Y_i = B_i X_i + v_i \dots \dots \dots (1),$$

Y_i = optimal output. X_i = input vector. β_i = the vector of the parameters to be estimated. v_i : random error, which represents the variables that cannot be controlled and are outside the control of farms, such as weather conditions, errors in measurement, random errors, with an independent and homogeneous distribution (iid) with an average of zero and a constant variance, and thus it equals $N(0, \sigma^2_v)$ where it takes positive or negative values v_i ($-\infty < v_i < \infty$). However, in practical life, we found that the actual output Y_i is less than Y_i^* the planned or desired output by the amount of u_i , and in this case it can represent the amount of lack of efficiency, meaning that the actual production is less than the optimal frontier production, and therefore this difference appeared (6).

$$Y_i = (\beta_i X_i + v_i) - u_i \dots\dots\dots (2).$$

$$v_i - u_i = e_i \dots\dots\dots (3).$$

$$Y_i = \beta_i X_i + e_i \dots\dots\dots (4).$$

Substituting equation 3 into equation 2, we get the stochastic frontier Production function, (SFPF):

$$Y_i = f(x_i; \beta_i) + \exp(v_i - u_i) \dots\dots (5). \text{ As}$$

$$\text{for the technical inefficiency function, } u_i = f(s_i; \delta_i) \dots\dots\dots (6).$$

u_i : Random errors due to inefficiency s_i : vector of random variables affecting inefficiency. δ_i : The vector of the parameters to be estimated for the random variables. TE_i : efficiency is defined as the ratio between actual output and optimal output (4), which takes values between zero and one, as in equation (6).

$$TE_i = \frac{f(x_i; \beta_i) + \exp(v_i - u_i)}{f(x_i; \beta_i) + \exp(v_i)} \dots\dots\dots (7).$$

$$TE_i = \exp(-u_i) \dots\dots\dots (8).$$

An efficient farm is the one that achieves the ratio of one and the actual production is equal to its optimal production. Many researches were conducted on the technical efficiency of potatoes, including a study of technical efficiency and its determinants in potato production in Punjab, Pakistan through data from 100 farmers and it was found that potato growers are distinguished by technical efficiency of 84%(1). Also, there was a study

on the technical efficiency of potato production for smallholder farmers in Oromia, Ethiopia with a randomized study of 149 smallholder potato producers (22). The results of the study showed significant differences in technical efficiency among potato producers. The average technical efficiency of farmers was 0.74. Furthermore, a study titled analysis of the technical efficiency and profitability of potato production by smallholder farmers in Ethiopia used sectional data of 147 households included the survey and the average technical efficiency of farmers in potato production was 0.89 (11). In addition, study of technical competence in seed production systems in Uganda through a sample of 636 households 499 informal seed producers and 137 official seed producers. Data were collected for two seasons and average technical efficiency showed informal and formal potato producers 81.4 and 80.4%) respectively (2).

Description of the study sample

The sample of the study consisted of a sample of potato production farms in Baghdad /Yusifiyah, district was chosen as the crop is grown in two seasons which are fall and spring for the 2016. The farms grow potatoes and by a total of 173 farms where data was collected through personal interviews with farmers. Average of the study variables which are distinguished according to production seasons are shown in table 1. It shows that there are significant differences in the quantity of production and the amount of seeds used as the amount of production in the spring season exceeded the amount of production in the fall season as well as the seeds used in the fall season exceeded the quantities used in the spring season The reason for that is due to the farmers 'use of seeds of self-provision resulting from the spring season. As for the remain of the study variables, they were close between the two seasons, and there were no significant differences between them for the two seasons. As shown in table2.

