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RESEARCH PAPER

# The Economic Assessment of The Production and Technical Efficiency of Bakeries (Focus on Social Factor Using Stochastic Frontier Analysis)

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**Abstract**
Determining the extent to which the bakeries of Gonabad, Iran have succeeded in the optimal use of certain resources and to explore the possibility of production increase with a certain set of production resources and factors, the technical efficiency of bakeries in this city was estimated. Data were collected from 98 bakeries in Gonabad using simple randomization in 2016. To accomplish research objectives, the stochastic frontier production function and technical inefficiency were simultaneously estimated by the Cabb-Douglas production function. The results showed that the average technical efficiency of the bakeries is 71.12% influenced positively and significantly by the variables of flour and labor. Also, bakers' age and experience had a negative relationship with their technical inefficiency, but their educational level had no significant effect. On the other hand, the difference between the minimum and maximum technical efficiency was calculated to be 72.75%. According to the results, experience is a requirement to enhance production and efficiency.
**Keywords**: Efficiency of Bakeries, Production Management, Stochastic Frontier Analysis, Social Factors, Gonabad.
**JEL Classification**: C15, D61, B41.

## Introduction

This list of personal and collective needs of people is growing at a tremendous pace. On the other hand, the resources for the production of commodities and services to satisfy individuals' requirements are limited. Therefore, there has always been a gap between supply and demand. This gap can be removed in three ways: physical development of resources and inputs (especially capital), consumption reduction, and productivity enhancement. The first is possible in two ways: obtaining international loans but this may have negative impacts and cause dependence, or attracting domestic capital but this can be done to a limited extent. Consumption reduction is, also, possible in two ways: controlling population growth or reducing per capita consumption in which the latter is practical and optimum to a certain extent, but it calls for a long-term plan. However, reducing per capita consumption will impair the economic welfare of the society and will entail its negative side effects. The first and second approaches are difficult solutions with low effectiveness; in contrast, the third approach, i.e. productivity enhancement, is effective, rapid, and decisive (Imami Meybodi, 2000: 95).

The 8$^{th}$ per capita consumption of wheat in Iran is 135 kg, a great part of which is used as

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bread. The average per capita global wheat consumption is 68.7 kg, so we are among the intensive wheat-consuming countries. As a food item, bread is of significance in various aspects. This food results from the hard work of a plethora of people, so it plays a key role in employment. Wheat production, transportation, and bread production bestow employment to workers of the agricultural sector, transportation, mills, flour storing, and finally bakers and people who work in the food industry. Irrespective of the role of bread in the employment of different economic sectors, its role in the supply of food requirements of people, especially low-income groups, should be emphasized. Bread is an important food source for these people. This food item is crucially important as a supplier of a part of calories, proteins, vitamins, and nutrients required by the human body. The average per capita consumption of bread is 320 $gd^{-1}$ in the optimal pattern of the household food basket in Iran. Bread consumption has increased in recent years for several reasons. Thus, given the limitation of the resources and facilities, it is imperative to adopt the easiest ways to satisfy people’s nutritional needs, especially low-income people. One approach is to make high-quality bread. This requires the knowledge of flour recognition, methods to prepare the dough and leave it to rise, baking systems, and solving the problems of the bakeries. A major reason for bread waste is the lack of adequate skill and knowledge among those who work in bakeries and, in general, the poor efficiency of bakeries. The lack of uniformity in flour quality caused by the mixing of wheat is one of the many factors that can be blamed for bread waste (Rademehr, 2015).

Furthermore, waste is caused by the lack of recruiting experienced bakers, the lack of observance of sound practices in dough preparation, the use of baking soda instead of leaven, inattention to the steps of fermentation, carelessness in baking, an imbalance between demand and supply, the form and thinness of the loaves of bread, and many other reasons. This is although the second-largest government subsidy is devoted to the flour and bread sector after energy carriers. The government of Iran directed a large part of subsidies (45,000 billion IRR) to flour and bread to support vulnerable people in 2009. Thus, one of the main objectives of this sector is to improve the efficiency of bakeries. The statistics of the Customs Office show that Iran imported 3,753,000 t hard wheat grains costing 1,299,000,000 US$ in March-September of 2015. This shows a 124.41 percent increase in weight and a 94.98 percent increase in cost as compared to the same period in 2014. One of the main uses of wheat and its flour is in bread making. The devotion of tremendous subsidy to bread, the presence of 50,000 bakeries, and the direct employment of 200,000 skilled and semi-skilled people in this sector are the evidence as to why it is necessary to study bread, especially the economic study of the final product and the need for its application in socio-economic development plans (Rademehr, 2015).

