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Research Article

Using qualitative response models in determining rainfall rates and their impact on wheat crop productivity in Iraq for 1995-2018

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Abstract: This work aimed to predict the wheat crop's productivity based on annual rainfall rates and analysis in the manner of a qualitative response model. The research sample included a time series from 1995 to 2018, including the production and productivity of wheat crops in addition to the rainfall rates in the rainy and semi-dimensional region and the reality in northern Iraq. Three models have been used for a qualitative response, the linear probabilistic, Lagat and Probet models. The best one was the linear probability model. The dependent variable is the level of rain per year and the explanatory variable is the yield of a dunum of wheat. For the level of rain in which the crop yield was more than 250kg/dunum, the value 1 was considered for it, and if the dunum yield was less than 250kg/dunum, value was zero. Based on the results, the level of the annual rainfall affected the productivity of the dunum of the wheat crop because the riparian region is greatly affected by it. An increase of 1mm of rain annually led to the possibility of increasing the productivity of wheat crops by 0.2%kg/dunum.

Keywords: Qualitative model, Wheat productivity, Rain.

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Introduction

Grain crops are the most important agricultural products through ages and civilizations i.e. human civilization was associated with the extent of human efficiency and ability to produce grain crops, especially wheat. Therefore, food has economic and political forces. Presently, Iraq is facing an important food challenge, one of the most prominent features of which is the scarcity of water and the failure of its food production to meet its needs of the main food commodities, foremost of which is cereals. Wheat is considered one of the most important main grains on which the Iraqi people depend for food, and the country tends to import most of its need, which poses a threat to its food security and, thus, national security.

There are many studies on wheat production and some variables' effect on the crop's productivity and its effects on it. The extent of the impact of rain on the level of productivity in the northern region, which is considered guaranteed or semi-guaranteed rain, can be expected through the available data by following the method of qualitative response models. It takes the dependent variable, which is a qualitative variable with values (0-1). Here, the dependent variable is the yield of a dunum of wheat, and the explanatory variable is the level of rainfall per year. The crop yield, which is more than 250kg/dunum, was taken as one, and the dunum yield less than 250 kg/dunum was taken as zero. The problem of national food security is one of the most urgent problems, especially the provision of the main crops, especially wheat, which is the basic food staple for the Iraqi people. Therefore, the variables affecting wheat

production in Iraq must be monitored and studied to develop important recommendations that the competent departments can practically use to reach sufficiency.

The annual rainfall rates significantly impact the wheat crop's productivity level, especially in the semi-damaged and rainy regions, and through its increase or decrease, and thus the possibility of predicting the quantity of wheat production and the country's needs for this crop. This work aimed to predict the wheat crop's productivity based on annual rainfall rates and analysis in the manner of a qualitative response model. The research methodology took two approaches (Jawad 2010): the Descriptive Analytical Approach and (Al-Hani 2023) the Standard approach through qualitative response models. The research sample consisted of a time series for 1995-2018, including production, productivity and annual rainfall rates.

Materials and Methods

By looking at Table 1, it becomes clear to us that there is a clear fluctuation in the rates of seasonal rain, which is sometimes negatively and sometimes positively reflected on the productivity of the wheat crop in the northern region of Iraq, especially the region that is guaranteed and semi-guaranteed by rain. The timing of rainfall during the agricultural season greatly impacts the yield, which explains the decline in production in some years despite the increase in the annual rainfall rates for the same years.

First: Productivity: It is the crop yield obtained by dividing production by the cultivated area. Measuring productivity is a natural part of the follow-up, evaluation and successful management process. The regulator must measure productivity to improve it. Productivity is divided into two types: (Al-Shahwani 2007), First partial productivity, that is the ratio of outputs to one of the elements of production. These measures are reflected in the change in production efficiency, as well as changes in the mixing of inputs from the production elements,

Table 1. Production, productivity and rainfall rates in northern Iraq for the period (1995-2018).

Year	Rain level (mg/year)	Productivity (kg/dunum)	Production (100 tons)
1995	296.2	191.4	10914
1996	328.7	206.5	11500
1997	360.7	172.2	9467
1998	221.5	255.1	14749
1999	165.1	185.1	11016
2000	354.4	241.5	10403
2001	574.2	425.4	22194
2002	681	392.6	25895
2003	629.5	340	23292
2004	401	297.5	18321
2005	601.7	347.6	22284
2006	951.1	377.6	22863
2007	535.7	350.8	22028
2008	415.4	342.7	21757
2009	604	336.7	17000
2010	474	495.8	27492
2011	543.9	429.3	28093
2012	651.3	442.9	30628
2013	887.4	566.6	41781
2014	698.2	592.8	50550
2015	489.8	637.9	26454
2016	608.7	625.7	30538
2017	667.08	573.18	35990
2018	670.2	599.236	37062

Source: Ministry of Planning and Development Cooperation, Central Agency for Statistics and Information Technology, Annual Statistical Collection, for several years.

and partial productivity expresses the relationship between outputs and one production element with the stability of other elements. The most important characteristic of the idea of partial productivity is simplicity and ease, but it is wrong with this criterion that average productivity measures the efficiency of one of the factors of production and this is not correct in many cases. Therefore, this criterion should consider the changes that occur in the rest of the factors of production. Thus, this criterion is misleading because it suggests the existence of a causal relationship between the product and the item to be measured (Al-Nuaimi 1997).

