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# Nonstationary Time Series Models Using ARDL and NARDL Estimation

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**Abstract:**

The paper features an examination of the link between the behavior of the Money supply and Bank deposit in both an autoregressive distributed lag ARDL, plus a nonlinear autoregressive distributed lag NARDL framework. The regression relationship between any two nonstationary time series suffer from the problem of superior regression and the results may be incorrect and unreliable, and to overcome this problem the aim of this paper was find a balanced relationship in the long - run between the variables of Money supply and Bank deposits using the method of cointegration by focusing on the behavior of the residuals of the cointegration model based on monthly data for a time series for the period (2010-2015). The time series stationary test was done by conducting the Unit Root Test based on the Philips-Perron test to find out the stationary of the variables and then detect the existence of the cointegration using the bounds testing, the tests showed the nonstationary of the time series at level I(0) and their become stationary after taking the first differences I(1). Bounds test showed the existence of cointegration .The Error correction model for the ARDL model was the best, despite the convergence of most of the test results for the two models, but the ARDL model was the more accurate with the speed of adjustment in the short -run to return to long-run equilibrium, as it reached (37%) and a period of two months for the ARDL model, while the percentage for the NARDL model was equal to (28%) and a period of time of approximately three and a half months.

**Paper type**: *Research paper*

**Keywords:** ARDL, NARDL, Co-integration, Philips-Perron, Bounds Test, Money Supply.

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**1.Introduction:**

The money supply is one of the most important tools of the monetary policy for any country because it is an active ingredient in achieving stability and economic growth as aim pursued by economic policy. In general, all economies of the world seek to achieve their aims, and one of these aims is to increase the volume of bank deposits continuously, using many monetary policy tools, especially money supply changes.

Monetary policy is generally affected by domestic or external shocks and this is reflected in the achievement of economic aims and because of that, central banks make changes in their monetary policy to adjust and direct their tools in order to influence the economy through a mechanism that works to transfer the impact of the volume of bank deposits to the final aims to affect the size of the money supply. Most developed countries are characterized by high economic growth rates, unlike developing countries, which are characterized by low growth rates.

The variable of bank deposits is one of the explanatory variables in the economic growth function. For the purpose of studying the short and long-run relationship between the variables of bank deposits and money supply, this paper applies the regression model of co-integration, but the tests (Angel and Granger-Johansen) for co-integration require that the variables under study be integrated of the same rank, As a result of these two problems, Autoregressive distributed lag model (ARDL) and Nonlinear autoregressive distributed lag model (NARDL) have become commonly used in recent years and introduced by (Pesran et al, 2001). Integrating auto-regression models with autoregressive distributed lag model in one model, and in this methodology the time series is a function in lags its values and evaluating explanatory variables and lags them by one period. And then determine the most appropriate methodology for the data in the light of the results of the co-integration tests between the two variables of the study.

**1-1 literature review:**

Chang et al. (2001) developed asymptotic theory for a general class of nonlinear non-stationary regressions, extending earlier work by (Phillips and Hansen, 1990) on linear co-integrating regressions. The model considered accommodates a linear time trend and stationary regressors, as well as multiple I(1) regressors. Shaheen et al. (2011) studied utilized the autoregressive-distributed lag (ARDL) approach for cointegration and Granger causality test, to explore the long run equilibrium relationship and the possible direction of causality between international trade, financial development and economic growth for the Pakistan. Abdul Latif and Al-Juboury (2012) studied a comparison between the methods of estimating the regression of co-integration, where four methods were selected. Saidu (2015) Studied the relationship between corporate taxes and foreign direct investment in Nigeria for the period (1970-1980). Emeka and Aham (2016) showed that the adoption of the ARDL cointegration technique does not require pretests for unit roots unlike other techniques .Consequently, ARDL cointegration technique is preferable when dealing with variables that are integrated of different order, Irina and Dmitry (2017) studied the nature of the relationship between oil prices, employment and the total level of real wages in the Russian economy during the period (1990-2016) using the model of (VECM) Lanouar and Karim(2020) explored the disproportionate short- and long-run impact of oil price shocks and changes in oil and gas revenues on Qatar's economic performance and economic diversification. Faisal, G. (2022) studied analyze the impact of monetary policy on bank credit in Iraq. He depended on the application of standard methods by applying a nonlinear autoregressive distributed lag (NARDL), based on monthly data for a time series for the period (2005 - 2021).

## 2. Study Methodology:

### 2.1 Analysis Methodology:

To achieve the objectives of the study, the descriptive approach was used to describe the variables of this study in addition to the standard analytical method, where this study will test the statistical properties of the time series of variables through the use of unit root tests such as the Phillips-Perron (pp) test to verify the stationary of these variables, and then the relationship between the interpretive variable and the dependent variable will be tested and estimated using the cointegration according to the ARDL and NARDL methodologies and then determine the optimal model using Eviews-12 data analysis program.

