USING SOME NONPARAMETRIC ESTIMATORS OF THE ERROR CORRECTION MODEL TO MEASURE THE EFFECT OF CHANGES IN BANK DEPOSITS ON THE MONEY SUPPLY

Mayson Abid Hussien & Dr .Munaf Yousif Hmood
Maysoon.Abdulhusseinl1201a@coadec.uobaghdad.edu.iq
munaf.yousif@coadec.uobaghdad.edu.iq
University of Baghdad – College of Administration and Economics – Department Statistics

Abstract

In this paper, the effect of changes in bank deposits on the money supply in Iraq was studied by estimating the error correction model (ECM) for monthly time series data for the period (2010-2015) . The Philips Perron was used to test the stationarity and also we used Engle and Granger to test the cointegration . we used cubic spline and local polynomial estimator to estimate regression function .The result show that local polynomial was better than cubic spline with the first level of cointegration.

Keywords: Cubic Spline, , Engle and Granger. Cointegration , Phlilips Perron, Local polynomial, ECM.

1-Introduction

Econometrics aim to find the mathematical models and formulas that express the relationship between the studied economic variables, and the aim is to build the model of these phenomena, and formulate problems according to equations or inequalities that represent the quantitative relationship of the various factors and circumstances surrounding the problem that requires obtaining statistical data about it over time, which are often in the form of time series.

One of the modern statistical methods that are interested in studying the relationship between variables in the long-run, even if these variables move away from their equilibrium values in the short- run, is the method of analyzing the regression of cointegration, if the differences between the values of the variables allow the time series to back stationary, but they lose all information associated with the behavior of these variables in the long- run.

Granger's contributions led to the clarification of the concept of cointegration between two or more variables which is the existence of a long-run equilibrium between these two variables and became used, especially in cases where long-run relationships affect the present value of the variable under study. Most economic data are described as nonstationary time series, which makes the regression relationship between its variables suffer from falling into the problem of spurious regression and the results are incorrect and cannot be relied upon, So to overcome this problem, the method of cointegration is used, by focusing on the behavior of residuals of this model by finding a long-run equilibrium relationship between two or more variables .

Sometimes the parametric methods do not give us a good results clear investment decisions and for the short and long- run, due to assume a linear relationship between the variables and do not take account the nonlinear behavior between the variables [17] .There for we can resort to Nonparametric methods toget an accurate results.

There are many papers that studied the both methods with the cointegration (Dursun .A , Memmedaga .M and Rabia Ece Omay)[2] (2013) In this paper, the smoothing parameter selection problem has been examined in respect to a smoothing spline implementation in predicting nonparametric regression models.(Dennis Nchor & Vaclav Adamec) [20] (2016) studied the demand for money in Ghana for the period (1990-2014) and this study used the model of cointegration and the model of error correction (Hammoud, Manaf Youssef and Burhan, Yaqeen Khalil) [14] (2018) estimated the transfer function using local linear regression and Cubic Spline and compared these methods with proposed semiparametric based on single indicator model . The results showed that the proposed method was the best. (Doan Van Dinh)[4](2020)the study investigates the impact of inflation rate on economic growth to find the best-fit model for economic growth in Vietnam. The study applied Vector Autoregressive (VAR), cointegration models, and unit root test for the time-series data from 1996 to 2018. (Maharani. M ,Saputro.Dewi)[17] (2021) A study was conducted on the smoothing spline nonparametric regression model on GCV. The results showed that with the GCV method the minimum GCV value was obtained which would determine how well the smoothing parameters shown by the estimator did not change significantly even though the number and position of the knots varied.

The main objective of this paper is to study the relationship between bank deposits and money supply using two nonparametric estimation methods to estimate Error Correction Model through cointegration regression .

2-Cointegration

The method of cointegration is a modern econometric method that is used to determine the equilibrium relationship between variables in the long -run, which requires that the variables subject to this test be nonstationary in their level, but have the same degree of stationary that is become stationary after taking the first or second differences.