Table 1. Average of the variables used in the research

variable	season	unit of measurement	Average	variable	season	unit of measurement	Average
Human work	spring	hours	200.5	production	spring	tons / dunam	6.8
Human work	autumn	hours	210.9	production	autumn	tons / dunam	4.3
The age of the farmer	spring	Year	54	Seed	spring	Kg/ dunam	553
The age of the farmer	autumn	Year	55	Seed	autumn	Kg/ dunam	878
The number of workers on the farm	spring	Number	7	Urea fertilizer	spring	Kg/ dunam	107
The number of workers on the farm	autumn	Number	8	Urea fertilizer	autumn	Kg/ dunam	99.8
Years of Experience	spring	Year	34.4	Automated work	spring	hours	19.5
Years of Experience	autumn	Year	34	Automated work	autumn	hours	18.4
The ratio of farm income to annual income	spring	percentage	74	Dab fertilizer	spring	Kg/ dunam	194.2
The ratio of farm income to annual income	autumn	percentage	72.9	Dab fertilizer	autumn	Kg/ dunam	187.7
Planting season	spring	Number of farms	79	The number of irrigations	spring	Number	9.3
Planting season	autumn	Number of farms	94	The number of irrigations	autumn	Number	9.1

Source: Prepared by the researcher based on the questionnaire data

Table 2. Analysis of variance of variables in which there is a significant difference.

	source of the difference	Sum of Squares	df	Mean Square	F	Sig.
y	Between Groups	297.2	1	297.2	24.6	0
	Within Groups	2066.1	171	12.08		
	Total	2363.4	172			
X3	Between Groups	4536504	1	4536505	56.2	0
	Within Groups	13793217	171	80662		
	Total	18329722	172			

Source: Prepared by the researcher based on the questionnaire data

Work steps

We estimate the Cup-Douglas production function and choose the best functional form using the probability ratio test and estimating the rate of production inefficiency using variables that have statistically significant coefficients and founding the efficiency of the study sample farms.

Choices

1- Random effect test: It is a test of whether or not a random effect is performed and is based on two criteria: A. the value of gamma (γ), the null test: gamma (γ) = zero, which means that the test is not significant and therefore the model is rejected meaning that the model is not random. The assumption of the substitute gamma (γ) \neq zero, which means

the significance of the test and thus acceptance of the random model for estimating the efficiency. The comparison between the gamma ratio test and the tabular value of t is at a significant level (0.05) and degrees of freedom (n-k-1). If the calculated value of a gamma (γ) is greater than the tabular value we reject the null hypothesis and accept the existence of randomness, which means that the variance in the error limit is due to the element of inefficiency (10). But if gamma (γ) = 1, the total difference observed between farmers is due to technical inefficiency, and then the boundaries are better than the random ones.

2- Test the maximum probability Likelihood Ratio (LR) test to compare the function when the null is imposed (OLS estimation) and its

value when the alternative hypothesis is Maximum Likelihood (ML) and compare it to the Chi square distribution. If the value of the Chi square is greater than L. R accepts the null assumption, That is, when using the model with OLS method, if the value of the Chi square is less than the LR then the assumption of the alternative is assumed, which means there is a benefit in using the random model (10).

Research methodology

Estimation of the Stochastic Frontier Production Function:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + v_i - u_i \dots \dots \dots (1).$$

- Y_i: production (ton).
- X₁: number of hours of human labor for the farm (hours).
- X₂: The amount of nitrogen fertilizers (urea) for the farm is tons.
- X₃: The amount of seeds used for the farm (tons).
- X₄: The amount of phosphate fertilizer (DAP) for the farm (tons).
- X₅: number of hours of automated work

Likewise, using the variables of the inefficiency function (local and imported seed source), the agricultural season, a spring loop and an autumn loop) the age of the farmer, experience in growing potatoes, the percentage of farm income from total income, and the number of irrigation) in order to estimate the effect of the variables on efficiency as it is an influential source in inefficiency and the following model was described:

$$ui = \sigma_0 + \sigma_1 S_1 + \sigma_2 S_2 + \sigma_3 S_3 + \sigma_4 S_4 + \sigma_5 S_5 + \sigma_6 S_6 \dots \dots \dots (2).$$

σ₁, σ₆ unknown parameters to be estimated. S₁.....S₅ = represents the social variables (source of seed (local 0 and imported 1) agricultural season (Spring 0 and Fall 1), farm age and experience in growing potatoes and the percentage of farm income and irrigation times)). Program Frontier 4.1 was used for the purpose of obtaining the values of the parameters of the stochastic frontier function, as well as estimating the parameters of the function inefficiency and technical efficiency.

