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ESTIMATION OF WHEAT FLOUR PRODUCTION FUNCTION IN A STOCHASTIC FRONTIER ANALYSIS FOR THE YEAR 2019 BAGHDAD GOVERNORATE CASE STUDY

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Abstract

The study aimed to estimate a stochastic frontier production function and the inefficiency function for the production of wheat flour, in addition to estimating the technical efficiency of flour mills in Baghdad Governorate for the year 2019, as a sample of 53 mills was collected. The function was estimated in two periods according to a stochastic frontier method using the frontier 4.1 program. The results showed that the sign of the working hours parameter appeared positive and explained the positivity of the variable on the quantity of flour production in the study sample, and the value of elasticity indicates in the second stage of production stages, but its effect is not significant in the efficiency model. As for the parameter of the variable capital quantities, its sign appeared negative and was at a significant level of 1%. It indicates the presence of waste in the quantity of the input and indicates the value of elasticity in the third stage of production. As for the variable quantities of raw wheat, its parameter sign is positive and below a significant level of 1%. The elasticity value indicates that it is in the first stage of the production stages. As for the inefficiency model, the experience was the only variable that affected the model, the result of which was that the producers with little experience had a significant impact on the inefficiency model at the 10% level. As for estimating the technical efficiency, all sample mills moved away from achieving the optimum size of production. The study recommended the necessity of modernizing milling machines and allocating additional quantities of raw wheat, because the second period witnessed high levels of technical efficiency for sample mills.

Key words: Productivity, Stochastic frontier analysis, Technical efficiency.

Introduction

Wheat production ranks first in the world among strategic crops, which meets the requirements of most people in the world because it has great nutritional value (usda. 2019).Countries China, India, USA, Russia ranked first in the production of raw wheat (Robert , 2022). Raw wheat is the main source in the food processing industries, the most important of which is the manufacture of bread and pastries that meet the needs of the community, Likewise flour production residues (bran) are included as a secondary source in raising livestock after the flour manufacturing process. In Iraq, the production of raw wheat in the study year was about 4.3 million tons. This quantity represents the country's actual need for the production quantities of the crop (Ministry of pl., 2019).Since raw wheat is the main source in flour production, the product has been included in the priority of successive governments since the past three decades because it represents the main item within the ration basket provided by the Ministry of Commerce to meet the needs of community members. Therefore, the state was interested in expanding the flour manufacturing sector by increasing the number of public and private sector mills, and the fact that public sector mills represent approximately 5% from the total mills of Iraq, the state contributed to meeting all production requirements to support the private sector. However, the last two decades reduced support for production inputs, which confused the owners of private sector mills to continue their work because the input markets are not subject to the factors of government control, causing the instability of their prices. This forced many mill owners to change their production capacities due to the mills' deterioration or by increasing the mills' working hours, to compensate for the decrease in the quantities of flour produced from previous periods and It should also be noted that the company's management neglected the economic aspect of the mills' performance by continuing to increase the number of mills against the fixed quantities of raw wheat In other words, the stability of the produced quantities of flour accompanied by an increase in the number of mills, which will have a negative impact on the performance of those mills. The issue of deviation of the input path towards achieving their economic efficiency has become very far. So the problem of the study on this topic. The aim of the research is to estimate the stochastic frontier production function and the inefficiency function, and technical efficiency of flour mills in Baghdad Governorate for the year 2019, within the random limits of the study sample of 53 mills within the borders of Baghdad governorate and showing the most important inputs of the efficiency model as well as showing the importance of the economic, social and qualitative characteristics used in the inefficiency model. With regard to the practical aspect of some of the previous studies, there were a few researches and studies that were concerned with estimating production functions in stochastic frontier model to the flour mills sector, which this study benefited from, the most important of which were (Akik, 2018), (Alyami,, 2015) and (Bekele et al.,2007).

MATERIALS AND METHODS

The production function was used according to a stochastic frontier method in evaluating the technical efficiency of a sample of mills, and according to the formula of the Cobb-Douglas production function, it has an appropriate representation of production. Moreover, it gives the effect of the functional form on the efficiency. Technical fields of application.

Using the Frontier 4.1 program, the parametric formula (Battese,&others.,1977) emerges from it, which replaces the variance resulting from random error σv2, and the variance resulting from technical inefficiency σu2 with their sum, which represents the total variance σ^2 (sigma square). The program also directly estimates γ (gamma) by dividing the variance resulting from technical inefficiency by the total variance σ^2 to determine the extent to which the technical inefficiency component contributes to the total variance in the performance of decision-making units. And to estimate the technical efficiency TE using the Analysis Frontier Stochastic SFA method with the maximum likelihood ML according to the following steps (Ali &others, 2015):

1. Using the Ordinary Least Squares OLS method to get the best unbiased linear estimate of the parameters of the production function, except for the y-axis that is biased.
2. Relying on the corrected ordinary least squares COLS method to obtain unbiased linear parameters including the y-axis cut-off.
3. Obtaining the maximum probability estimates for the parameters of the Frontier Stochastic production function, using the method Likelihood Maximum according to the form of the production function.