Cointegration is defined as the synchronization between two or more series so that the fluctuations in one of them to eliminate the fluctuations in the other series in a way that makes the total ratio between their values constant over time, and there are several tests to test the unit root in the time series, such as [21] Phillips–Perron test (1988).That is based on correcting the autocorrelation in the residuals of the unit root test equation using the method of nonparametric of model variation, in order to take into account the existence of autocorrelation.

Methodology - Engle and Granger 3

According to this methodology, the cointegration test is based on the algorithm proposed by Engle and Granger (1987), which is based on two stages[5] method.

First stage : The most important condition for integration is that both series are cointegration of the same degree, if they are not cointegrated with the same degree, this means the property of cointegration is not achieved. And it’s necessary to determine the type of general trend for each variable and also the degree of integration (d).

Second stage: Estimating the long-run relationship:

To test the null hypothesis that both Y_t and $X_t$do not have cointegration within the framework of the Engel and Granger model (EG) through the hypothesis that the error (residuals) is integrated in the first level;. The steps of conducting the cointegration test [23] are as follows.

A- Estimated the long-run relationship between the two variables according to the following formulas for cointegration.

$$Y_t = \alpha + f(X_t) + u_t \qquad \dots (1)$$

Then estimation residuals according to the following formula:

$$\hat{u}_t = \hat{e}_t = Y_t - \hat{\alpha} - \hat{f}(X_t) \qquad \dots (2)$$

To accept the cointegration relationship, the residuals series e_t must be stationary and the test of stationary is done by the Philips-Perron or Dickey-Fuller test.

-Test the stationary of the residuals from equation (2) by using the statistic .

We determine the calculated value (τ) and compare with the tabulated value of tables specially prepared by both Engle and Granger so:

$$\tau^*_\alpha = \frac{\hat{\alpha}}{S_{\hat{\alpha}}} \qquad \dots (3)$$

Then compare this statistic with the tabulated value from Engle and Granger table. Also Mackinnon (1991) simulated tables that depend on the number of observations and the number of independent variables that appear in the stationary relationship. If the calculated value is greater than the tabulated value, the null hypothesis is rejected, and then the residual series is stationary and the data of the two series are characterized by the property of cointegration, and then estimate the Error correction model (ECM).

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4-Error Correction Model (ECM)

Economic variables characterized by cointegration in the long- run tend towards stationary or the so-called equilibrium mode, and because of temporarily changes in the situation of variables deviates from its course, and for this reason the error correction model is used in order to match between the long-run and short -run behaviors of economic relations

The error correction model expresses an adjustment pathway that allows changes resulting from the short- run to be brought into the long-run relationship [7] and therefore this model was called the error correction model, as this model enables us to correct the error by examining and analyzing the behavior of variables in the short- run in order to reach a balance in the long –run.

Based on Granger's theory, the dynamic model of integrated series can be converted into an error correction model, which is a better way than partial modification models to study the response of the dependent variable as it contains short and long-run information where the lack of short-run equilibrium is inferred through the adjustment process to long-run equilibrium (Engle and Granger, (1987), and then consistent estimates can be obtained for both the short and long - run.

According to the Engel–Granger method for estimating the Error Correction Model (ECM), The estimators of the long-run relationship residual series are introduced as an independent variable with lags equal one. Estimating the error correction model requires the following[25]:

1-Check the stationary level of model variables, and determine the rank of integration of each variable separately by unit root test.

2- Ensure that there is a balanced relationship between the variables of the model, and this is done through the Cointegration test between these variables The relationship between the dependent variable and the independent variable can be formulated as follows [7]

$$Y_t = \alpha + \beta X_t + e_t \quad \dots \quad (4)$$

where ((Y_t) and (X_t) are first-order integrated time series I(1).

To clarify the error correction model, the following steps are followed- :

1- Estimating the relationship between (X_t) and (Y_t) in the long- term as follows

$$\hat{Y}_t = \hat{\alpha} + \hat{\beta} X_t \quad \dots \quad (5)$$

Estimate the dynamic relationship in the short and long- run as follows.

$$\Delta Y_t = \alpha_1 \Delta X_t - \alpha_2 e_{t-1} + \mu_t \quad \dots \quad (6)$$

$$\Delta \hat{Y}_t = \hat{\alpha}_1 \Delta X_t - \hat{\alpha}_2 (Y_{t-1} - \hat{\alpha} - \hat{\beta} X_{t-1}) + \hat{\mu}_t \quad \dots \quad (7)$$

Where:

(Δ): represent the first difference .