RESULTS AND DISCUSSION

- 1- The value of the sigma-squared σ₂ (0.241) was significant at a significant level (0.01 0.05) .
- 2- The gamma value (0.906) is at a significant level (0.01 0.05) and indicates that the largest part of the values' move away from the boundary product (variance of values) is due to technical inefficiency and is not the result of random error, as it indicates that (0.906) of deviations in production due to inefficiency in production due to the technical variables mentioned in the study (13), and it was only 0.094 due to factors out of control, and this is consistent with what was reached by other studies (16).
- 3- The value of the one side logarithmic probability error test (LR) (123.64), it is significant at a (0.05 0.01) level where it was greater than the Chi square (14.6 and 20.27) and therefore the alternative hypothesis confirms that there is a significant relationship between the study variables (source of seeds, agricultural season, age of farms, experience in growing potatoes, and contribution of farm income to income ratio the total number of farms and the number of irrigation) on the farm and between the inefficiency of potato farms in border production (10) and rejects the null hypothesis, which states that there is no significant relationship between the above-mentioned study variables and the inefficiency of potato farms in border production. This indicates that the study variables play an important role in explaining the variation in potato production.
- 4- The value of the parameters of the production function with (ML) showed the parameters of the production function were significant and positive for each of the number of working hours and the quantity of seeds, which means an increase in the number of working hours and the amount of seeds by 1%, which leads to an increase in production by (0.29 and 0.97), respectively. As for the amount of seeds, it is consistent with what was reached by other studies (7). While the parameter of the amount of phosphate fertilizer (DAP) was negative and significant. This means according to table (1) that the quantities used for the two seasons are more than the recommended instructions (19). The

parameters of the number of hours of automated work were positive and this means the use of additional hours of automated work by 1% leads to an increase in production by (0.049) and the parameter was not significant and this lack of dependence on automated work and this is corresponds to other studies (3) where the use of modern technology, including mechanization, increases efficiency due to the increase in dunum productivity. As for the parameter of the amount of nitrogen fertilizers, it was negative but not significant. This means adding quantities of nitrogen fertilizers by 1%, which leads to a decrease in production by (0.1) because it leads to adding urea nitrogen fertilizers to increase vegetative growth at the expense of the growth of tubers and thus decrease productivity.

5- Estimating the technical inefficiency model shown in equation (1) where it is assumed that the inefficiency is the dependent variable. The explanatory variables were the source of seed tubers and the agricultural season, such as variables of quality and age of the farmer, experience in growing potatoes, the ratio of farm income to total income, and the number of irrigation of the crop as variables affecting inefficiency, and the value of the parameters are shown below:

A- The parameter of the qualitative variable S1 (seed source) is positive and important. This means that the cultivation of local seeds increased inefficiency and consequently reduced technical efficiency on the farm giving that all farms in spring used imported seed tubers except for only two of the farms and the farms using imported seed tubers achieved technical efficiency by 69%, while the use of seed tubers achieved Domestic technical efficiency increased by 34%, consistent with other studies (7), and contrary to another one (5).

B. The parameter of the qualitative variable S2 (planting season) is positive and significant. This means that cultivation in the fall season led to an increase in inefficiency and consequently reduced the technical efficiency in the farm and this is as in table 1 as production in the fall season approaches half of the production of the spring.

C - The parameter of the random variable S3 (the age of the farmer) is positive, which means that increasing the age of the farmer leads to an increase in incompetence and therefore led to a decrease in technical efficiency in the farm, but the parameter is not significant, meaning that age has no significant effect as the farm depends on the labor in the main degree consistent with other studies (20).

