**Using a semi-parametric regression model to study the most important factors affecting the gross domestic product of oil prices for the period (1980-2020)**

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**ABSTRACT**

 In recent years, researchers' focus at semi-parametric regression models has increased, which is the effect of the integration between the parametric and non-parametric regression models. These models received a clear interest in most research and studies that take a more advanced and sophisticated nature in the process of accurate statistical analysis aimed at obtaining capabilities with a high level of efficiency.

 In this research, we deal with methods to address some problems, including the problem of autocorrelation between random errors, by relying on a semi-parametric partial regression model, which consists of two parts, a parametric part and semi-parametric one and merge the two parts in one of semi-parametric. This new regression contain strict constraints of the first and high flexibility of the later. Then we estimate the parameters of the parametric part using the general least squares method (SGLS) and the double residuals method (DR) , alsothe Generalize Difference Based Liu Method*)* GDBL) . As for the nonparametric regression model, we applied the core regression method using the Nadaray - Watson estimator and the Smoothing Spline method.

 The most important goal of this research is to create a semi-parametric regression model in which the methods used, both parametric and non-parametric, are applied, and make comparison to indicate the preference by relying on the Mean Squared Error (MSE) scale.

**Keywords: General linear Regression, Autocorrelation, Semi- Parametric, Partial linear Regression model, estimate methods**

**1 - introduction**

 **Scientific** progress in all fields and specializations in our current age requires that it be matched by a development in statistics, this science that adapts all its theories to serve other sciences, whether scientific or human and other sciences, because it depends on collecting data and information and then tabulating and analyzing it in order to reach results required

 **The topic** of semi-parametric partial linear regression models **(Partial Linear Regression Model)**  has gained great acceptance in the recent period due to the ability of these models to perform the process of merging parametric models with parametric models at the same time and creating a new model characterized by its ability to overcome the problem of dimensions (the Curse of Dimensionality) , This model also provided a larger environment for application than that which would be in the case of parametric models , This is because the parameter model may be affected by some independent variables that do not have a known parameter distribution, and in some cases it may not fully represent the function under study because some variables behave linearly and others behave non-linearly.

 **After** reviewing the types of models, we come to the importance of estimation, as estimation has great importance in practical applications, and the main objective of the estimation process is to reach the best estimator among all possible estimates, so the optimal method must be chosen to estimate the unknown parameter, as estimating the parameters of any regression model is Interpreting the relationship between the response variable and several explanatory variables in a mathematical form, and there are several different ways to estimate the parameters of the semi-parametric linear regression model and the diversity of these methods depends on the availability of a set of assumptions that it suffers from a problem or does not suffer from any problems of the model

 **In this research**, the estimation of the semi-parametric linear regression model is addressed in the presence of the autocorrelation problem of the first degree between random errors that violate one of the assumptions of the parametric regression model, and that the presence of this problem will have its repercussions on the capabilities and variances of the estimated parameters using the least squares (OLS) method. Therefore, we must first rule out the effect of this problem on the model, and then go towards estimating the parameters

**2 - Problem of Research**

 **In order** to estimate the semi-parametric linear regression model, which consists of a parametric component and a non-parametric component, it must have certain characteristics that depend on the assumptions related to the parametric and non-parametric components , And if these assumptions are not achieved, you will suffer several problems that make the estimation process wrong or sometimes not possible, and among these problems is the problem of autocorrelation between random errors, so we will address in this research to address this problem and then go Towards estimating milestones .

**3- the Objective of Research**

 **The research** aims to study some modern methods to address the problem of first-order autocorrelation in the parametric complex of the semi-parametric linear regression (SPR) model, as this problem is addressed using the semi-parametric general least squares method (SGLS), as well as the double residuals method (DR) , In addition to Liu's method based on general differences (GDBR) to estimate the parameter part, as well as the use of the Nadaraya-Watson method, as well as the use of the preliminary segments method (Smoothing Spline) to estimate the non-parametric part of the semi-parametric partial linear regression model , Perhaps the most important thing that the research focuses on is highlighting the comparison between the methods of dealing with the problem of autocorrelation of the first degree, as well as comparing the non-parametric precursors and showing the best parametric method with the best non-parametric method, depending on the mean squares error (MSE) scale.