Secondly, the total productivity, reflects the total productivity, the efficiency of using the available economic resources (material and human), to obtain the largest possible amount of goods and services in

the same quantity or a lesser quantity of production elements. It is the best measure of the productive efficiency of the national economy. Economists prefer the total indicators of productivity over the partial indicators because the latter are affected by the difference in the intensity of the use of production factors. The greater the intensity of the production factor, the lower its productivity, according to the law of diminishing marginal productivity. Productivity was used to explain the determinants of economic advancement and developing countries began to search for ways to reach a high level of economic well-being, using a number of studies of total productivity, and using it as a tool to identify sources of growth as the most important factors of rapid growth (Mahboub 1998).

Second: production function: The term function is used in mathematics to denote the relationship between the explanatory (independent) variables and the dependent variable. It is the relationship between the quantity of production inputs and the quantity of output, or what happens to the output when the quantity of production factors used changes. Or it is a natural or technical relationship between production and one or more factors of production, assuming the stability of technical knowledge and experience. The production function is the relationship between the economic resources used in the production process and the production we get from this production process. Productivity growth can increase income and reduce poverty, productivity growth lowers production costs and increases investment returns. Some of which turn into income for the owners of projects and investors, and some into the returns of the owners of the factors of production.

Third: Qualitative Response Models: The development of the use of sham variables as explanatory variables, but the idea of an idea belongs to a limited hypothesis, and perhaps this is due to the many problems that arise when using these variables as dependent variables (Attia 2000). However, there are models available in which the dependent variable is qualitative in nature, and it cannot be measured quantitatively, due to which the hypotheses and requirements of the models are met. Therefore, they cannot describe and explain the relationship between the variables, the clarification, and the dependent variable in its nature. Therefore, the need to develop statistical methods that have the power of linear regression to reach to the best-fit equations and treat the time cases, the models of ordinary linear regression models in the case of the common variables (Jawad 2010). Its use is increasing in different areas of social sciences and medical research, but in the case of the model, the dependent variable is a quantitative variable (Attia 2000; Gujarati 2004). Our goal is to estimate the expected or average value of this variable conditioned by the values of the variables it slopes on, whether those variables are quantitative qualitative response regression models take a special case that deserves attention through their estimation and interpretation. In the case of qualitative response regression models, the dependent variable is qualitative, dual-label, limited to the answer with yes or no, and it takes the two values (1.0), such as dividing the labor force between males and females, and owning a house or not owning a house, etc. One of them takes the number (1) and the other takes the number (0), or it may take more than two values when there are three or more options. Three methods for probabilistic models of the qualitative response variable are (Attia 2000; Gujarati 2004): Linear Probabilistic Model (LPM), Lajet model and Propt model, and the probabilistic model (probability unit).

A: Linear Probabilistic Model (LPM):

$$Yi = B0 + B1Xi + Ui \quad (1)$$

Model (1) represents a qualitative linear regression model, where Y takes values (1, 0) and represents the occurrence of the event or not. Thus it is a bi-label qualitative variable since Y will fall to a given value of X, meaning that Y represents a conditional value of X.E(Yi/Xi). Assuming that the event rate is P, the non-occurrence rate is 1-P. This means the following: Event incidence P=1, Event does not occur 1-P=0,

So we get: E(Yi) = 0(1-p)+1 (p) (2)

Compared to model (1), we get: $E(Y_i/X_i)+B_1X_i$ (3)

Therefore, the conditional expectation of Model (1) can be interpreted as follows: the conditional probability of Yi. In general, the expectation for a Bernoulli random variable is the probability that the dependent variable is equal to (1) if there are N of independent options, the probability of P, i.e. the incidence of the event, equal to (0) for the non-occurrence of the event (1-P), and X will represent the binary distribution, The mean of the double-label distribution is NP, and its variance is NP(1-P). However, this model suffers from standard problems, the most important of which are (1), the Unnaturalness of Ui, heterogeneity of variance for Ui, the possibility of the estimated value of Yi to lie outside (1-0), and R^2 values are generally low. Because of these problems, the linear probabilistic model (LPM) was developed using the weighted least squares WLS method to eliminate the heterogeneity problem and by increasing the sample size to solve the problem of abnormality limit error.