$\hat{\alpha}_1$: represents the short-run parameter..

$\hat{\beta}$: expresse the response of the variable Y_t according to the variable X_t in the long - run

$\hat{\alpha}_2$ speed of adaptation for long-run equilibrium or Speed of Adjust facter.

Therfore when estimating this equation, the residual series is regarded as independent variable with lag for one year and the model is modified to the following:

$$\Delta Y_t = \alpha_0 + \sum_{i=1}^{p} \rho_i \Delta Y_{t-i} + \sum_{i=0}^{q} \alpha_i \Delta X_{t-i} - \alpha_2 (Y_{t-1} - \alpha - \beta X_{t-1}) + \mu_t \quad \dots \quad (8)$$

$$\Delta Y_t = \alpha_0 + \sum_{i=1}^{p} \rho_i \Delta Y_{t-i} + \sum_{i=0}^{q} \alpha_i \Delta X_{t-i} - \alpha_2 ECT_{t-1} + \mu_t \quad \dots (9)$$

5-Cubic Smoothing Spline

The smoothing spline method is one of the commonly used methods as one of the smoothing methods, and this method depends on the sum of the squares of the residuals (RSS) as a criterion for the goodness of fit [14] of function f(.) to the data.

$$\sum_{t=1}^{n} [Y_t - f(X_t)]^2 + \lambda \int \left[\ddot{f}(X)\right]^2 dx \quad \dots \quad (10)$$

The first part of the above equation refers to the sum of the squares of the residual RSS. The second part refers to roughness penalty.

λ: Denote to the penalty parameter and its value is greater than zero . This parameter plays a key role in controlling the trade-off between the goodness of fit and smoothness of the estimate..

The necessary condition for the function $f(X_t)$ is that it be differentiable twice with the possibility of obtaining the integration of the square of its second derivative. In the smoothing spline method, the number of nodes is equal to the number of observation of the studied time series, i.e.(Knot = n). Green & Silverman (1994) has proposed the method of Roughness penalty, which is a method for calculating the Roughness penalty part, as follows: If we have(n) time series observations such as ($X_1, X_2 \ldots\ldots X_n$) represented by the time period $[a, b]$ The function (f) refers to the cubic spline if the following two conditions are met:

1- The function (f) is a cubic polynomial cubic spline in Period$(a, X_1), (X_1, X_2) \ldots (X_n, b)$
A piecewise polynomial is suitable at the point X_t for the first and second derivatives of the function (f) and continuous at points X_t that is, (f) is continuous in the interval $[a, b]$.
The idea of a smoothing spline it is to place a node on each data point, so it probably fits perfectly with the number of observations, but its parameters estimate is by reducing the sum of squares plus the. Roughness penalty and then find smoothing parameter that reduces (penalized residual sum of squares) [14] plus the (Roughness penalty).
The smoothing parameter plays an important role in controlling the trade-off between the goodness of fit, which is measured by the (Generalized Cross Validation) (GCV) follows:

$$CV(\lambda) = \frac{\mathbf{1} \sum_{t=1}^{n} \{\mathbf{Y_t} - \hat{\mathbf{f}}_\lambda(\mathbf{X_t})\}^2}{\mathbf{n}\left\{\mathbf{1} - \frac{1}{n}\mathbf{Trace}(\mathbf{S}_\lambda)\right\}^2} = \frac{\frac{1}{n}\|(\mathbf{1} - \mathbf{S}_\lambda)\mathbf{Y}\|^2}{\left[\frac{1}{n}\mathbf{Trace}(\mathbf{1} - \mathbf{S}_\lambda)\right]^2} \quad \ldots (11)$$

6-Local Polynomial estimator

local Polynomial estimator is one of the important methods in estimating the nonparametric regression curve, and the polynomial degree, bandwidth and kernel function type play an important role in determining the amount of smooth in the estimated curve, especially in nonlinear data.