The present study seeks to discover the social factors underpinning the technical efficiency of bakeries and to answer the question as to whether social factors and attributes of bakers influence their efficiency. To this end, along with interviews, a questionnaire was administered to the statistical population in urban areas and the collected data were analyzed and summarized to find out the major factors influencing the efficiency of urban bakeries. In this regard, the main research questions are whether bakeries of the city of Gonabad, Iran have suitable technical efficiency, how much the efficiency of each bakery is, which bakeries are efficient, and which are inefficient, and what factors related to bakeries (socio-economic characteristics) influence their efficiency.

The governments of Iran have always given special attention to bread due to the high level of its consumption and people’s interests. So, the high economic, social, cultural, and political importance of bread calls for the adoption of a particular method to reduce its waste (Zargarani, 2011).

## Literature Review

Efficiency has been subject to extensive research in various fields. Some literature is reviewed below.

Naderi Kazak (2005) addressed the efficiency of usury-free banking in different countries (Bahrain, Jordan, Iran, Qatar, etc.) with the data envelopment analysis (DEA) method. He first compared the efficiency of usury-free banks and then, compared the efficiency of usury-free banks with usurious banks of the world. The results showed that the efficiency of usury-free banks in Bahrain and Qatar, and in general, the efficiency of usury-free banks that work along with usurious banks in a competitive environment is higher than the efficiency of the banks that work in the content of usury-free banking system (of Iran, Sudan, and Pakistan).

In a study on the efficiency of commercial banks using DEA in Iran, Babaei (2006) focused on the case of Melli Bank and measured the efficiency of 29 branches of this bank in 29 provinces of Iran in 2004. It was found that the increase in the number of branches allows enjoying the advantages of the economy of scale and also, the banking network can exploit the improved volume of saving accounts.

In a study on the factors influencing the technical efficiency of palm farmers with a case study on Dashteshtan County, Aghapour Sabaghi (2008) concluded that the average technical efficiency of palm farmers was 63 percent. The research showed that the local farmers' technical efficiency was positively influenced by educational level, palm orchard area, farming experience, and ownership, and it was negatively affected by the secondary job.

Sardar Shahraki et al. (2012) focused on the efficiency and return to scale of grapevine producers in the Sistan region with DEA and concluded that Zehak County had the highest return to scale of 71 percent, that the return to scale scores of Zabol, Zehak, and Hirmand counties were 1.35, 1.18 and 1.34, and that grapevine farmers use all inputs, except for waged labor, reasonably and economically.

Huq and Arshad (2010) worked on the technical efficiency of chili producers and concluded that educational level and age had a positive impact and farm size harmed technical efficiency.

Ghosh and Kathuria (2016) estimated the impact of governmental and state regulations on the efficiency of thermal power generation in India using the Translog production function and inefficiency impacts model. They obtained the average technical efficiency for 77 power plants at 76.7 percent with panel data for 1994-1995 and 2010-2011 periods. The results revealed that regulations at the state level influence the performance of power generation positively, but the central government regulations should be mostly for monitoring and the sharing of experience.

The review of the literature, both in Iran and in other parts of the world, indicates that a lot of studies by researchers and economists have been conducted on efficiency in different topics and on the crops that play a key role in the supply of foods for developing countries, but little attention has been paid to flour and bread sector. Given the highest importance of bread in the consumption pattern of Iranians, this strategic commodity has gradually found a special niche in the economy of Iran. Thus, the decisions on bread are usually accompanied by economic, social, and sometimes political conflicts. The present study aims to explore the possibility of improving the efficiency of bakeries in the city of Gonabad as a case study by better use of the available resources to help the policymakers. Thus, the objective of the research can be listed as below:

- Determining the technical efficiency score of bakeries in the city of Gonabad
- Determining the factors underpinning the technical inefficiency of bakers in the city of Gonabad
- Making recommendations to improve the efficiency of bakeries in the studied city.