D- The parameter of the random variable S4 (the experience of the farmer is negative and significant, and this means that the farmer's experience in potato cultivation has led to a decrease in inefficiency and consequently to an increase in technical efficiency in the farm and this is consistent with other studies (16).

E - The parameter of the random variable S5 (ratio of farm income to total income) is negative and important, meaning that the increase in farm income from the ratio of total income led to a decrease in inefficiency and thus an increase in technical efficiency in the farm and this stems from an increase in the contribution of farm income to total income. This leads to the interest of the farmer in all inputs and factors that increase production, and thus increase technical efficiency.

F. The parameter S6 (number of irrigations) is negative and significant. This means that the increase in the number of irrigations led to a decrease in incompetence and consequently to an increase in technical efficiency on the farm.

Table 3. Results of estimating the Stochastic frontier production function

The parameters	OLS	T-Ratio	COLS	ML	T-Ratio
B0	-1.51	-3.63	-0.906	0.434	1.553**
B1	0.541	5.44	-0.541	0.29	4.60***
B2	0.055	0.35	-0.055	-0.1004	-0.883
B3	0.352	2.94	-0.35	0.977	10.15***
B4	-0.009	-0.056	-0.009	-0.132	-1.092*
B5	0.098	0.909	0.098	0.0486	0.663
S0				0.9575	2.62***
S1				0.4356	1.69**
S2				0.7716	2.79***
S3				0.0044	-0.77
S4				0.0044	2.205***
S5				-0.022	-0.392
S6				0.00084	-2.739***
Sigma squared	0.325			0.2416	5.466***
Gamma				0.906	14.789***
Log likelihood	-145.37			-83.55	
LR test				123.64	

Source: Prepared by the researcher, based on the results of the Stochastic frontier production function.

Results of technical efficiency

By reviewing the results of technical efficiency of potato farms in table (4) we found that the rate of technical efficiency was (0.50), and this means that potato farms in order to be efficient the amount of their production must be increased by 50% while remaining at the levels of the actual elements or reducing the elements 50% productivity with this level of efficiency. By comparison between the two seasons of agriculture, we found that the spring season achieved the highest technical efficiency, as it averaged 0.70, which was reflected in the increase in dunum productivity, average Actual production 7.086 tons /dunum, when compared with border productivity (efficiency), which was an average of 9.742 tons / dunum. Average productivity loss due to efficiency was 2.655 tons / dunum on farms in the spring season, while the fall season

achieved an average efficiency of 0.33. This was reflected in a decrease in the productivity of a dunum, with average actual production 4.455 tons per dunum compared with border productivity that was an average of 12.832 tons / dunum. Average productivity loss due to efficiency was 8.377 tons /dunum. As for the distribution of farm numbers according to the agricultural season and the efficiency ratio, it was as shown in figure (1) that farms which have achieved technical efficiency less than 50% were 89.4 farms, and which achieved 89.4% were 10 farms, which accounted for 10.6%, their efficiency was between (51-74)% in the autumn season. Whereas the spring season, 8 farms that accounted for 10% as for the rest of the potato farms , while 74 farms accounted for 90% of the spring season farms and their efficiency ranged between 0.51-0.94%.

Table 4. Farmers Efficiency (1), Productivity (Efficiency (2), Actual (3) and Loss (4) due to efficiency according to the agricultural season (No. 0 for the spring season and 1 for the autumn season).

variable	Season (1, 0)	N	Mean (tons / dunam)	Std. Deviation	Std. Error	Minimum	Maximum
2	0	79	7.086	4.115	0.463	0.667	29.1
	1	94	4.455	2.83	0.2919	0.02	12.513
	Total	173	5.656	3.706	0.2818	0.02	29.1
3	0	79	9.742	4.462	0.5021	1.419	31.29
	1	94	12.832	4.495	0.4636	0.182	25.06
	Total	173	11.421	4.726	0.3593	0.182	31.29
4	0	79	2.655	1.664	0.1872	0.37	8.16
	1	94	8.377	3.02	0.3115	0.16	15.56
	Total	173	5.764	3.789	0.2881	0.16	15.56
1	0	79	0.706	0.1688	0.0189	0.28	0.94
	1	94	0.33	0.1424	0.0146	0.04	0.77
	Total	173	0.5024	0.2431	0.0184	0.04	0.94