The method, NARDL, as in ARDL, detects short-run and long-run effects in a single equation, and does not necessarily require long time series compared to a nonlinear co-integration method. As well as its flexibility in the use of integrated variables of order I(0) or I(1). That is, whether the variables are stationary in the first plane, the first difference, or the combination of them ( of course, stationary variables in the second difference, i.e. with the order of integration I(2), are not taken into account. The NARDL method enables us to test a composite hypothesis as to whether the relationship between the two variables under study is linear or non-linear or even there is no co-integration relationship between them.

### 2.2 Research Structure:

It includes four topics in addition to the introduction, which is as follows:

1- The theoretical framework of the relationship between money supply and bank deposits and previous studies**.**

2- The methodology used and the study sample

3- Analysis of the relationship between money supply and bank deposits.

4- Presentation and analysis of results.

5. Conclusions and recommendations .

## 3.Material and Methods:

### 3.1 Co-integration:

Modelling time series in order to keep their long-run information correct can be done through cointegration. Granger (1981) and Engle and Granger(1987) formalize the idea of cointegration, providing tests and estimation procedure to evaluate the existence of long-run relationship between set of variables within a dynamic specification framework(Abdul Latif et al, 2012). Cointegration is an econometric concept that mimics the existence of a long-run equilibrium among underlying economic time series that converges over time. Thus, cointegration establishes a stronger statistical and economic basis for empirical error correction model, which brings together short and long-run information in modelling variables. Testing for cointegration is a necessary step to establish if a model empirically exhibits meaningful long run relationships. If it failed to establish the cointegration among underlying variables, it becomes imperative to continue to work with variables in differences instead. However, the long run information will be missing. There are several tests of cointegration, other than Engle and Granger (1987) procedure, among them is Autoregressive distributed lag co-integration technique or bound cointegration testing technique. The cointegration technique development was based on hypothesis Validity of time series stationary (Nkoro and Uko ,2016).

The co-integration of two or more variables means that there is a long-run equilibrium relationship between those variables, while the same equilibrium relationship may not exist in the short -run, and then the short-run imbalances must be corrected at a certain rate for each time period according to the time periods under study. this rate can be calculated by estimating the so-called error correction model it helps to check the stationary of time series.

An integral of degree zero is written as I(0) and the integral of the first degree is written as I(1) and in general is written as I(d).There are several tests to confirm the unit root in time series, including Phillips - Perron Test, which was used in this paper ( Rashad , 2011).

**3.1.1 Autoregressive Distributed Lag Model (ARDL):**

The autoregressive distributed lag model (ARDL) for co-integration framework has become widely used in recent years, which was introduced by (Pesaran et al ,2001), autoregressive models were combined with distributed Lags models into a single model, and in this methodology, the time series is a function of their lags and their values of the current explanatory variables and their lags by one or more periods. The general form of the ARDL model, which shows the relationship between the dependent variable (Y) and the independent variable( X) according to (Pesaran et al ,2001) since the model works on the principle of Autoregression, the Lags of the dependent variable are added to the equation as follows :

$$\Delta Y_{t} = \alpha_0 + \beta y_{t-1} + \theta x_{t-1} + \sum_{j=1}^{p} \rho_j \, \Delta y_{t-j} + \sum_{j=0}^{q} V_j \, \Delta x_{t-j} + \varepsilon_t \qquad (1)$$

Through Bounds test ARDL will be used in three stages(Nkoro and Uko,2016).

**Firstly:** Cointegration is tested in the framework of UECM, which takes the formula (1) by assuming the relationship between the dependent variable (Y) and the independent variable (X), where:

$\theta,\beta$ : represents long-run relationship coefficients.

$V_j$, $\gamma_j$: represent short-run relationship information.

$\Delta$ : the first difference of variables.

q ,p : The number of lags that are not necessarily equal.

$\varepsilon_t$ : random error with zero mean and constant variance with no serial Autocorrelations.

In this step, the existence of co-integration is based on the (F) test (Wald test), estimated under the hypothesis (Fernandez et al, 2018)

Ho: $\beta = \theta = 0$ (null, i.e. No long- run co-integration exist).

H1: $\beta \neq \theta \neq 0$ (Alternative, i.e. the- long run co-integration exists).

The null hypothesis is rejected based on computing the (F) statistic with the tabulated value within the critical bounds proposed by (Pesaran et al ,2001) where the table consists of two terms (Lower Critical Bound, LCB) which assumes that the variables are integrated from the degree I(0) and the value of the upper limit (Upper Critical Bound, UCB) which assumes that the variables are integrated from the degree I(1) If the calculated value of ((F) is greater (UCB), then the null hypothesis is rejected and accepted The alternative hypothesis (the existence of cointegration) if the value of (F) that calculated less than LCB, in this case the null hypothesis (the cointegration does not exist) is accepted, but if the value of( F) falls between UCB and LCB, in this case the result is unresolved and there is no decision.