According to the model (Battese &others 1995), the technical inefficiency of firm i can be obtained from the following equation, (Zine El Abidine, 2020):

TEit = exp (-Uit) = exp (-Zitδ – Wit)……...1

Thus, the Frontier Stochastic production model becomes as follows (Junaedi et al, 2016):

$Yi = (Xi : \beta)$ exp $(Vi - Ui)$ $i = 1, 2, , n$……**2**

Where

Yi: The quantity of output or output of the firm (i).

Xi: the quantity of inputs to the facility (i).

βi: the parameters to be estimated in the model.

Ui: a random variable that expresses inefficiency as a result of differences in the efficiency of the facility or production unit. If Ui = 0, this means that the production unit lies on the frontier curve and has achieved full efficiency. But if the value of Ui < 0, this means that the facility or production unit does not lie on the frontier curve and the facility is inefficient, this variable is always positive, so it is assumed in the analysis of the frontier stochastic function that it follows the positive part of the normal distribution. [u~N(0 , σu2)].

Vi: random error that reflects measurement errors and other factors that were not included in the model, and the errors may be positive or negative, and it is assumed that it follows the normal distribution [vi~|N(0, σv2)|]. (Nicolás et al, 2015).

On the other hand, when Ui < 0 is less than zero, this means that technical efficiency is the value of what Ui takes, which then represents the actual production. Technical efficiency can be found by dividing the actual production by the possible production Ui = 0 (AL Saeed S., 2013).

Mathematically, the technical efficiency of the production unit can be estimated through (Al-Hachami et al., 2020).

$\boldsymbol{TEi} = \boldsymbol{f}(\boldsymbol{xi}\ ;\ \boldsymbol{\beta i}\ ) + \mathbf{exp}(\boldsymbol{vi} - \boldsymbol{ui}\ )\ /\ \boldsymbol{f}(\boldsymbol{xi}\ ;\ \boldsymbol{\beta i}\ ) + \mathbf{exp}(\boldsymbol{vi})$ …………... **3**.

$\boldsymbol{TEi}$ = The firm's actual output / The firm's potential output.

The value of the efficiency is limited between zero and one, when the efficiency is equal to one, this means that the efficiency of the facility is complete, but if it is less than one, this means that there are factors that negatively affected the efficiency and it is called inefficiency (Meshaal,, 2017) and it may share the errors of the random limit in the model and other factors other out of the model.

And for the purpose of determining the shape of the frontier production function that requires its estimation, by conducting the likelihood ratio test, which shows the selection of the appropriate functional form according to the available data (Pérez-Quesada& et al., 2018).

The gamma parameter γ lies between zero and one, and its value provides a useful test for the relative magnitude of inefficiency effects. If γ = 0, this indicates that the deviations from the limits are entirely due to randomness. If 1 = γ, it indicates that all deviations are entirely due to economic inefficiency other than randomness (Coelli et al. 1999).

As for the inefficiency that we get from this method, it represents a measure of total inefficiency, as it depends on factors beyond our control, at least in the short run. Therefore, net efficiency must be calculated (from estimating the efficiency of controlling and uncontrollable factors), and this gives us measures of efficiency levels when all components are assumed to face the best conditions. (Coelli, 1995).

DESCRIPTION OF THE STUDY SAMPLE

In this study relevant data were collected from both primary and secondary data sources, which are of a qualitative and quantitative nature, the primary data was collected from a sample of wheat flour producers using questionnaires in the personal interview, in addition to a discussion of the questions included in the questionnaire form with the producers. The questionnaire consisted of two parts, the first part is used to collect information about the social and economic characteristics of producers. The second part included the types of inputs, the quantities used and the outputs obtained by the producers.