## Methodology

The theoretical framework of efficiency is based on the optimization of producer behavior, or in other words, the theory of production in microeconomics. The concept of efficiency and the methods of its calculation can be looked upon from different perspectives of the theory of production. The optimization process of a manufacturing enterprise can be examined from two directions: one through following the profit, and the other based on the cost minimization process. Efficiency can be measured from both directions. In the theory of production, the optimal behavior of an enterprise is analyzed against a set of basic assumptions according to which the hypotheses on producer behavior are tested. The empirical evidence mostly shows that producers are not always thriving in solving their optimization problems and do not always exhibit perfect efficiency. In addition to this assumption, to be technically efficient does not guarantee the enjoyment of perfect efficiency in other aspects (Kumbhakar, 1993; Kumbhakar and Lovell, 2000).

## The Concept of Efficiency

The theory of concepts on efficiency was first posed by Farrell. He decomposed the economic efficiency into technical efficiency and allocative efficiency and used the notion of maximum or frontier production to measure them. The model that was first presented by Farrell was non-parametric because no specific form of production function was introduced. By Farrell's definition, the ability of a manufacturing unit to accomplish maximum production with a fixed set of available resources is called technical efficiency.

The status of absolute efficiency of the manufacturing units is not observable. So, to examine the efficiency, the efficiency of a manufacturing unit should be compared with that of another unit. Several methods have been presented to explore the efficiency of the manufacturing units in the recent half-century, but there are two main methods to estimate a manufacturing unit's efficiency, including parametric and non-parametric methods (Bailey et al., 1989; Bauer, 1990; Jensen and Vestergaard, 2003; Mazhari and Koopahi, 1999). Figure 1 depicts the methods to determine efficiency.

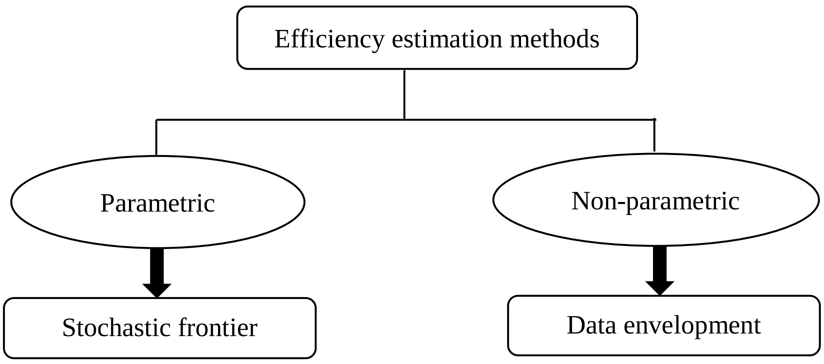


**Figure 1**. The Main Methods to Estimate Efficiency
**Source**: Bailey et al., 1989.

The parametric method to analyze stochastic production frontier function, as presented by Aigner and Chu (1968) and Meeusen et al. (1977), considers the intrinsic relationship between inputs and output and is used to estimate the function parameters by statistical techniques. The non-parametric method of data envelopment analysis, which was proposed by Farrell (1957), employs linear programming and does not consider any assumption on the intrinsic relationship between inputs and outputs. Efficiency estimation methods were developed by

Bjurek et al., 1990; Bauer, 1990; Greene, 1993; and Coelli, 1995 (Bravo and Evenson, 1994; Farrel, 1957; Greene, 1993).

Therefore, stochastic frontier analysis and data envelopment analysis are two distinct methods to acquire the isoquant curve of production and/or the required frontier functions for efficiency measurement (Imami Meybodi, 2000; 95). The present study uses stochastic frontier analysis, which is displayed in Figure 2.