**Secondly** : after proving the existence of cointegration in the first stage, the long-run equation is estimated at this stage according to the following formula:

$$Y_{t} = \alpha_0 + \sum_{j=1}^{p} \delta_j \, y_{t-j} + \sum_{j=0}^{q} \vartheta_j \, x_{t-j} + \varepsilon_t \qquad (2)$$

Where:

$\delta_j$ , $\vartheta_j$: long-run variable coefficients.

$\varepsilon_t$ : represents the random error.

p,q : represents the lags of the variables.

Lags are determined according to the (AIC).

**Third:** At this stage, the short-run equation is estimated by building an Error Correction Model (ECM), as the residual series obtained from estimating the long-run equation are added as an independent variable with one lags to the short-run equation according to the following formula:

$$\Delta Y_{t} = \alpha_0 + \sum_{j=1}^{p} \lambda_j \; \Delta y_{t-j} + \sum_{j=0}^{q} \varphi_j \, \Delta x_{t-j} + \emptyset ETC_{t-1} + \varepsilon_t \qquad (3)$$

Where:

$ECT_{t-1}$: represents the error correction term.
$\varphi_j$ , $\lambda_j$ : short-run coefficient.
$\emptyset$ : error correction coefficient that measures the speed of adjustment at which the imbalance is adjusted disequilibrium in the short- run towards long-run equilibrium.

**3.1.2 Non-Linear Autoregressive Distributed Lag Model (NARDL) :**

All that has been mentioned regarding (ARDL) applies to the nonlinear autoregressive distributed lag model (NARDL) and although most of the models started from the linearity of Econometrics phenomena, they assume similar relationships between the variables under measurement (Symmetric relations), but we find that the (nonlinear phenomenon) occupied the attention of most researchers several years ago because most of the relationships between economic variables It is characterized by non-linearity, as positive and negative changes in independent variables lead to asymmetric changes in the phenomenon under study and the fact that most of the time series of economic phenomena are nonstationary. Nonlinear econometrics models have emerged that are concerned with estimating cointegration relationships and error correction ECM, and is a nonlinear autoregressive distributed lag model one of the most recent of these models, which was developed by ( Pesaran and Shin, 2001) and (Pal and Mitra, 2016) as an extension of the linear autoregressive distributed lag model (ARDL), which takes into account the asymmetric effect of nonlinear variables in the short and long- run between variables, the mechanism of the NARDL model is to separate positive and negative variables in independent variables (Regressors) and put them in the form of Partial sums For the lags of these variables, as we can observe the equilibrium relationship between $Y_t$and $X_t$ divided into positive $X_t$ and negative $X_t$, as it detects short-run and long-run effects in one equation as follows:

$$X_t = X_0 + X_t^+ + X_t^- \qquad (4)$$

The dependent variable thus becomes a function of the Partial sums of the separated positive and negative variations (Decomposition of partial sum) .

$$Y_t = \alpha_0 + \beta^+ X^+ + \beta^- X^- + u_t \qquad (5)$$

where the error lterm in (5) with zero mean and constant variance, and $\alpha_0$denote to intercept while both

$\beta^+$and $\beta^-$ represent asymmetric parameters in the long- run Parameters .
$X^+$and $X^-$ are calculated as in the following equations (Shin,Y. el at, 2013).

$$X_t^+ = \sum_{i=1}^{t} \Delta X_t^+ = \sum_{i=1}^{t} \max(\Delta X_i , 0) \qquad (6)$$

$$X_t^- = \sum_{i=1}^{t} \Delta X_t^- = \sum_{i=1}^{t} \min(\Delta X_i , 0) \quad (7)$$

Based on the principle of dividing the independent variable (X), the introduction of both variables $X^+$and $X^-$ in the ARDL model we get the model (NARDL) (p,q) and according to the approach (Pesaran et al, 2001) and the general formula for this model can be written according to the following(Shin et al,2013):

$$\Delta Y_t = \beta_0 + \sum_{i=1}^{p} \lambda_i \Delta Y_{t-j} + \sum_{i=0}^{q} \delta_i^+ \Delta X_{t-i}^+ + \sum_{i=0}^{q} \delta_i^- \Delta X_{t-i}^- + \rho Y_{t-1} + \theta^+ X_{t-1}^+ + \theta^- X_{t-1}^- + \varepsilon_t \quad (8)$$

Whereas:

$\theta^+$ *and* $\theta^-$: represent the long-run information of the asymmetric relationship in the model.
$\delta_i^-$ و $\delta_j^+$ : represents asymmetric estimators in the short- run.