The sample was collected for most of the mills in Baghdad Governorate, which consisted of 53 mills for the year 2019 and included data for two periods, each period was represented by the semi-annual data for the study year because the second period witnessed an increase in the quantities of raw wheat processed to the sample mills by 7% by

Table 1 Description of the study variables for the first and second periods of 2019

Variables	Unit used	Total quantities First period	Total quantities Second period
Flour production quantities (Y)	tons	**1551320**	**1657917.5**
working hours (L)	hours	**163806.5**	**202985.8**
Variable Capital Amounts (K)	Units	**2430235**	**2732923**
Raw wheat quantities(W)	tons	**1924715**	**2059525**

Source: Based on the data of the General Company for Cereal Manufacturing and the producers' questionnaire form

Y: The dependent variable represents the total quantities of flour production/ton.
L: An independent variable represented by the total number of working hours/hour.
K: An independent variable represented by the total number of units used (electricity, water, fuel, maintenance parts).
W: An independent variable, represented by the total quantities of raw wheat/ton.
As for the description of the economic and social variables for the sample mills, they are represented in Table 2.

Table 2 Description of the economic and social variables of the sample mills

Economic & social variables	Unit	Quantity or description of the variable
Actual production capacity of each mill	**Tons/day**	**44 -2147**
The distance of grain transportation from the source to the mill	**Km**	**11- 24**
Ownership	**Public/ Private sector**	**4/ public sector 49/ private sector**
Mill manager experience	**Years**	**5- 39**
Education level of mill manager	**Levels**	**Intermediate/ 9 Secondary/ 16 Diploma/ 8 Bachelor/ 20**

Source: Based on the data of the producers' questionnaire form

A unilateral analysis of variance was conducted for the variables. The SPSS ver.22 program was used for the study variables for the purpose of clarifying the significance of the differences between the variable and its period, which indicated the results shown in Table 3, which estimated the value of F* for the variables work and the amount of capital (3.983, 66.66) in order, and a significantly for each of them (0.049, 0.0) respectively, who indicate the existence of statistically significant differences between their two quantities according to each period, ie by rejecting the null hypothesis and accepting the alternative hypothesis. On the other hand, the results of the value of F* for the two variables, the quantities of flour production and the quantities of raw wheat, showed that they were not significant in the analysis, and it was inferred that there were no statistically significant differences between their two quantities according to each period, that is, by accepting the null hypothesis and rejecting the alternative hypothesis.

Table 3 Anova for the variables, indicating the significance of the difference

Variables	Source of the difference	Sum of Squares	df	Mean Square	F	Sig.
Y	Between Groups	377151.44	1	377151.44	0.836	.363
	Within Groups	46944036.09	104	451384.96		
	Total	47321187.53	105			
L	Between Groups	35794249.14	1	35794249.14	3.983	.049
	Within Groups	934552407.7	104	8986080.843		
	Total	970346656.8	105			
K	Between Groups	43710622559	1	43710622559	66.66	.000
	Within Groups	68191226207	104	655684867.4		
	Total	111901848766	105			
W	Between Groups	274483.35	1	274483.35	0.421	.518
	Within Groups	67765997.02	104	651596.12		
	Total	68040480.38	105			

Source: Based on SPSS 22 results

Research Methodology

The formula for the double logarithmic function of the Cobb-Douglas function was chosen for this study as follows:

$\ln Y_i = B_0 + B_1 \ln L + B_2 \ln K + B_3 \ln W + (v_i - u_i)$ ……….. 4

The efficiency model under the production function included variables L, K, and W.

As well as the economic, social and qualitative variables Zs, it shows the inefficiency model shown below:

Vi = random variable uncontrolled errors, ui = random variable representing technical inefficiency and the formula for the equation is:

$Ui = \delta_0 + \Sigma\ \delta i\ Zi$ ……..**5**

Z_1: Actual production capacity tons/day. Z_2: Units of distance km for transporting raw grain from the silo. Z_3: Ownership status public sector 0, private sector 1. Z_4: Mill manager experience (years). Z_5: Education level (Intermediate 1, Secondary 2, Diploma 3, and Bachelor 4). As for the dependent variable Y, it represents the quantity of flour production. When estimating the model parameters for the Cobb-Douglas production function, the significance of the parameters t is tested, as well as the estimation of the variance of the parameters sigma squared σ^2 and the value of gamma $\gamma$and the LR test is conducted.

Results and discussion

The sample included a number of mills that differ in their capacities and productivity ton/day, according to the quantities of raw wheat determined for them by the management of the General Company for Grain Processing. The quantities of raw wheat were prepared based on the production capacities designed for the mills. When conducting a field survey of the study sample, it was found that there is a clear waste in production quantities ton/day for each mill, which represents the difference between what is actually produced and what is designed for the milling machine as shown in Table 4. This difference has a significant impact on the performance of these mills because it will require them to increase the number of working hours and may extend to an increase in working days, so that these mills can complete the quantities of raw wheat grinding specified for them. Among the most important reasons for the delay in the milling process, including the technical aspect (the milling machines are old, their need for periods of maintenance time, the long periods of electricity and water cuts supplied by the state), Or for administrative reasons related to the delay in prior planning in preparing the quantities of wheat actually required for each mill, which caused delays in milling wheat. It should also be noted that the company's management neglected the aspect that increasing the number of mills against fixed quantities of raw wheat has a negative impact on the performance of those mills.