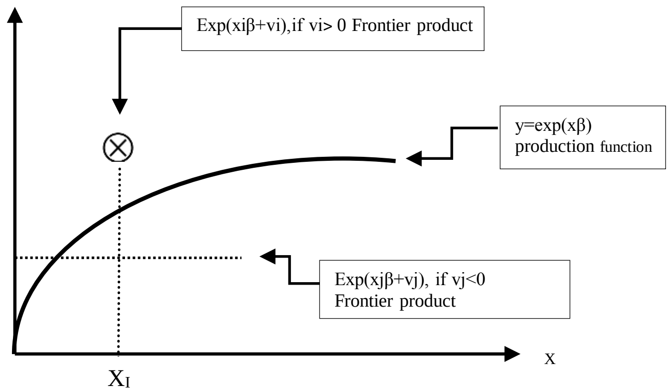


**Figure 2.** The Basis of the Stochastic Frontier Analysis
**Source**: Greene, 1993.

The known component of the frontier model $(y = \exp(x\beta))$ has been drawn assuming a diminishing return to scale. The *i*th enterprise uses input $x_i$ and produces output $y_i$ that is denoted by $\otimes$ the input-output value of the enterprise above $x_i$. The amount of stochastic frontier production of the *i*th enterprise, i.e. $y_i^* \equiv \exp(x_i\beta + v_i)$, is shown with $\otimes$ above the production function, which is $v_i$ due to the positive stochastic error term. Similarly, the *j*th enterprise uses inputs $x_j$ to produce output $y_j$. But, since the frontier output $y_j^* \equiv \exp(x_j\beta + v_j)$ of this enterprise is lower than the production function, this is due to the presence of the negative stochastic error component $v_j$. As a result, the known component of the stochastic frontier model is placed between the stochastic frontier outputs. The outputs observed from the stochastic frontier model will be greater than the known component of the stochastic frontier model when the stochastic error term is greater than the impacts of inefficiency (Basanta et al., 2003). That is:

$$y_i \rangle \exp(x_i\beta) \quad if \quad v_i \rangle u_i \tag{1}$$

The stochastic frontier analysis is a non-parametric method because a specific form of the frontier function should be considered to estimate the function parameters. The commonly used forms are Cobb-Douglas, Translog, and transcendental (Debertin, 1997: 243).

Aigner and Chu (1968) estimated the parametric stochastic frontier function in the form of Cobb-Douglas production function using an N-fold sample of the manufacturing units. The model is defined as below (Battese et al., 1997):

$$Ln(\mathrm{y}_t) = X_t\beta - U_t \quad , \quad i = 1, 2, 3, ...., N \tag{2}$$

The logarithm of the product is for the *i*th unit. $X_i$ is the row vector of the inputs used by the *i*th enterprise with the order $k+1$ so that the first element of the vector is 1 and the remaining elements of the logarithm of the data used by the *i*th enterprise:

$$\beta = (\beta_1, \beta_2, ..., \beta_k) \quad (3)$$

The column vector of the model parameters is the one that should be estimated. $U_i$ is a non-negative error variable that is related to the inefficiency of the production by a specific enterprise. This model which came to be known as the deterministic frontier model has a constraint, i.e. it cannot consider the possible effects of error or other error terms in estimating the stochastic frontier. So, it does not regard all deviations from the frontier as the consequence of inefficiency (Mousavi and Khalilan, 2005: 41). Meeusen and Broeck (1977) and Aigner and Chu (1968) used a stochastic frontier production function separately in that the model is obtained as below by adding stochastic error term $V_i$ in addition to non-negative random variable $U_i$ as obtained from Equation (1):

$$Ln(\mathrm{y}_t) = X_t \beta - U_t \quad , \quad i = 1, 2, 3, ...., N \quad (4)$$

$V_i$ describes the ordinary error term that describes the factors that are out of the producer's control, such as external desirable and undesirable events as well as error in statistical measurements and the unimportant variables excluded from the model. On the other hand, $U_i$ represents inefficiency (Imami Meybodi, 2005). Aigner and Chu (1968) assumed that $V_i$'s with stochastic, independent, and deterministic normal distribution with the average of 0 and fixed variance of $s_n^2 y$ independent of $U_i$ have stochastic distribution because the output values are limited from above by the random variable ($exp(X_{ib} + V_i)$). The random error term may be positive or negative. So, the values of the product obtained by the stochastic frontier differ from those obtained from the deterministic part ($exp(X_{ib})$) of the frontier model (Chukwuji et al., 2007).