That can be estimated using the usual least squares method. One of the merits of this model is that it shows asymmetric long and short- run changes and works under different variables in the degree of integration and performs well with small sample sizes.

To apply the co-integration analysis approach within the framework of the NARDL model, the optimal (Lags) must be chosen before estimating the relationship in the short and long -run between the dependent variable and the economic variables affecting it, as it is necessary to know the optimal number of lags for these variables, which correspond to the lowest value of, (AIC) (Akaike Information criterion (Allawi and Rahi, 2015).

$$AIC(q) = NL_0q\left({}^{SSE}/_{N}\right) + 2q \quad (9)$$

Whereas:
N : number of observation.
SSE: residuals of sum squares.
q : number of parameters.

**3.1.3 Bounds Test:**
This test is used to find out the extent to which there is a long-run balanced relationship between the dependent variable and the explanatory variables included in the function by means of a test statistic (F), It doesn't depend on trend in estimation, and calculates the value of the statistics (F) according to the following formula: (Fernandez and Fernandez, 2018).

$$F = \frac{(SSeR - SSeu)/M}{SSeu/(n-k)} \quad (10)$$

Where:
SSeR: the residuals of sum squares for the constrained model under the null hypothesis, i.e. the absence of a long-run equilibrium relationship between the variables (lack of cointegration between variables).

SSeu: the residuals of sum squares for the unconstrained model under the alternative hypothesis, i.e. the existence of a long-run equilibrium relationship between the variables (indicating the existence of co-integration between the variables).

M: number of parameters of the constrained model.
n: number of observations (sample size).
K: number of parameters of the unconstrained model (or number of explanatory variables).
The existence of cointegration between variables is tested using the F-test according to the following two hypotheses:

$$H_0: \beta_0 = \rho = \emptyset^+ = \emptyset^- = 0 \quad \text{(no co-integration)}$$
$$versus \quad H_1: \beta_0 \neq \rho \neq \emptyset^+ \neq \emptyset^- \neq 0 \quad \text{(co-integration).}$$

The calculated value (F) is compared with the two critical values of the test (F) calculated by (Pesaran et al, 2001).

1- Lower limit: - It assumes that all variables are stationary at their original level, i.e. integrated whit level Zero I (0).
2- Upper limit: - It assumes that all variables are stationary in their first difference, i.e. integrated from the first level I (1).

The decision is made on the basis of comparing the calculated value of the (F) with the lower limit if the variables are integrated with zero level I (0), but if they are integrated with one level I (1), Then the decision will be made on the basis of comparing the value of the calculated (F) statistic with the tabular value (F) of the upper limit.

The NARDL method is characterized by an additional test, which is the long-run symmetry test, where the following hypothesis is tested, using the Wald test.

$$H_0: (\beta^+ = -\frac{\theta^+}{\rho}) = (\beta^- = -\frac{\emptyset^-}{\rho}) \qquad \text{versus} \qquad H_1: (\beta^+ = -\frac{\theta^+}{\rho}) \neq (\beta^- = -\frac{\emptyset^-}{\rho})$$

If the existence of a symmetry relationship is proven by assuming that the threshold is equal to zero, this result means that there is similarity in the positive and negative effects caused by the independent variable in the dependent variable, while the existence of an asymmetric relationship between them means that the changes in the independent variable in a particular direction do not necessarily mean that they are equivalent to changes in the opposite direction. Linear testing can also be done in the short term using the Wald test as follows:

$$\sum_{j=0}^{q-1} \delta_j^+ = \sum_{j=0}^{q-1} \delta_t^-$$

In this case the relationship is linear with the short- run, to test the cointegration using NARDL through the Bound Test the NARDL we need the three stages:

**First:** Cointegration is tested in the framework of UECM, as in (8) by imposing the relationship between the dependent variable (Y) and the independent variable (X).

Where:

$\theta^+, \theta^-, \rho$ : Represents the long-run information of asymmetric relationship in the model.
$\lambda_i, \delta_i^-, \delta_j^+$: Represents asymmetric estimators in the short – run.
$\Delta$: It means the first difference of variables.
q , p: The number of lags that are not necessarily equal.
$\varepsilon_t$ : The random error term with zero mean and constant variance and no serial Autocorrelations.

In this step, the existence of co-integration is confirmed by the bounds test (Shin et al, 2013) according to the (Pesaran et al, 2001)) procedure, which is based on the (F) test (Wald test), in which the coefficients estimated from equation (8) are used and the hypothesis is tested:

Ho: $\rho = \theta^{-} = \theta^{+} = 0$ (the long- run cointegration does not exist).
H1: $\rho \neq \theta^{-} \neq \theta^{+} \neq 0$(the long- run cointegration exists).
And the decision is the same in ARDL.