Table 4 Amounts of wastage in production and their percentage for a sample of mills in 2019

Total quantities of design production capacities(tons/day)	Total quantities actually produced (tons/day)	quantities wastage (tons/day)	Rate wastage %
8455.76	**5842.94**	**2612.82**	**%30.89**

Source: Based on the data of the producers questionnaire

With regard to estimating the results of the production function by the method of the maximum likelihood of producing flour for the average of the two periods for the study sample. The results of Table **5** showed that the value of the constant discontinuous part B_0 by the method of maximum likelihood ML amounted to 0.207 and the parameter did not appear under any significant level and appeared with a positive sign, that is, the presence of quantities of production with the value of the parameter in the event that the explanatory variables were excluded. This means that there are excess quantities of flour previously stored, resulting from previous meals, and this is consistent with the actual reality indicated by the questionnaire form. As for the parameters of the explanatory variables of the double logarithmic function, they were represented by the values of its production elasticity's. The sign of the parameter L was identical with the logic of the economic theory with a positive effect of the variable on the produced quantity of flour in the study sample. By changing the variable L by 1%, the amount of flour will change by the value of its parameter in addition to that it had no significant effect on the model and it is located in the second stage of the stages output. As for the value of parameter K, its sign appeared negative and contrary to the logic of economic theory, in addition to that it included a morale level at 1%, and it is located in the third stage. It indicates the presence of waste in the amount of input K, and the technical and administrative reasons mentioned earlier. As for the parameter W, it was below a significant level 1%, and its high elasticity values indicate that it is in the first stage as a result of the sample mills not being equipped with sufficient quantities of raw wheat, Also, the interpretation of the variable W can include an increase in the number of mills against the fixed quantities of raw wheat, which confuses the mills from not reaching the maximum production capacities for milling the grains. As for the inefficiency model that included the variables (actual production capacity, unit distance of transporting raw grains from the source, ownership status, mill manager experience, educational level). The results showed that experience was the only variable that affected the model, and that producers with little experience had a significant impact on the inefficiency model at the 10% level. In addition, the logarithmic function of the maximum probability reached a value of

87.134, that is, the technical changes had a positive impact on the random variable, including an impact on the technical efficiency of the sample mills. The sigma squared σ^2 variance value, which reached 0.030, indicates that the inefficiency component of the estimated model is of little importance in the total change in flour production, and that its significance level σ^2 is 1%. As for the value of Gamma γ it reached 99.9% below the level of significance 1%, and its standard deviation was very low, and its value indicates that 99.9% of the inefficiency variances are caused by the factors controlled by the mills and that 0.1% belongs to Random factors out of control. The value of the LR test was about 28.7, which is higher than the tabular value of Chi square, which amounted to 10.501 at the level of significance 1%, so the null hypothesis is rejected and the alternative is accepted.

Table 5 the results of the flour production function by the maximum likelihood method for the study sample 2019

Variables X´s	Coeff.	Coeff. Value	Stan.error	t-ratio
Efficiency model				
Constant	B0	0.207	0. 131	1.582
Ln L_1	B1	0.030	0.027	1.108
Ln K_2	B2	-0.04	0.007	-5.470***
Ln W_3	B3	1.001	0.016	60.321***
Inefficiency model				
Constant	δ0	-0.098	0.166	-0.593
Z_1	δ1	0.00017	0.00030	0.574
Z_2	δ2	-0.000005	0.00027	-0.0037
Z_3	δ3	0.046	0.101	0.453
Z_4	δ4	0.0013	0.0015	0.846
Z_5	δ5	0.018	0.0098	1.842*
sigma squared (σ^2)		0.0308	0.0036	8.494***
Gamma (γ)		0.999	0.0000009	1042352***
LR test		28.7021		

Log likelihood function = 87. 13483

Source: Prepared by the researcher based on the results of the statistical program Frontier 4.1

*****: Significant with a significance level of 1%.**

***: Significant with a significance level of 10%**

Technical efficiency Levels

The results of the analysis showed that no mill obtained the full efficiency rating. Although the quantities of raw wheat increased in the second period by 7%, the results showed that there is a small difference between the levels of technical efficiency in the two periods shown in Figure 1.