**4 - The General Linear Regression Model**

 **The general** linear regression model is the most common in the analysis of most economic and social research and studies that require studying the relationship between the explanatory variables affecting the response variable **[9]** , especially with the availability of ready-made statistical programs, which made the possibility of providing the results of regression analysis easy and fast , When studying any phenomenon, the variables affecting that phenomenon must be determined and the relationship between those variables formulated in the form of a model, and that the linear relationship between several variables, one of which is the response variable and the rest are explanatory variables called multiple linear regression, which takes a linear mathematical form and its formula is as follows: **[18]**

Using matrices, the general linear model can be formulated in the form [2] .

Since :

 : A vector represents the observations of the response variable of the degree (n×1) .

 : Represents the matrix of observations of the explanatory variables of the degree) ).:

 : The vector represents the unknown parameters of the degree: .

 K : The number of explanatory variables .

n : The number of observations

 : It represents a random error vector of the degree).

 **The** **regression** model was built on a set of assumptions [4], including that the random error follows a normal distribution with mean (0) and a constant variance of (). When these assumptions are met, we get the best estimator for the model parameters using the Ordinary Least Squares (OLS) method and It is one of the best methods as its estimators have the property of Best Linear Unbiased Estimator (BLUE) [**9**].

Since:

 **It represents** the estimator of the ordinary least squares, and in the event that one of these assumptions is not achieved, it leads to the emergence of a problem in the accuracy of the estimation and therefore it is necessary to address the problem and to develop solutions and treatments that are suitable and suitable for it.

**5- Autocorrelation Problem**

 **The problem** of autocorrelation is one of the precise problems that can occur during the statistical analysis process for the data of the phenomenon studied, as it is commonly found in research and studies that take the form of time series data, as well as in studies that depend on cross section data **[9]**, The phenomenon of autocorrelation may arise as a result of excluding some independent variables in the studied relationship, or this phenomenon may also occur as a result of the wrong description of the nature of the functional form of the model or as a result of the researcher making some modifications to the data or resorting to estimating the values ​​of some observations based on the values ​​of other observations. **[5]**

**There are three types of autocorrelation: [18]**

**First - the First Order Autocorrelation**

 **This** type of autocorrelation occurs when the value of the random error is related to its previous value**.**

**Secondly -** **the Second Order Autocorrelation**

 **This** type occurs when the values ​​of random errors are related to the previous two values.

**Third - the Order Autocorrelation**

 **This** type also occurs when the values ​​of random errors are associated with more than two values.

 **In the** presence of this problem, we note that the estimations of (OLS) are linear and unbiased, as well as have an asymptotically normally distributed estimation, as well as their estimations remain consistent but inefficient , The reason for this is due to the variance obtained by the (OLS) method, which is greater than the value of the variance obtained from other estimation methods. At that, the (OLS) method loses the (BLUE) property and thus the results of the tests (T, F) are shaded and illogical, in addition In addition, the value of the coefficient of determination () becomes higher than its true value. **[9]**

**6 - Autocorrelation Problem Presence Test**

 **There are** several tests to detect the existence of a first-degree autocorrelation problem AT(1), and in this research the (Durbin - Watson) test will be addressed as follows: **[5]**

 **1- 6Durbin - Watson Test**

 **The** (Durbin - Watson) test is one of the most common and used measures and tests in the field of detecting the existence of a first-degree autocorrelation problem between random errors. This test is based on the following statistical hypothesis: **[11]**

The value of this test can be calculated by applying the following formula:

whereas :

It is assumed from this test that there are no missing observations in the data, as well as that random errors are assumed to follow a normal distribution.

**7-the Semi Parametric Regression Model[6] [14]**

 **The** semi-parametric regression (SPR) model consists of integrating the parametric regression models with the non-parametric regression models simultaneously , The specialists studied the possible treatments and made great efforts to develop methods that reduce the problem of dimensions in regression models that arise as a result of the increasing number of explanatory variables included in the analysis, which will lead to a decrease in the accuracy of the estimator , It indicates that semi-parametric regression models reduce the complexity of the dimensional problem through the use of partially parametric models [7] , And that semi-parametric regression models refer to the use of variables of discrete type and continuous type, that is, these models allow the analysis of a model where some of its variables are linear, i.e. take the linear form, and others are non-linear variables whose random distribution is unknown and go to the nonparametric [4] , Also, the semi-parametric regression model achieves the general characteristics of parametric and non-parametric regression and agrees with them in the same goal, which is to obtain the best data curve that matches or approaches the correspondence with the response variable (Y) curve by integrating between the parametric and non-parametric estimation methods [8] .