**Second**: after proving the existence of cointegration in the first stage, the long-run equation is estimated at this stage according to the following formula:

$$Y_{t} = \alpha_0 + \sum_{j=1}^{p} \delta_j \, y_{t-j} + \sum_{j=0}^{q} \theta_j^{+} \, x^{+}_{t-j} + \sum_{j=0}^{q} \theta_j^{-} \, x^{-}_{t-j} + \varepsilon_t \qquad (11)$$

Where:

$\delta_j, \theta_j^{+}, \theta_j^{-}$: Long-run variable coefficients.
$\varepsilon_t$ : represents the random error term.
$p, q$ : Represents the lags of the variables.

Lags intervals are determined according to the (AIC) before the specified model is estimated by the OLS method with the aim of Autocorrelation sequentially in random errors (Faisal, 2022).

**Third:** At this stage, the short-run equation is estimated by an (Error Correction Model, ECM), as the residual series obtained from estimating the long-run equation are added as an independent variable with one lags to the short-run equation according to the following formula:

$$\Delta Y_{t} = \alpha_0 + \sum_{j=1}^{p} \lambda_j \, \Delta y_{t-j} + \sum_{j=0}^{q} \varphi^{+}_{1j} \Delta x^{+}_{t-j} + \sum_{j=0}^{q} \varphi^{-}_{1j} \Delta x^{-}_{t-j} + \varphi ETC_{t-1} + \varepsilon_t \qquad (12)$$

$ECT_{t-1}$: represents to Error Correction term.
$\varphi^{+}_{1j}, \varphi^{-}_{1j}, \lambda$: Short-run coefficients.
φ: error correction coefficient that measures the speed of adjustment at which the imbalance is adjusted Disequilibrium in the short- run in the direction of long-run equilibrium.

**4. Discussion of Results** :

The Money supply is the main tool used by the Central Bank to influence various economic variables, which is the amount of payment available to society during a certain period of time that are in the possession of individuals, projects and various institutions meaning the total amount of money that circulating in the economy during a certain period of time (Salman and Mohammed , 2020). Bank deposits can be considered as an agreement whereby the depositor pays a sum of money by means of payment. The bank is obligated accordingly to refund this amount to the depositor upon request or when its time due, and may also be obligated to pay interest on the value of the deposit, and the deposits can be in the form of cash amounts recorded in the commercial banks and due to depositors(Chikri et al,2021). To estimate the Nonlinear relationship between money supply and bank deposits in Iraq, the nonlinear autoregressive distributed lag NARDL model introduced by (Shin et al,2013) which is an that up dated version of ARDL model, was used.

The NARDL model is used to test whether the positive effects are the same as the negative effects of independent variables on the dependent variable. Hence, a comparison was made with the ARDL model. By processing time series data using Eviews12. The data was obtained for a monthly series from the Central Bank of Iraq for the period (2010-2015) and the dependent variable was represented by the money supply variable and the independent variable by the bank deposit variable and the unit of measurement of the two variables is (one million Iraqi dinars) .The descriptive statistics of the two variables are included in the following table:

**Table 1**: Descriptive statistics of study data

| V | Maximum | Minimum | Std. Dev. | Skewness | Kurtosis | Jarque -Bera | P-value |
|---|---|---|---|---|---|---|---|
| Y | 79174203 | 41035394 | 11139793 | -0.607412 | 2.012267 | 7.149951 | 0.028016 |
| X | 74073336 | 40404453 | 9177322 | -0.464623 | 1.90738 | 6.000506 | 0.049774 |

Before conducting integration tests for the ARDL and NARDL models and presenting the results, it should be noted that conducting stability tests for time series to find out the degree of stationary is not a necessary condition for the application of ARDL and NARDL models, but they do not work accurately if there are some variables whose degree of stationary is I (2), so must check the stationarity at level zero and one I(0) , I(1) respectively.