B: Lagit model: To remove the problems faced by the probabilistic linear model, the Lagit model was developed, which has several advantages, which are: The expectation of the occurrence of the event P is between (1-0) and takes the normal distribution of Z, which lies between - ∞, + ∞., L is linear in X, the probability itself is non-linear, and this property varies with the linear probability model LPM and equation (Jawad 2010) where the probability increases linearly with X. We have a single inclusion of the explanatory variable X only, and the researcher can include several explanatory variables as dictated by the economic theory. If L is positive, it means that when the value of the explanatory variables increases, the incidence of the event for the dependent variable equal to 1 (that is, the occurrence of the desired event) increases. Conversely, if L is negative, the incidence of the desired event decreases. The assumption of the linear probabilistic model LPM is that P is linearly correlated with X, while the Lagit model assumes that the logarithm of the event rate is linearly correlated with X.

$$Li=\ln(Pi/(1-Pi) =B0+B1Xi+Ui \quad (4)$$

The model includes two types of data: data at the individual level. This type of data cannot be solved by the least squares method (OLS), but it can be solved by the greatest possibility (ML) method. The second type of data is at the aggregate level, which is the method of calculating the relative frequency, which is the ratio of n/N where n represents the partial sample of the event. As for N, it is the large sample of which n is a part. Thus, P=n/N and thus, we can get the dependent variable's data and apply the least squares OLS method, and the estimation of parameters, if X is distributed independently as a two-label variable from Ui, with mean equal to zero, and variance equal to 1/NP(1-P) (Gujarati 2002).

C: Propt model: In this model, the behavior of the two-label dependent variable is according to the appropriate cumulative distribution function, where the LAGT model uses the cumulative logistic function. This model is based on an unobserved utility index Ii that is determined by one or more explanatory variables and the formula is $I_i=B_0+B_1X_i$, where (I_i) is the utility index or utility index.

Results and Discussion

The three were estimated and in the linear probability model on the data of the average level of rainfall as an explanatory variable and productivity in its qualitative form 1 for the productivity of more than 250kg/dunum, and zero for the productivity of 250kg/dunum and less. Therefore, depending on the productivity of the wheat crop's dunum, the critical productivity of the dunum has been adopted, which is approximately 250kg/dunum. Less than this, productivity takes the number (0). More than 250kg/dunum takes the number 1. This productivity is based on the profitability of one dunum, as at this productivity, the average revenue of a dunum is equal to *(374) thousand Iraqi dinars, with the average variable costs per dunum using the available resources in the studied area. Table 2 shows the items of the average variable costs per acre.

Table 2. The average variable costs per acre.

Variable cost	seed	Fertilizer	mechanical work	manual labor	exterminator	Other costs	Average cost per acre
Value (thousand dinars)	57.8	69.6	91.4	63.1	58.8	32.7	373.4
Relative importance %	15.5	18.6	24.5	16.9	15.7	8.8	100

Source: Prepared by researchers based on the questionnaire.

The linear probabilistic model LPM was used to express the percentage change in the level of rain on the productivity of a dunum of wheat crop in Iraq for 1995-2018. From Table 1, we notice a decline in the yield of the dunum to levels less than 200kg/dunum, and the rainy area is significantly affecting production and productivity in general due to the impact of the level of rain. However, it is relatively low compared to the global productivity, which reached approximately 2tons/dunum. Therefore, we considered the productivity of a dunum of less than 250kg/dunum to be zero drought years, meaning it takes the value zero, while the other years take the value of one as a reliable variable. The result of the analysis was as follows:

$$Y=-0.192+0.04X$$

$$t= (-1.527)\ (5.430)$$

$$R^2= 0.61,\ F= 29.481,\ D.W= 1.741$$

The result of the analysis showed that the positive sign of the level of rain, which represents the (independent variable) and its size, was consistent with the economic theory, and it means that productivity increases by 0.4% whenever the level of rainfall increases by one unit (mg). Also, the value of it was greater than 2, which means that the independent variable's parameter is significant according to the rule of thumb (2). R2=0.61 shows 61% of the changes in productivity are due to changes in the level of rain. The F statistic confirms the significance of the model as a whole. D.W indicates that it is between 4-d_L and 4-d_U, which is the area of indecisiveness, and the researcher believes that the model does not suffer from the problem of autocorrelation (Mahboub 1998).

$$d_U<d<4-d_L$$

$$1.429<1.741<2.574$$

As a conclusion, the level of annual rainfall impacts the productivity of the dunum of the wheat crop, because the rainy area is greatly affected. An increase of one mm of the annual rainfall leds to the possibility of increasing the productivity of the wheat crop by 2%kg/dunum.

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