8 **- Partial Liner Regression Model [11]**

 **It is one** of the most important semi-parametric models, and it is sometimes called the Simple Semi parametric Model, and it was suggested by the researcher (Engle, G et al) and others **[8]** in 1986 AD and is symbolized by (PLM) and it is one of the regression models that It depends on linear and non-linear variables, and they are often continuous explanatory variables, and these linear and nonlinear variables influence the response **[17]**

The semi-parametric regression model can be represented by the following formula: **[8]**

Pointing

 : represents the vector of the dependent variable or the response variable of degree (nx1).

X : represents the matrix of explanatory (parametric) variables of degree (nxp).

 : vector of unknown parameters of degree (px1).

As represents the parameter part of the studied model

t : It is a continuous variable and usually represents the nonparametric variable in the data of degree (nx1).

: represents an introductory undefined function (t) of degree (nx1).

 : the vector of random errors of degree (nx1) that is independent and has a normal distribution with a mean of zero and a constant variance of.

**9 - model Estimation Methods (PLM )**

 In this model, the parametric part methods will be applied, and then the non-parametric methods will be applied, as follows:

**9-1- Estimation Method parametric partial :**

 There are many methods used in estimating regression models related to the parameter part, including:

9-1-1The Semi Parametric Generalized Square Method

 **The** (SGLS) method was proposed by the scientist (Speckman), and the mechanism for obtaining estimators is this method according to the following: **[13]**

If we have a partial linear regression model,

whereas :

As for the weight function to estimate the kernel function by the density function with the measurement parameter that modifies the size and shape of the weights close to (t), it can be defined as follows: **[8]**

whereas :

k: Kernel function

 : Bandwidth Parameter

After finding the weights, the transformed variables are found by relying on the above weights, and according to the following formula:

We assume that the covariance matrix () is known and that () is full-order since:

Then, the general least squares (GLS) method is used to estimate the parameter vector by relying on the following formula:

After the parametric part has been estimated, then the non-parametric part in the first part formula is estimated by applying the general formula in the semi-parametric regression functions as follows:

whereas :

 **:**  indicates the series of weights, and the weight function is normal

After the parameter and non-parametric part have been estimated, we get the estimated formula of the Partial Linear Regression Model (PLM) as follows: **[13]**

**9-1-2- Double Residual Method[12]**

 **This** method of estimators is sometimes called the double residual estimator, which is expressed according to the following formula: **[16]**

In the case of an autocorrelation problem, the above estimator will be according to the above formula: **[10]**

whereas :

 It is called the Feasible Generalized least square estimator.

**9-1-3 - Generalize Difference Based Liu Method [2]**

 **This** method was suggested by (Akdenizeet al), where the technique of general differences was employed, which is the (Liu) method, and the (GDBL) formula can be expressed according to the following equation: **[4]**

whereas :

*:* represents the estimation of the parameters vector (B) using the (GDBL) method.

 : represents the estimation of the parameters vector (B) using the (GDB) method.

d: represents the bias parameter, which is a positive quantity whose value is (0 ≤ d ≤ 1).

 **Also**, the value of this parameter reduces the mean square error (MSE), and thus the obtained estimations are the best estimations, and the value of Leo parameter (d) can be calculated by applying the following formula: **[1]**

whereas :

: represents the variance in the presence of the problem of autocorrelation.