In Figure 2, the known component of the frontier model ($Y = exp(X_{ib})$) is drawn assuming a diminishing return to scale. The $i^{th}$ enterprise uses input $X_i$ to yield output $Y_i$ which is shown with symbol $X$ the input-output value of the enterprise above $X_i$. The amount of the stochastic frontier product of the $i^{th}$ enterprise, i.e. $Y = exp(X_{ib} + V_i)$, is specified with $X$ above the production function which is due to the positive stochastic error term $V_i$. Similarly, the $j^{th}$ enterprise produces the product $X_j$ using the inputs $Y_j$. Of course, since the product $Y_j = exp(X_{ib} + V_i)$ of this enterprise is lower than the production function, this is placed on the stochastic frontier due to the presence of the stochastic error term. The products observed from the stochastic frontier model are greater than the impact of inefficiency, i.e. $Y_i \succ exp(X_{ib}) f_i V_i \succ u_i$ (Basanta et al., 2003; Chukwuji et al., 2007). In the stochastic frontier model, it is necessary to select the inefficiency impact distribution form ($U_i$) as is often used in empirical studies. The type of probability distribution of inefficiency components has been studied by many researchers who have presented very diverse forms among which the most famous are the generalized semi-normal distribution by Stevenson (1980) and the gamma distribution by Greene, 1993 (Ghosh and Kathuria, 2016). Presently, most empirical studies employ the generalized semi-normal distribution. This distribution is obtained by breaking the normal distribution in 0 with the average of μ and the variance of $\sigma^2$. If μ = 0, the distribution will be semi-normal. The generalized semi-normal distribution will be in different forms depending on the value and sign of μ. In the semi-normal stochastic frontier estimation, the parameter μ and the other parameters of the model are simultaneously estimated by the maximum likelihood method (Battese and Coelli, 1992; Greene, 1993).

## Technical Efficiency Estimation by the Stochastic Frontier Method

In this section, the technical efficiency model of the bakeries in the studied city was calculated by the stochastic frontier model as below:

$$\begin{aligned} Y_{it} &= f\,(x_{it}, a) + \varepsilon_{it} \\ \varepsilon_{it} &= V_{it} - u_{it} \\ V_{it} &= iid\left[N\,(m_{it}, \sigma_v^2)\right] \\ m_{it} &= m(z, \delta) = \delta_0 + \sum_{k=1}^{m} \delta kzk, it \end{aligned} \tag{5}$$

Normally, the parameters of a stochastic frontier production function are estimated by the Cobb-Douglas, transcendental and Translog functions. In most studies on efficiency assessment, the best fitting model is specified in the first place by econometric statistics out of certain function forms. To pick up the best production function, we first compare the Cobb-Douglas and transcendental functions. The Cobb-Douglas model is obtained by applying linear constraints on the transcendental model. The statistical tests to examine linear constraints include F-statistic and likelihood ratio. F-statistic that is a general method to test a hypothesis on one or more parameters of the K-variant regression model is calculated as below for the comparison of the Cobb-Douglas and transcendental functions:

$$F = \frac{(R_{ur}^2 - R^2)/m}{(1 - R_{ur}^2)/(n-k)} \tag{6}$$

in which $R_{ur}^2$ is a non-useful model coefficient, $R^2$ is a useful model coefficient, $m$ is the number of new independent variables, $n$ is the sample size, and $k$ is the total number of descriptive variables. These tests prove the superiority of the Cobb-Douglas function over the Translog and transcendental functions. The general form of the Cobb-Douglas function is expressed as below:

$$LnY = \beta_0 + \beta_1 LnX_1 + \beta_2 LnX_2 + \beta_3 LnX_3 + \beta_4 LnX_4 + \beta_5 LnX_5 + V_i \tag{7}$$

The technical efficiency and factors underpinning the technical inefficiency are concurrently estimated by using the abovementioned stochastic frontier production function.