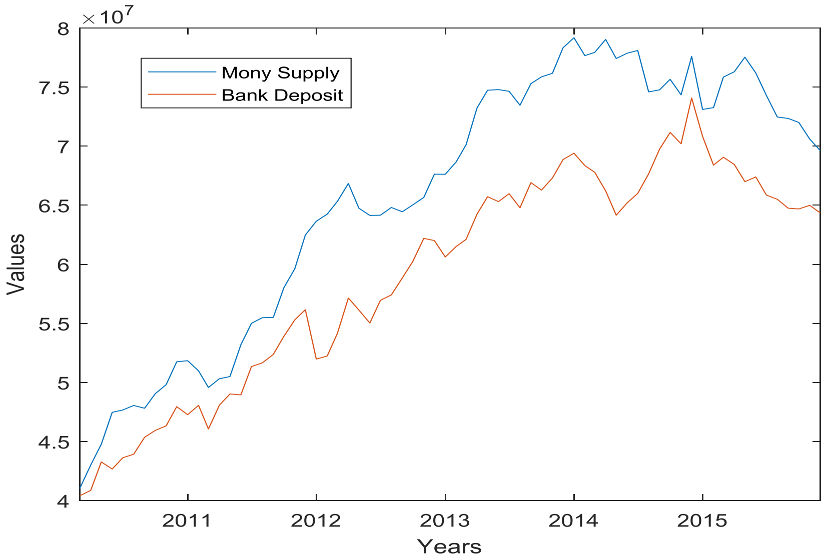



**Figure 1**: Plots of Behavior of Money supply(Y) and Deposit Banks(X)

Through the initial drawing of the time series of the study variables, noted their non stationarity at level I(0) .To confirm this, we perform a unit root test. For this purpose, will be used the Phillips-Perron test Table (2) refers to the results of this test for the Money supply variable at levels I(0) and I(1) respectively:

**Table** 2: Philips-Perron test for the unit root under 5% for 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 |

It is noted from the results of Table (2) 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 has become stable and in the same way the series of bank deposit variable is tested and Table (3) shows the test at I(0) and I(1).

**Table3**: 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 |
| Prob. | 0.9668 | 0.0000 | 0.1961 | 0.0000 | 0.9717 | 0.0000 |
| decision | Nonstationary | stationary | Nonstationary | stationary | Nonstationary | stationary |

**Table 4**: ARDL parameter estimation results

| **Dependent Variable: Money supply<br>Method: ARDL(8, 3)** | | | | |
|---|---|---|---|---|
| Variable | Coefficient | . t-Statistic Std. | Std. Error | P- value. |
| Y(-1) | 0.861871 | 0.136811 | 6.299726 | 0.0000 |
| Y(-2) | 0.074319 | 0.182748 | 0.406677 | 0.6860 |
| Y(-3) | -0.119184 | 0.163638 | -0.728340 | 0.4699 |
| Y(-4) | -0.125448 | 0.144366 | -0.868962 | 0.3891 |
| Y(-5) | 0.248801 | 0.143969 | 1.728154 | 0.0903 |
| Y(-6) | 0.012626 | 0.146239 | 0.086340 | 0.9315 |
| Y(-7) | -0.157923 | 0.149841 | -1.053936 | 0.2971 |
| Y(-8) | -0.164609 | 0.122369 | -1.345187 | 0.1848 |
| X | 0.613219 | 0.109231 | 5.613958 | 0.0000 |
| X(-1) | -0.459210 | 0.156361 | -2.936863 | 0.0050 |
| X(-2) | 0.057056 | 0.168411 | 0.338793 | 0.7362 |
| X(-3) | 0.244577 | 0.123978 | 1.972743 | 0.0542 |
| C | -3029677. | 1647205. | -1.839284 | 0.0719 |
| R-squared | 0.987419 | | Akaike info criterion | 30.91526 |
| Adjusted R-squared | 0.984338 | | Durbin-Watson stat | 2.069584 |
| F-statistic | 320.4846 | | Prob(F-statistic) | 0.000000 |

**Table 5:** results estimation Coefficient for NARDL Model

| Dependent Variable: Money supply | | | | |
|---|---|---|---|---|
| Method :NARDL(12, 2, 4) | | | | |
| Variable | Coefficient | . t-Statistic Std. | Std. Error | P-value |
| Y(-1) | 0.715856 | 0.138839 | 5.156000 | 0.0000 |
| Y(-2) | 0.052758 | 0.170926 | 0.308661 | 0.7593 |
| Y(-3) | 0.067498 | 0.172725 | 0.390780 | 0.6982 |
| Y(-4) | -0.244877 | 0.162937 | -1.502899 | 0.1414 |
| Y(-5) | 0.322115 | 0.154799 | 2.080860 | 0.0444 |
| Y(-6) | 0.058287 | 0.154095 | 0.378253 | 0.7074 |
| Y(-7) | -0.193704 | 0.158807 | -1.219746 | 0.2303 |
| Y(-8) | -0.133856 | 0.166711 | -0.802922 | 0.4271 |
| Y(-9) | -0.037398 | 0.166366 | -0.224795 | 0.8234 |
| Y(-10) | -0.022396 | 0.177402 | -0.126244 | 0.9002 |
| Y(-11) | -0.224336 | 0.167527 | -1.339104 | 0.1887 |
| Y(-12) | 0.360490 | 0.123832 | 2.911112 | 0.0061 |
| X_POS | 0.264080 | 0.222403 | 1.187397 | 0.2426 |
| X_POS(-1) | -0.334259 | 0.325601 | -1.026592 | 0.3113 |
| X_POS(-2) | 0.497200 | 0.227339 | 2.187045 | 0.0351 |
| X_NEG | 0.829241 | 0.225346 | 3.679863 | 0.0007 |
| X_NEG(-1) | -0.387585 | 0.322800 | -1.200695 | 0.2375 |
| X_NEG(-2) | -0.229023 | 0.311136 | -0.736085 | 0.4663 |
| X_NEG(-3) | 0.029060 | 0.317038 | 0.091659 | 0.9275 |
| X_NEG(-4) | 0.356966 | 0.233539 | 1.528506 | 0.1349 |
| C | 13147801 | 4121261. | 3.190237 | 0.0029 |