The basic idea of this method is to estimate f(x) locally by estimating $(p + 1)$ from the parameters at point (x) as a neighborhood in the form$(x - h, x + h)$ where (h) is the bandwidth or the smoothing parameter which determines the width of the neighborhood around (x) and we will only use the observations (Y_t) that fall Data points(X_t) within the previous period in estimating the function f(x) and, If we assume that the function f(x) has derivatives of the rank $(p + 1)$ at the point (x) and the points (X_t) lie in the neighborhood of the point x, then the estimate of the function f(x) using a local polynomial of degree (p) is to find the solution:
$\beta = (\beta_0, \beta_1, \ldots\ldots \beta_p)^T$ by using the weighted neighborhood
Using the weighted Least Square method by minimizing the following criteria [3] :

$$Q = \sum_{t=1}^{n} \left[Y_t - \sum_{j=0}^{p} \beta_j (X_t - x)^j\right]^2 \quad K\left[\frac{X_t - x}{h}\right] \quad \ldots \quad (12)$$

Where:
K : denote to the Kernel function.
Equation No.(16) can be written using matrices as follows:

$$Q = (Y - X\beta)^T W(Y - X\beta) \quad \ldots \quad (13)$$

Where X is a matrix of degree n * (p+1) called the design matrix defines as follows:

$$X = \begin{bmatrix} 1 & (X_1 - x) \ldots.. & (X_1 - x)^p \\ 1 & (X_2 - x) \ldots.. & (X_2 - x)^p \\ & \vdots & \\ 1 & (X_n - x) \ldots.. & (X_n - x)^p \end{bmatrix}$$

W: diagonal matrix of degree n*n is written as follows:

$$W = \operatorname{diag}\left\{K\left(\frac{X_t - x}{h}\right)\right\} = \begin{bmatrix} K\left(\frac{X_n - x}{h}\right) & & 0 \\ & \ddots & \\ 0 & & K\left(\frac{X_n - x}{h}\right) \end{bmatrix}_{nxn}$$

$Y = (y_1, y_2, \ldots \ldots .. y_n)^T$

Using the partial differential with respect to β, we get

$\hat{\beta} = (X^T W X)^{-1} X^T WY$

and the estimator for the regression function is

$\hat{f}(x) = \hat{\beta}_0 = e_1^T (X^T W X)^{-1} X^T WY$ ... (14)

Where: e_t : is a vertical vector that has the same dimension as the vector β and is called the unit vector of the degree$((p + 1) * 1)$ with the first element equal to (1) and the rest of the elements are equal to zero.

7-Application

To determine the effect of changes in bank deposits on the money supply, we analyzed data by processing time series data using Matlab and Eviews12. The data were obtained from a monthly database of the Central Bank of Iraq for the time period (2010-2015) and the relationship between the two variables of the study was studied using the Engel- Garnger methodology, which requires knowing the degree of integration of time series using the unit root test by (Philips-Perron). Before conducting cointegration tests and presenting the results, the tests of stationarity must be conducted for time series to find out the degree of stationarity, as one of the conditions for applying the Engel-Granger methodology is that the degree of stationarity of time series is of the first degree I(1), so it must be ensured that the stationarity of the series of variables, whether if they are of degree I(0) or I(1).