## Research Variables

Considering the literature review, how bread is made, and the feasibility of data collection, five production factors were finally selected as the variables of the frontier model. The leaven and salt were excluded from the production function because they are used in small quantities and are usually added without measurement. The variables included in the model were production rate in number ($Y$), electricity use rate in kWh per day ($X_1$), gas use rate in m$^3$ per day ($X_2$), water use rate in m$^3$ per day ($X_3$), labor use rate in person-day ($X_4$), and flour use rate in kg ($X_5$). Also, the following factors underpinning technical inefficiency were used as the descriptive variables in the calculation of technical efficiency by the stochastic frontier method:

Baker's age ($Z_1$), baker's educational level ($Z_2$), baker's experience ($Z_3$), family size ($Z_4$), baker's main job ($Z_5$) (1 in case it is a bakery; otherwise, 0), bakery ownership type ($Z_6$) (1 if it is privately owned; 0 if it is rented), floor area in m$^3$ ($Z_7$), and apprenticeship duration ($Z_8$) (1 if the baker had been apprenticed; otherwise, 0).

## Data Collection and Analysis

The statistical population was composed of all bakers of Gonabad city in Khorasan-e Razavi province. Data were collected with a questionnaire. The sample was taken by simple randomization. Since the population size was definite, the sample size was determined by Cochran's formula as presented below

$$n = \frac{N.t^2.p.q}{N.d^2 + t^2.pq} \tag{8}$$

in which $n$ is the sample size, $N$ is the total number of a statistical population, $t^2$ is the t-student value when the significance level is smaller than 0.5, $d^2$ is the approximation in population estimation that is equal to 0.068, $p$ is the probability of the existence of the trait, and $q$ is the probability of the lack of the trait. In Equation (7), $p$ and $q$ were considered to be 0.5, and since the confidence coefficient is 95%, $t$ is equal to 1.96. Finally, $d$ represents the error that is 0.07 here. Data were collected in 2016 and they were used to measure efficiency. All data were analyzed in the Frontier$_{4.1}$ and Eview$_8$ software packages.

## Results and Discussion

When a bulk of quantitative data is collected for a study, they need to be organized and summarized to be comprehensible. So, all variables included in the frontier model, as well as the variables influencing inefficiency, were organized in this section to describe the general attributes of bread production. According to Table 1, the bakeries seek to use labor to the least possible amount. Also, the standard deviation of this variable indicates that the data have a narrow distribution and are close to average. The average, minimum, maximum, and standard deviation of production criterion and inputs are presented in Table 1.

**Table 1**. Average, Minimum, Maximum, and Standard Deviation of Production Criterion and Inputs

| Variables | Average | Minimum | Maximum | Standard deviation |
|---|---|---|---|---|
| Production (number) | 854.6154 | 300 | 3000 | 552.5283 |
| Electricity use (kWh per day) | 12.90924 | 5.767013 | 28.83506 | 5.132343 |
| Gas use (m$^3$ per day) | 54.18253 | 31.11111 | 111.1111 | 18.09709 |
| Water use (m$^3$ per day) | 1.275477 | 0.410256 | 4.102564 | 0.974985 |
| Flour (kg per day) | 258.4615 | 120 | 600 | 90.29644 |
| Labor (person-day) | 3 | 2 | 5 | 0.821781 |

**Source**: Research finding.

**Table 2**. Statistical Description of the Inefficiency Model Variables

| Variables | Average | Minimum | Maximum | Standard deviation |
|---|---|---|---|---|
| Baker's age | 46.37179 | 25 | 74 | 12.99861 |
| Educational level | 0.897436 | 0 | 3 | 0.920046 |
| Experience | 20.29487 | 5 | 34 | 7.812925 |
| Family size | 4.217949 | 2 | 7 | 1.191392 |
| Main job | 0.307692 | 0 | 1 | 0.464526 |
| Ownership type | 0.769231 | 0 | 1 | 0.424052 |
| Floor area | 102.34662 | 75 | 200 | 26.4368 |
| Apprenticeship duration | 0.897439 | 0 | 1 | 0.305352 |

**Source**: Research finding.

Table 3 shows the coefficients of the final model of the stochastic frontier production function, according to which three inputs of water ($X_3$), flour ($X_4$), and labor ($X_5$) have a positive and significant effect on production, among which flour has a larger role. But, the effect of gas ($X_2$) is negative on production. This means that bakers are in the third zone of production in terms of gas use and they should curb the use of gas to move towards their efficiency frontier and improve their efficiency. This may be related to the out-of-date technology that they use and impairs the optimal use of gas. The salient fact about the technology of bread production is that even after several decades of technology introduction, bread is mostly produced traditionally. In addition to people's preferences, bakeries cannot afford the capital equipment to convert the traditional system to an industrial system. The situation is aggravated when the shortcomings in the governmental supervision of bread production and pricing, as well as the ordinary profit rate specified by the government, are considered. According to the t-statistic in Table 1, it is evident that electricity ($X_2$) does not influence production significantly.