| R-squared | 0.988897 | Akaike info riterion | 30.87912 |
|---|---|---|---|
| Adjusted R-squared | 0.982895 | Durbin-Watson stat | 2.007266 |
| F-statistic | 164.7701 | Prob(F-statistic) | 0.000000 |

When observing the results of the previous two tables, noted that the variables are integrated of the first degree I(1) and there is no integration of the degree I(2), which allows conducting a cointegration test with the ARDL and NARDL methodology. The optimal lags are selected for the variables of the first difference for each variable of the models depending on the AIC criterion. The results of the statistical tests in table (4) indicate the relative quality of the estimated model through the high coefficient of determination ($R^2$ =0.987419 ) and show that the model explains 98% of the changes in the money supply, which is a very strong percentage.The results also indicate that the relationship between the money supply variable and the bank deposit variable is not Spurious, as the value of the Fisher test statistic (F-statistic = 320.4846), which means that the model is statistically significant. We note the value of (Durbin-Watson stat), which is equal to (2.069584), it indicates that there is no problem of serial Autocorrelation of the residual. The results of the statistical tests of the regression equation shown in table (5) indicate the relative quality of the estimated model through the high coefficient of determination ($R^2$ = 0.988897) and show that the model explains 99% of the changes in the money supply, which is a very strong percentage.

The results also indicate that the relationship between the money supply variable and the bank deposit variable is not spurious, as the value of the Fisher test statistic (F-statistic = 164.7701), which means that the model is statistically significant. We note the value of (Durbin-Watson stat), which is equal to (2.007266), it indicates that there is no problem of serial Autocorrelation of the residuals.

Now to detect the existence of a long-run equilibrium relationship (co-integration) between the money supply and the bank deposit variables, the bound test is used, by comparing the value of (F) calculated for long-run coefficients and computed it with the value of the tabular (F) statistic according to the limits set by (Pesaran et a1, 2001) note that this test is based on the following hypothesis:

$H_0$: No long-run Cointegration $H_1$: long-run Cointegration

**Table 6:** Bounds test results according to ARDL and NARDL models

| model | Number of variables (K) | F- stat. | Critical value at the level of significance 5% | |
|---|---|---|---|---|
| | | | Lower Bound | Upper Bound |
| ARDL | 1 | 7.434418 | 3.62 | 4.16 |
| MARDL | 2 | 8.146438 | 3.1 | 3.87 |

From Table (6) can see that the value of the statistics (F) for both the ARDL and NARDL models was estimated respectively at (7.434418) and (8.146438), which exceeds the upper limits at 5% significant level which leads to rejected the null hypothesis that there is no long-run relationship moving from independent variables to the dependent variable and the acceptance of the alternative hypothesis, which is the existence of a long-run relationship. To find the result of long-run estimation of the ARDL and NARDL model. The Table (7) below refers to the result of ARDL and NARDL model.

**Table 7**: shows the results of the long-run relationship of the ARDL and NARDL model

| **Long-run Coefficient estimates for a model ARDL** | | | | |
|---|---|---|---|---|
| **Variable** | **Coefficient** | **Std. Error** | **t-Statistic** | **P-value** |
| X | 1.232978 | 0.059676 | 20.66128 | 0.0000 |
| C | -8198363. | 3852964. | -2.127807 | 0.0384 |
| EC = Y - (1.2330*X – 8198363) | | | | |
| **Long-run Coefficient estimates for a model NARDL** | | | | |
| Variable | Coefficient | Std. Error | t-Statistic | P-value. |
| X_POS | 1.527454 | 0.204304 | 7.476365 | 0.0000 |
| X_NEG | 2.141404 | 0.561503 | 3.813701 | 0.0005 |
| C | 47029649 | 4140881. | 11.35740 | 0.0000 |
| EC = Y - (1.5275*X_POS + 2.1414*X_NEG + 47029649) | | | | |