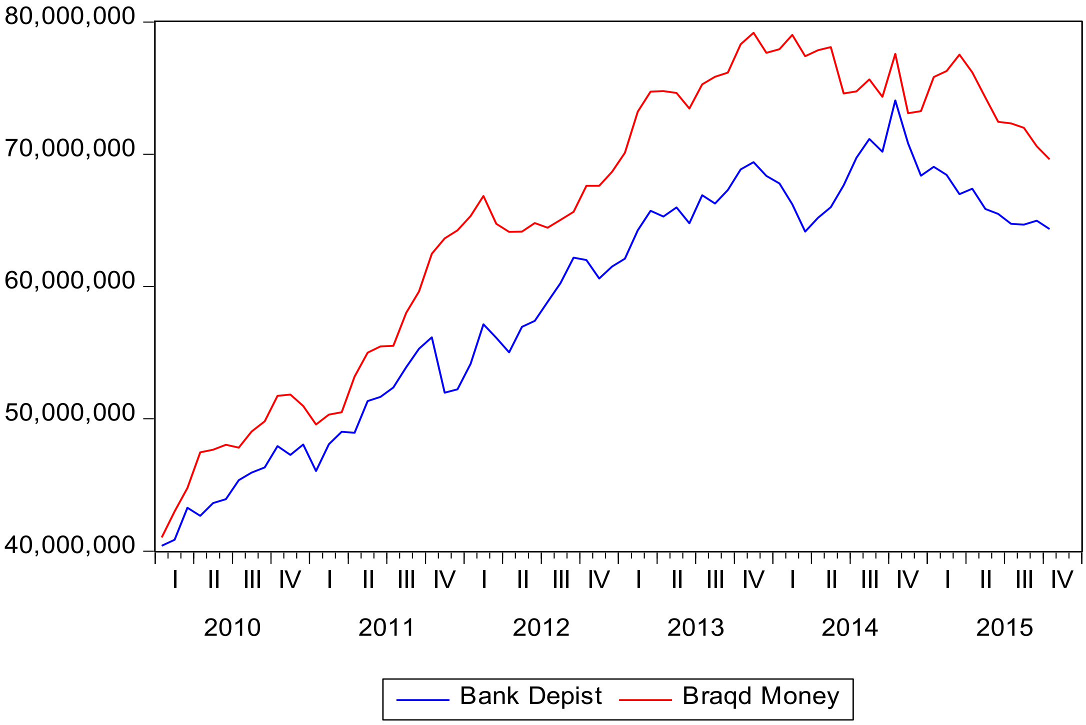

Figure **(1):** Behavior of Money supply(Y) and Deposit Banks(X) Separately

Through the figure(1) that denote to the behavior of the two time series separately. We notice their both series are nonstationary at level zero I(0) ,and to confirm this matter, We conduct the unit root test by philips perron for the level zero and one i.e I(0) and I(1) and the result of the test are demonstrate in table(1).

Table 1: Philips-Perron test for the unit root under 5% of the money supply variable

variable	Trend and Intercept		Intercept		None	
Money supply	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
Statistic	-0.161926	-8.162404	-2.781339	-7.361504	1.491313	-7.049863
P-value	0.9927	0.0000	0.0662	0.0000	0.9654	0.0000
Decision	nonstationary	Stationary	nonstationary	Stationary	nonstationary	Stationary

We noted from the results of table no. (1) that the series of the money supply variable is nonstationary in I(0), which indicates the existence of the unit root for this variable and when taking the first difference, it is clear from the test that the money supply variable become stationary and in the same way the series of bank deposit variable is tested and Table No. (2) shows the test at I(0) and I(1).

Table 2: Philips-Perron test results for the unit root under 5% for the bank deposit variable

variable	Trend and Intercept		Intercept		None	
bank deposit	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
statistic	-0.726531	-9.014974	-2.234954	-8.344357	1.589896	-7.971769
P-value	0.9668	0.0000	0.1961	0.0000	0.9717	0.0000
decision	nonstationary	stationary	nonstationary	stationary	nonstationary	stationary

When observing the results of the two previous tables, we find that the parameters are integrated of the first order I(1), which allows the cointegration test with the Engel-Granger methodology between the series to ensure a long-run equilibrium relationship between the money supply and bank deposits,by using Cubic Smoothing Spline and the Local Polynomial Estimators.and the residual series that resulting from three methods .The stationarity of the series is tested using philips perron again, So that the residuals series are stationary at level zero,I(0) under the following hypothesis:

H_0 : Error has a unit root H_1 : The error does not have a unit root

Table (3) Philips- perron test for the residuals series with cubic spline and local polynomial methods