**Table 3**. Coefficients of Stochastic Frontier Production Function

| **Independent variables** | | **Parameter** | **Coefficient** | **Standard deviation** | **t-statistic** |
|---|---|---|---|---|---|
| **Constant coefficient** | | $\beta_0$ | 1.65 | 0.31 | $2.43^{**}$ |
| Electricity | $X_1$ | $\beta_1$ | 0.01 | 0.09 | 0.51 |
| Gas | $X_2$ | $\beta_2$ | -0.05 | 0.05 | $-1.21^{*}$ |
| Water | $X_3$ | $\beta_3$ | 0.03 | 0.02 | $1.31^{*}$ |
| Flour | $X_4$ | $\beta_4$ | 23 | 0.07 | $2.71^{***}$ |
| Labor | $X_5$ | $\beta_5$ | 15 | 0.08 | $2.63^{***}$ |

**Note**: ***: significance at $p < 0.01$; *: significance at $p < 0.10$.
**Source**: Research finding.

The results of estimating the model of technical inefficiency impacts are shown in Table 4. The factors influencing bakeries' inefficiency are the age and experience of the bakers. These two variables have a negative relationship with technical inefficiency given their negative coefficients. This means that the technical inefficiency of the bakers is alleviated as they age and they gain experience, increasing their technical inefficiency. The inefficiency model shows that the educational level does not influence bakers' technical efficiency. Other variables, also, have no significant effect on technical efficiency given t-statistic.

**Table 4**. Coefficients Estimated in Bakers' Inefficiency Model

| **Independent variables** | | **Parameter** | **Coefficient** | **Standard deviation** | **t-statistic** |
|---|---|---|---|---|---|
| **Constant coefficient** | | $\sigma_0$ | 0.74 | 0.37 | 2.04 |
| Age | $Z_1$ | $\sigma_1$ | -0.01 | 0.01 | $-1.38^{*}$ |
| Educational level | $Z_2$ | $\sigma_2$ | 0.17 | 0.1 | 0.12 |
| Experience | $Z_3$ | $\sigma_3$ | -0.02 | 0.02 | $-1.64^{**}$ |
| Family size | $Z_4$ | $\sigma_4$ | 0.08 | 0.14 | 0.56 |
| Main job | $Z_5$ | $\sigma_5$ | 0.16 | 0.15 | 0.05 |
| Ownership type | $Z_6$ | $\sigma_6$ | -0.16 | 0.15 | -0.06 |
| Floor area | $Z_7$ | $\sigma_7$ | 0.05 | 12 | 15 |
| Apprenticeship period | $Z_8$ | $\sigma_8$ | 0.06 | 14 | 0.009 |

**Note**: **: significance at $p < 0.05$; *: significance at $p < 0.10$.
**Source**: Research finding.

**Table 5.** Estimation of Production Function Parameters

| Variables | Coefficient | Standard deviation | t-statistic |
|---|---|---|---|
| Sigma-squared | 26 | 12 | 18.2* |
| Gamma | -37.42 | - | - |
| Log-likelihood | 9.39 | - | - |

**Note**: *: Significance at $p < 0.01$
**Source**: Research finding.

According to the results, the γ value is close to 1 (93%). In other words, the variation of wastes is partially caused by the inefficiency of *u*, and the contribution of the stochastic error, *v*, is very small. This finding is acceptable for the flour and wheat sector because the role of stochastic error in production function for developing countries that face uncertainty is very small. Therefore, as long as the error term is partially related to the factors controlled by the bakers, the maximum likelihood method is preferred to the ordinary least squares method and the technical efficiency has stochastic and observable distribution.