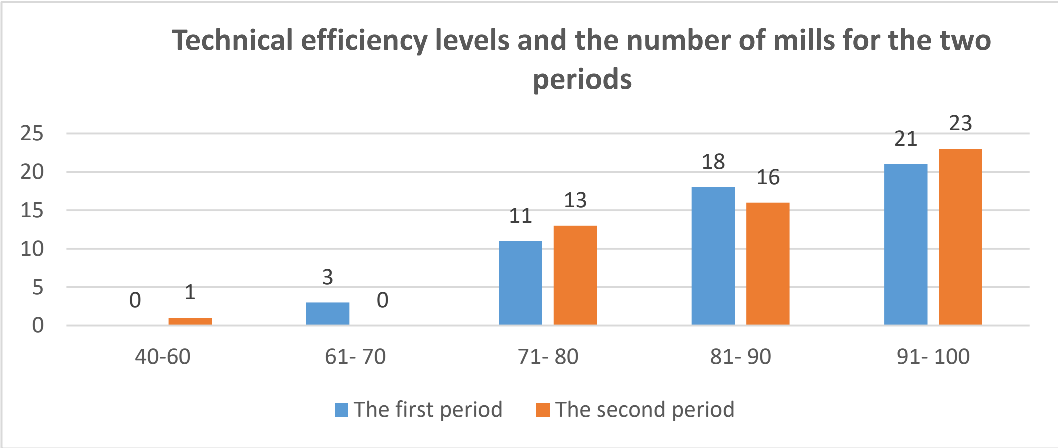

Figure 1 levels of technical efficiency and preparation of mills for the two periods of 2019
Source: Based on the results of the analysis according to Frontier 4.1

Which shows the superiority of the number of mills in the second period for the results of technical efficiency for levels 71-80 and 91-100. While the numbers of the rest of the mills decreased to other levels of efficiency, so the results indicate that there is a clear fluctuation in the results, as a number of mills headed towards the right track in achieving optimization of production. On the other hand, there are a number of mills that moved away from achieving optimization.

We conclude that Variable working hours did not show its parameter to any significant level of it. With regard to the variable amount of capital, its parameter came with a negative sign and with a significance of 1% and indicates the presence of waste in the quantity of the resource as a result of technical reasons, including the introduction of milling machines that caused the great waste in the quantities of the resource. As for the parameter of the variable raw wheat, the value of its parameter is greater than one, and it indicates a clear defect by the management of the General Company for Grain Manufacturing in taking the side of fixed quotas for the quantities of raw wheat instead of releasing them according to the actual production capacities of each mill, This gives us a clear perception that the General Company for Grain Manufacturing could have obtained the same required quantities of flour by optimizing the excess production capacities of the sample mills, without increasing the number of mills, which will negatively affect the performance of all mills in the governorate. In other words, if the mills that stopped working were included in the production process, the levels of technical efficiency of those mills would not improve in the second period. As for the study's recommendations, it revolves around the development of future plans about calculating the actual need of the mills for the quantities of wheat in each period. In addition, the old milling machines must be modernized to reduce the waste that occurs in the quantities of production inputs, which may contribute to raising the performance of those mills.

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Attachments

Table of the results of the flour production function by the maximum likelihood method for the study sample 2019

```
the final mle estimates are :

                  coefficient     standard-error    t-ratio

  beta 0          0.20772794E+00  0.13127579E+00  0.15823781E+01
  beta 1          0.30183237E-01  0.27229435E-01  0.11084783E+01
  beta 2         -0.40194943E-01  0.73473643E-02 -0.54706615E+01
  beta 3          0.10017575E+01  0.16606886E-01  0.60321813E+02
  delta 0        -0.98793354E-01  0.16642898E+00 -0.59360666E+00
  delta 1         0.17323038E-03  0.30149997E-03  0.57456183E+00
  delta 2        -0.10481199E-05  0.27765626E-03 -0.37748829E-02
  delta 3         0.46157078E-01  0.10180861E+00  0.45337105E+00
  delta 4         0.13295456E-02  0.15706466E-02  0.84649572E+00
  delta 5         0.18218589E-01  0.98853344E-02  0.18429917E+01
  sigma-squared   0.30680852E-01  0.36117157E-02  0.84948137E+01
  gamma           0.99999991E+00  0.95936869E-06  0.10423520E+07

log likelihood function =   0.87134831E+02

LR test of the one-sided error =   0.28702196E+02
with number of restrictions = 7
 [note that this statistic has a mixed chi-square distribution]

number of iterations =    100

(maximum number of iterations set at :   100)

number of cross-sections =    106

number of time periods =      2

total number of observations =    106

thus there are:    106  obsns not in the panel
```

Source: The results of the statistical program Frontier 4.1