Source: Prepared by the researcher, based on the results of the Stochastic frontier production function analysis

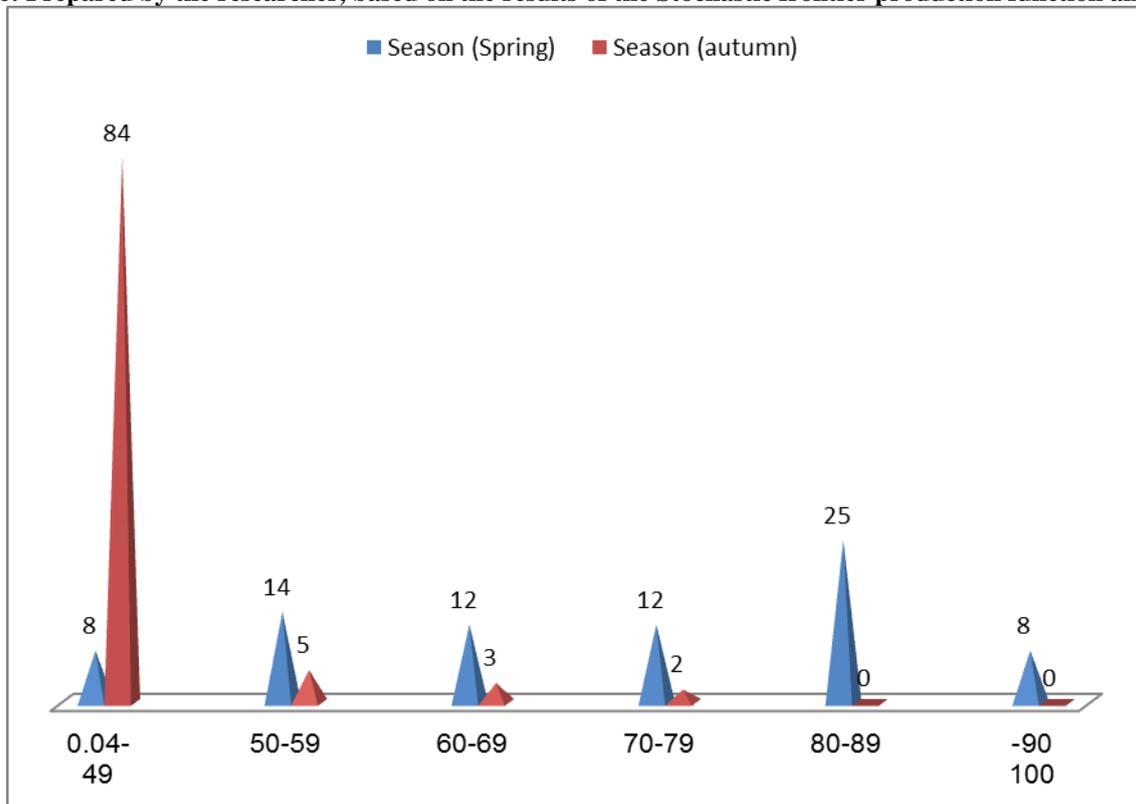


Figure 1. Distribution of farms according to efficiency and agricultural season

The research concluded that potato fields have a technical efficiency of 50%, which indicates a great potential for improving efficiency and would generate an increase in productivity by 50%. Deviations in actual production from possible production were due to variables (season, source of seed, age of farms and experience in the cultivation of potatoes and the number of irrigation). The most effective variables were agricultural season followed by

the source of seed in technical inefficiency. The average technical efficiency of all farms planted in the spring season was greater than the fall season. The research recommended providing seeds of authentic origin, encouraging the use of agricultural mechanization and non-reliance on local seed tubers, focusing on planting in the spring season and using fertilizers according to scientific recommendations.

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