Cubic Spline Smoother			Local Polynomail Estimator		
Phillips-Perron test statistic		-3.526886	Phillips-Perron test statistic		-3.257591
Significance level	1%	-2.598907	Significance level	1%	-2.598907
	5%	-1.945596		5%	-1.945596
	10%	-1.6137196		10%	-1.613719
P-value	0.0006		P-value	0.0015	

We note that the value of the test statistic (t) is (-3.526886) for the residuals series of the cubic spline and the value of the test statistic (t) is (-3.257591) for the residual series of local polynomial estimator, and both are greater than their tabulated values at all levels, and therefore the null hypothesis that the residual series contains the unit root is rejected, and the alternative hypothesis is accepted, which means that the series of errors does not have the unit root, So that it is stationary at zero level I(0) this means that the variables are integrated from the first order I (1) In other words, there is cointegration time series variables, i.e. a long-run relationship between variables. Based on this, we can estimate the error correction model according to the Engel -Granger methodology. Which involves the possibility of testing and estimating the long-run relationship of the model variables.

The error correction model can be used to determine the direction of this relationship in the long and short- run, where the error correction (ECT) or speed of adjustment refers to the amount of change in the dependent variable as a result of the deviation of the independent variable in the short- run from its equilibrium value in the long -run by one unit and this coefficient is expected to be negative, because it indicates the rate at which the short-run relationship is heading towards the long-run relationship.

The Coefficients indicate the direction of the relationship in the short -run, and the following table shows the results of estimating the ECM error correction model according to the Engel-Granger methodology.

The optimal number of lags is determined by using the (AIC) criterion ,where the lowest AIC value is selected that corresponds to the optimal lag.

Table (4): Estimation of ECM error correction model according to Engel-Granger

Dependent Variable: D(Y) / Error Correction Model					
Cubic Spline	**Variable**	**Coefficient**	**Std. Error**	**t-Statistic**	**P-value**
	C	251679.0	153873.2	1.635626	0.1067
	D(X)	0.500249	0.102325	4.888838	0.0000
	U(t-1)	-0.240303	0.072705	-3.305197	0.0015
	R-squared	0.330980	Mean dependent var.		414170.4
	Adjusted R-squared	0.310707	Sum squared residual		1.02E+14
	F-statistic	16.32590	Akaike info. criterion		30.94782
	Prob(F-statistic)	0.000002	Durbin-Watson stat		1.394426
Local Polynomial	**Variable**	**Coefficient**	**Std. Error**	**t-Statistic**	**P-value**
	C	262531.5	153198.6	1.713668	0.0913
	D(X)	0.493544	0.101710	4.852475	0.0000
	U(t-1)	-0.219701	0.064361	-3.413552	0.0011
	R-squared	0.337253	Mean dependent var.		414170.4
	Adjusted R-squared	0.317169	Sum squared residual		1.01 E+14
	F-statistic	16.79273	Akaike info criterion		30.93840
	Prob(F-statistic)	0.000001	Durbin-Watson stat		1.420556

methodology

From of the results of the error correction model in Table (4), we notice that ,For the cubic smoothing spline, the error correction coefficient (ECT) was negative and significant P-value=0.0015, and is equal to (-0.240303), that is, the speed of adaptation of the imbalance in the short-run to the long-term equilibrium is approximately 24% per month , in other words, the ECT error correction term also indicates to 24% of the error in the relationship of money supply with the variable of bank deposits is corrected during the same time period month, which indicates that correcting the error takes approximately four months $\left(\frac{1}{-0.240303} = -4.16141228829\right)$ .The money supply returns to its equilibrium level in the long- run

after a shock in the bank deposit variable assuming that other factors remain the same.
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The coefficients of the model, show the effect of variables in the short-run.as the following:

-The presence of a positive and significant effect of bank deposits on the short-run on money supply. Where the increase in available bank deposits by one unit leads to an increase in the money supply by (0.500249).