Among the characteristics of the (GDBL) method:

First - Bias: It can be expressed according to the following formula:

whereas :

Second - the covariance matrix:

whereas :

Third - the matrix of mean squares error: **[1]**

**9-2- Nonparametric Function estimation [15]**

 **The** (N - W) method is one of the simplest types of pulp smoothing methods and the most common and widely used in research and studies related to nonparametric regression, This method is characterized by that it represents a definite and continuous function with positive values ​​and its integral equal to the integer one, and this estimator can be expressed according to the following formula: **[15]**

whereas :

*:*  represents the estimated marginal density function related to the explanatory variable (t )

*:*  Bandwidth > 0

By substituting equation (20) into equation (21), we will get the following formula for the estimator: **[17]**

**9-2-1-2 Smoothing Spline method**

This method (SS) was proposed by the scientist (Whittaker), and this method is considered one of the most common methods that replace the (Kernel) method in data homogenization **[15]**, The introductory slides method emerges as an estimate intended to match the data well, on the one hand, and also, on the other hand, it must be sufficiently smooth. **[12]**

The model for the nonparametric explanatory variables (t) and the response variable can be expressed according to the following equation:

Therefore, the smoothing slices (SS) estimator can be obtained by applying the following formula:

whereas :

PRSS: represents the sum of the squares of the partial remainders

 : represents the nonparametric smoothing function.

: presents the smoothing parameter and lies between

*:*  the degree of the derivative of the function

**10 - Mean Square Error**

 **The** mean square error criterion is one of the most commonly used criteria, which is used for the purpose of making a comparison between statistical models , And in this research, this criterion was used for the purpose of evaluating the performance of methods for estimation, and then knowing the best method that achieves the characteristics of a good estimator in the presence of the problem of autocorrelation , Therefore, this criterion, which represents the difference between the real and estimated value of each observation of the data, and this criterion can be expressed according to the following formula: **[3]**

**Applied Aspect**

**11- Description of Data**

The data related to the research was collected by the Iraqi Ministry of Planning - the Central Bureau of Statistics - Department of National Accounts, Which are the most important factors affecting the gross domestic product (GDB) of Iraq at constant prices for the period (1980-2020) on a basis measured in million, as well as government spending (GE) and money supply (M1) measured in million dinars, as well as the price of a barrel of oil (oil price) measured in dollars The data can be clarified according to the following table :

Table (1) shows the real data related to the gross domestic product at constant prices and the factors affecting it for the period (1980-2020)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **M1** | **GE** | **GDP** | **Oli price** | **Year** |
| *423.4* | *525.3* | *6918.1* | *14.53* | *1980* |
| *562.2* | *822.8* | *8035* | *13.95* | *1981* |
| *635.8* | *843* | *9047.4* | *12.54* | *1982* |
| *854.8* | *1157.1* | *10589.8* | *13.48* | *1983* |
| *864.2* | *1074.4* | *12631.5* | *14.54* | *1984* |
| *1245.1* | *1384.1* | *10890.9* | *11.2* | *1985* |
| *1575.8* | *1646.3* | *12631.5* | *20.2* | *1986* |
| *2650.2* | *2451.2* | *15267.6* | *27.10* | *1987* |
| *3645.5* | *3446.2* | *19046.9* | *35.6* | *1988* |
| *4980.7* | *4468.2* | *18908.1* | *34* | *1989* |
| *5527.4* | *5475.3* | *19557.4* | *30.7* | *1990* |
| *5499.9* | *4989.1* | *17000.5* | *29.4* | *1991* |
| *5777* | *4431.8* | *16758.1* | *27.1* | *1992* |
| *6736.6* | *5252.6* | *16991.5* | *13.7* | *1993* |
| *8316.7* | *4989.1* | *17781.3* | *17.4* | *1994* |
| *9848* | *4431.8* | *19432.2* | *17.2* | *1995* |
| *5547.4* | *5252.6* | *19435.2* | *13.8* | *1996* |
| *11767.4* | *5673.8* | *18826.2* | *16.56* | *1997* |
| *351876* | *6260* | *31442.1* | *14.53* | *1998* |
| *1483836* | *5880.1* | *41771.1* | *11.6* | *1999* |
| *1728006* | *30206.3* | *42358.6* | *30.10* | *2000* |
| *2159089* | *5944657* | *43335.1* | *35.4* | *2001* |
| *2159089* | *6488987* | *40344.9* | *29.4* | *2002* |
| *30136601* | *7919968* | *26990.4* | *45.4* | *2003* |
| *6577360* | *7919968* | *41607.8* | *68.8* | *2004* |
| *5773601* | *3631595* | *4343.8* | *65.7* | *2005* |
| *10148625* | *136088947* | *47851.4* | *60.7* | *2006* |
| *11399125* | *14683390* | *48510.6* | *66.36* | *2007* |
| *15460060* | *14984454* | *51716.6* | *87.94* | *2008* |
| *21721167* | *20871484* | *54720.4* | *59.4* | *2009* |
| *28189934* | *26139166* | *48510.6* | *105.05* | *2010* |
| *3730030* | *27517760* | *51716.6* | *106.01* | *2011* |
| *51743489* | *35495631* | *54720.8* | *102.26* | *2012* |
| *62473929* | *4275484* | *57925.9* | *91.64* | *2013* |
| *63735871* | *42158634* | *63650.4* | *91.64* | *2014* |
| *63735850* | *4285482* | *71680.8* | *68.33* | *2015* |
| *8568081* | *42158634* | *76922* | *60.64* | *2016* |
| *73840828* | *5427451* | *77789.7* | *62.55* | *2017* |
| *72692448* | *6475472* | *77789* | *66.98* | *2018* |
| *83674491* | *4794695* | *10945.3* | *78.45* | *2019* |
| *82637281* | *54847800* | *88674.9* | *62.65* | *2020* |