The results in Table 6 refute the null hypothesis, implying that there exist the impacts of inefficiency, and the maximum likelihood method is the best to estimate the efficiency of the bakers. According to the estimators of the maximum likelihood ratio, the null hypothesis is refuted and it is found that the studied variables influence the technical efficiency of the studied units. The results of the technical efficiency of bakers estimated by the stochastic frontier analysis are presented in Table 7.

**Table 6**. Results of Testing the Hypothesis on the Estimation of Technical Efficiency Models and the Underpinning Factors

| Null hypothesis | Likelihood ratio | Degrees of freedom | Critical value | Decision |
|---|---|---|---|---|
| $\gamma=\delta 0=\delta 1=\ldots.=\delta 8=0$ | 29.9 | 10 | 14.85 | Refuted |
| $\gamma = 0$ | 18.69 | 2 | 5.13 | Refuted |
| $\delta 0=\delta 1=\ldots.=\delta_8=0$ | 27.23 | 9 | 4.13 | Refuted |

**Note**: **: significance at $p < 0.05$ (the critical values of the generalized maximum likelihood test is at $p < 0.05$ level derived from Kedde and Palm (1986).)
**Source**: Research finding.

It can be seen in Table 7 that the technical efficiency of bakeries has an average of 71.12% and varies in the range of 19.28 and 95%. This difference can be substantially reduced by applying extension and managerial practices.

**Table 7**. Statistical Description of Technical Efficiency Scores Using the Stochastic Frontier Method

| Number of bakeries | Maximum | Minimum | Average | Standard deviation |
|---|---|---|---|---|
| 78 | 95% | 19.28% | 71.12% | 16.94 |

**Source**: Research finding.

According to Table 8, the efficiency of about 50% of the 78 bakeries is >60%. In the next rank, the efficiency of 15 bakeries is 50-60%. As is evident, only 5% of bakeries have efficiency in the range of 20-30%.

**Table 8**. Frequency Distribution of Technical Efficiency Scores of Bakeries

| Efficiency variation range | Number | Percent |
|---|---|---|
| <10% | 0 | 0 |
| 10-20% | 5 | 6.41 |
| 20-30% | 4 | 5.12 |
| 30-40% | 6 | 7.62 |
| 40-50% | 11 | 14.10 |
| 50-60% | 15 | 19.23 |
| >60% | 37 | 47.43 |
| Average efficiency 71.12% | Total: 78 | 100 |

**Source**: Research finding.

## Conclusions and Recommendations

The present study explored the efficiency of bakeries in urban areas of Gonabad in Khorasan-e Razavi province, Iran concerning social factors in 2016. Data were collected with a questionnaire and the sample was taken by simple randomization. The sample size was determined to be 78 using Cochran's formula. Data were analyzed by stochastic frontier analysis. In summary, the input of gas ($X_2$) harms production. This means that bakers are in the third zone of production in terms of gas use and they should reduce the use of gas to improve their production and move towards their efficiency frontier and, finally, enhance their efficiency. However, this may be related to the application of the traditional baking method and the use of worn-out equipment that wastes the gas.

Also, the model of inefficiency impacts indicates that the parameters of bakers' age and experience have a positive and significant effect on the efficiency of the bakeries. But, the impact of educational level, family size, baker's main job, bakery ownership type, floor area, and apprenticeship period is insignificant on bakers' efficiency in Gonabad. According to the results, the bakeries have varying efficiency, and all units are not operated efficiently. There is no significant relationship between bakers' educational level and their efficiency, but the relationship of age and experience with bakers' technical efficiency is positive. The results lead us to the following recommendations to improve the efficiency of the studied bakeries.

- The results show the positive effect of bakers' age and experience on technical efficiency. Thus, it is necessary to provide the conditions for the transfer of experience from experienced bakers to novices through educational classes that can be held by the grain companies.
- Given the low educational level of bakers, it is imperative to hold educational courses to improve bakers' awareness of the new baking methods and industrial bread baking methods. The training of people to improve their job skills, along with the modern and better production methods, can create new employment opportunities and can improve the nutritional value of the bread.
- The bakeries in the studied city have almost acceptable technical efficiency. But, this high efficiency does not necessarily reflect the optimal level of efficiency, but it only shows that the units use the production factors desirably at the existing technological level and has no implications for the appropriateness of technology. So, it is recommended to grant loans and facilities to push the change in bread baking technology.

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