- The R^2 is equal to (0.330980), meaning that approximately 33% of the changes in the Braod money. It is explained by the variable of bank deposits in the model and the remaining percentage. 67%, is due to errors or other variables not included in the model

- The Durbin Watson (DW) statistic is (1.394426), that is mean the model does not suffer from the problem of Autocorrelation between the residuals.

For the method of local polynomial estimator, we note that the ECT error correction coefficient was negative and significant p-value=0.0011, and is equal to (-0.219701) i.e. the speed of adaptation of the imbalance in the short- run to the balance in the long- run is approximately 22% per month, in other words, the ECT error correction term also indicates to 22% of the error in the relationship of money supply with the variable of bank deposits is corrected during (one month), and this indicates that correcting the error takes approximately four and a half months. $\left(\frac{1}{-0.219701} = -4.5516406388\right)$ So that the money supply returns to its equilibrium level in the long term after a shock in the bank deposit variable assuming that other factors remain the same. Looking at the coefficients of the model, which show the effect of variables in the short -run, the following:

− The presence of a positive and significant effect of bank deposits on the money supply in the short–run where the increase in available bank deposits by one unit leads to an increase in the money supply by (0.493544).

− R^2 is equal to (0.337253), which means that approximately 34% of the changes in the money supply is explained by the variable of bank deposits in the model and the remaining 66% is due to errors or other variables not included in the model

-the Durban Watson (DW) statistic (1.420556), it is clear that the model does not suffer from the problem of Autocorrelation between the residuals.

Now to ensure the stationary and quality of the ECM error correction model used and test if there are no their problems, we performed the following tests:

- Breusch-Godfrey Serial Correlation LM Test
- White Test Heteroskedasticity
- Jarque-Bera Normality Tests

Table (5) shows the results of these tests for both estimators that used

Table 5: tests results for cubic spline and local polynomial estimators

Tests	LM Tests	White Test	Jarque-Bera
Cubic Spline Smoother	**F=6.161923**	**F=1.961376**	**χ^2=2.467059**
p-value	**0.0036**	**0.0967**	**0.291263**

Local Polynomial Estimator	**F=6.431485**	**F=2.512058**	**χ^2 =1.781015**
p-value	**0.0028**	**0.0388**	**0.410447**

It is noted from the table that the calculated LM- value for both methods was lower than 5%, and therefore the null hypothesis was rejected, in the sense that the model suffers from the problem of autocorrelation between the residuals. Whether the results of the white test shows that rejection of the problem of heterogeneity for the Cubic spline because the p- value is greater than 5%, .As for the method of Local polynomial estimator, the null hypothesis is accepted because the p-value was less than 5%, i.e. the model suffers from the problem of heterogeneity of variance.

For the test of normality, the results proved that the residuals of the ECM error correction model are distributed normally, and this is confirmed by the Jarque-Bera statistics. That is, we could not reject the null hypothesis that the residual series follows the normal distribution.

.Table (6) Comparison of the results of the two methods

Method	**Cubic Spline Smoother**	**Local Polynomial Estimator**
MSE	7.17E+12	5.44E+12
MAPE	0.030658	0.028134
ECT	-0.240303	-0.219701
Pvalue(ECT)	0.0015	0.0011
Adjustment speed ratio	24%	22%
R^2	0.330980	0.337253
Adjustment time period	4 months	4.5 months

8 –Conclusions

The most important findings of the study can be summarized as follows:

1-The unit root test showed that the model variables (money supply and bank deposits) are nonstationary in zero level I(0(but stationary after the first differences, i.e. they are integrated from the first order I(1).

2-The cointegration test of Engel-Granger showed a ciontegration relationship between the money supply and bank deposits, which makes these variables take a similar behavior in the long- run, i.e. the existence of a long-run equilibrium relationship between these variables.

3- The existence of a statistically significant positive relationship between both the money supply and bank deposits for both methods.

4- The results of estimating the equation of the error correction model of the short-run for money supply function using the "Engel-Granger" methodology showed that the bank deposit variable explains 33% of the changes in the money supply by cubic spline smoother method and 34% by the local polynomial estimator method.

5- In general, the Local polynomial estimator method showed better results than the cubic spline smoother method.

9- Reviewer

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