**12- Describe of the Semi parametric Model**

The characterization stage is one of the most important stages of preparing the econometric model, through which the relationship between the explanatory variables and the response variable included in the model is determined according to the data of the economic theory, For the purpose of clarifying the impact of the role of money supply, government spending and the price of a barrel, these variables are described as follows:

**12-1- Variable of the Parametric part**

The money supply: It is a parameter explanatory variable that represents the first explanatory variable and is linked with the gross domestic product by a linear relationship..

Second - Government spending: It is a parameter variable that also represents the second explanatory variable and is linked with the gross domestic product by a linear relationship.

**12-2 - Variable of the non-Parametric part**

The price of a barrel of oil is a variable that produces a non-parametric function and is associated with GDP with a non-linear relationship.

\*\* Response variable: Cross Domestic Product at fixed prices represents the studied phenomenon variable, which is measured in million, and through the correlation of the response variable with the explanatory variables mentioned, through this link, a semi-parametric regression model is produced, as follows:

**13 – Test for Autocorrelation Problem Presence**

In this research, the Durban Watson test was used to detect the existence of a first-order autocorrelation problem, as follows:

**13- 1 – Durbin – Watson Test**

For the purpose of testing the statistical hypothesis that there is no autocorrelation between random errors, we write the following statistical hypothesis**:**

A test was conducted to detect the presence of the problem by using the analysis program (Eviews10), and the results were shown in the following table:

**Table (2) shows the Durban Watson test to detect the presence of the autocorrelation problem**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Prob**  | **t- Statistic** | **St - Error** | **Coefficient** | **Variable** |
| *0.0000* | *14.99748* | *1197.371* | *17987.84* | C |
| *0.0001* | *4.34368-* | *0.000468* | *0.00151-* |  |
| *0.0000* | *8.380183* | *0.00495* | *0.002910* | GE |

|  |  |
| --- | --- |
| *0.90851* | R – square  |
| *0.89964* | Adjustes R – square  |
| *6247.951* | S.E of Regression  |
| *184.7342* | F – Statistic  |
| *0.0000* | Prob (F – Statistic ) |
| *0.7673* | Durbin –Watson Stat  |

The results of the statistical analysis related to the (D - W) test showed that the value of the coefficient of this test reached (0.7673) at a limit of the upper and lower values (1.52, 1.32), respectively, at a sample size (n = 40) and the number of explanatory variables (k = 2) and at the level of Significant (0.025), which we note that the value of (D - W) is less than the upper and lower values, so our decision will be reject (), and this means that there is a direct positive autocorrelation between random errors.

**14 – Estimation of the Semi parametric Regression Model**

 According to the method followed in the theoretical aspect, the estimation of the parameters of the parametric part is first addressed, and then the non- parametric part is estimated based on the first part as shown in the table below:

**Table (3) shows the estimations of the parameters of the parameter part in the (p L M) model:**

|  |  |  |  |
| --- | --- | --- | --- |
| **GDBL** | **DR** | **SGLS** | **Coefficients** |
| *0.1639513* | *0.001667413* |  *1.9570785-* |  |
| *0.9547705-* | *0.77630787* | *0.7833983-* |  |
| *1.5457892* | *0.893720601* | *1.4701142* |  |

The results of the statistical analysis of Table (3) above revealed that the first explanatory variable represented in the money supply has a negative impact on the gross domestic product, Also, this increase in demand will lead to an increase in the volume of imports due to the weak response of the production sectors, so the nature of the impact came in line with the economic theory.

The results of the above table also showed that the second explanatory variable represented in government spending, as it showed that this investment of this variable on the health and education sector will have a positive impact on the gross domestic product, and that this relationship was consistent and compatible with the economic theory, because investment in this field is one of the The most important sectors of investment in human capital.

**Table (4) shows the estimations of the parameters of the non-parameter part in the (P L M) model:**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ***GDBL*****S .S** | ***GDBL*****N . W** | ***D R*****S . S** | ***D R*****N . W** | **SGLS****S . S** | **SGLS****N . W** | **Coefficients****Estimator** |
| *8.36353-* | *0.16294-* | *0.00119-* | *0.017-* | *1.53013* | *1.96805* |  |
| *3.52195-* | *0.11233* | *0.34474* | *0.30514* | *2.13594* | *2.24466* |  |
| *2.70390-* | *0.04672-* | *0.08727* | *0.12084* | *2.13560* | *2.08454* |  |

After the process of estimating the teacher part has been completed, the role comes to show the best method of estimation between the two models of the parameter and the non- parameter regression by relying on the mean squares error (MSE) criterion.

**Table (5) shows the mean squared error (MSE) for the (PLM) regression models:**

|  |  |
| --- | --- |
| Parametric Method  | Non- Parametric Method  |
| GDBL | DR | SGLS |
| *1 0.0093695* | *0.0158137* | *0.0097576* | N – W |
| *0.00647284* | *0.03426431* | *0.0115872* | S S |

The results of the above table (5) revealed that the best method in the regression model (PLM) was with (GDBL) method as estimating the parametric part with (SS) method as estimating the non- parametric part, because it obtained at least (MSE) , also followed by (SGLS) method as the second best method when Estimating the parametric component with the (SS) method as estimating the non- parametric part**.**

**15-Examine the Data After Applying the Best model on her**

In order to verify the data processing after applying the best model to it, we return to the use of (Durbin - Watson Test) and this is done by using the (eviews10) program, the following results were obtained :

 **Table (6) shows the Durban Watson test after data processing**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Prob**  | **t- Statistic** | **St - Error** | **Coefficient** | **Variable** |
| *0.0000* | *6.424464* | *0.012145* | *0.068544* | C |
| *0.0058* | *3.013448-* | *0.548748* | *1.434051-* |  |
| *0.0000* | *6.047114* | *0.306648* | *1.861368* |  |

|  |  |
| --- | --- |
| *0.594968* | R – square  |
| *0.576214* | Adjustes R – square  |
| *0.078354* | S.E of Regression  |
| *48.64418* | F – Statistic  |
| *0.0000* | Prob (F – Statistic ) |
| *2.4423* | Durbin –Watson Stat  |

The results of the analysis in Table (6) above showed that the value of the Durbin - Watson Test) amounted to (2.4423) and this value lies within the limits (4-du=2.47, du=1.53), which is an indication that there is no problem of autocorrelation between errors. Randomness and therefore no shading in the results of the analysis.

**16- Conclusions**

The results of the analysis revealed that the best estimation method was when using the (GDBL) method as an estimation of the parameter part with (S S) method as estimating the non- parameter part, because it obtained a least (MSE) , also The results of the analysis revealed that the second best estimation method was when using the (SGLS) method as an estimation of the parameter part, with a method with (S S) method as estimating the non-parameter part, in order to obtain a least (MSE).

The results of the analysis showed that the worst estimation method was when using the (DR) method as an estimate of the parameter part, with a method with the method (S S) as an estimate of the non- parameter part, because it obtained the largest (MSE), also The results of the analysis, by relying on Table (3), showed that the explanatory variables (, GE) have clear and high effects on the response variable represented by the gross domestic product at the level of significance (5%).

It is clear from the results of the analysis that the nature of the relationship that governs the parameter explanatory variables with the response variable (GDP) is a linear relationship, while with the parameter variable represented (in the price of a barrel of oil) with the response variable (GDP) is a non-linear relationship.

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