From Table (7) noted in the part of the ARDL model that the variable of bank deposits is associated with a positive and statistically significant relationship in the long -run, as the effect of the variable of deposits variable on the variable of money supply positively and with a significant value (0.0000), which is less than 5% and that the increase in bank deposits by 1% leads to an increase in the money supply by 1.23%, as for the NARDL model shown in the second part of the table, we note that the variable of bank deposits is associated with a positive and statistically significant relationship in the long -run with the variable of money supply Because the estimated positive and negative parameters are significant with a value of (0.000) in the positive shock and (0.0005) in the negative shock, which are less than 5%, and the positive and negative changes in the bank deposit variable positively affected the money supply variable. The increase in bank deposits by 0.1% in a positive shock leads to an increase in the money supply by 1.52% and in a negative shock decreases by 2.14%. In the case of a decrease in deposits by 1% and from this model we get the residual series according to the formulas in the last field of each table above and add them to the short-run equation with one lag to estimate the short-run relationship, To estimation the NARDL and ARDL model in the short term (error correction model).Where the error correction limit and the lags for one month is added as an independent variable, which measures the amount of short-run imbalance that is being corrected to return to balance in the long -run.

**Table8**:showing the results of the short-run relationship of the ARDL and NARDL

| Estimates of correction and short-run error coefficients( ARDL) | | | | |
|---|---|---|---|---|
| **Variable** | **Coefficient** | **Std. Error** | **t-Statistic** | **Prob.** |
| D(X) | 0.613219 | 0.100357 | 6.110387 | 0.0000 |
| D(X(-1)) | -0.301633 | 0.116530 | -2.588466 | 0.0127 |
| D(X(-2)) | -0.244577 | 0.120856 | -2.023700 | 0.0485 |
| ECT(-1) | - 0.369547 | 0.076700 | -4.818048 | 0.0000 |
| Durbin-Watson stat | 2.069584 | | R-squared | 0.550203 |
| Estimates of correction and short-run error coefficients( NARDL) | | | | |
| **Variable** | **Coefficient** | **Std. Error** | **t-Statistic** | **Prob.** |
| D(X_POS) | 0.264080 | 0.192145 | 1.374378 | 0.1776 |
| D(X_POS(-1)) | -0.497200 | 0.196318 | -2.532622 | 0.0157 |
| D(X_NEG) | 0.829241 | 0.200243 | 4.141183 | 0.0002 |
| D(X_NEG(-1)) | -0.157003 | 0.188276 | -0.833898 | 0.4097 |
| D(X_NEG(-2)) | -0.386025 | 0.184528 | -2.091959 | 0.0434 |
| D(X_NEG(-3)) | -0.356966 | 0.210847 | -1.693012 | 0.0989 |
| ECT(-1) | -0.279564 | 0.047102 | -5.935305 | 0.0000 |
| Durbin-Watson stat | 2.007266 | | R-squared | 0.691520 |

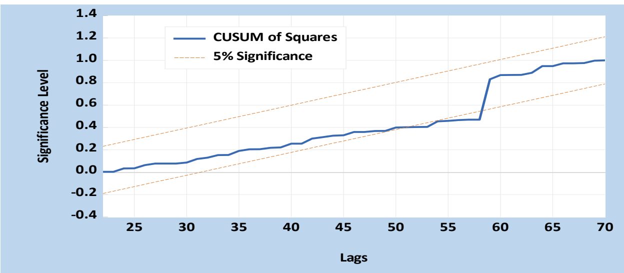
From Table (8) Noted that the results are consistent with the results of the long- run, and we also note that the coefficient of the error correction term is equal to (-0.369547) for the ARDL model and noted its significance with a probability of (0.0000) and this means that (0.37) of imbalance in the short -run can be treated in the long –run and this requires (2.70601574) approximately three months and through testing the short-run parameters of the independent variable all turned out significant, which indicates the strength of benefiting from this model in estimating the relationship short-run, as the probability value of the deposit variable parameter is (0.000), which is less than 5%, and that increasing deposits by 1% leads to an increase in the Money supply by (0.61) As for the NARDL model, the value of the error correction term coefficient is equal to (-0.279564) significantly (0.000), which means (0.28) of the imbalance in the short term- run can be treated in the long- run, and this requires approximately (1/(-0.279564) = 3.5769984 months, and through testing the short-run parameters of the independent variable, the positive shock was positive and non-significant with p-value (0.1776), which is greater than 5%, and thus there is no positive shocks to the Money supply, while the negative shock of the deposit variable has positively and significantly affected its value ( 0.0002) which is less than 5% and reducing deposits by 1% leads to a decrease in the Money supply by (0.83). The Table (9) below , result to short-run and long-run symmetry tests (Wald Test).

$H_0$ : No long- run asymmetry $H_1$ : long- run asymmetry

**Table 9**: Results of Asymmetry statistics of NARDL Model

| | Long-run asymmetry | | | Short-run asymmetry | | |
|---|---|---|---|---|---|---|
| **Wald Test X** | Coefficient | F-stat | P-value | Coefficient | F-stat | P-vlue |
| | -0.135741 | 18.51307 | 0.0001 | 1.535417 | 35.18549 | 0.0000 |

When observing the results of Table (9) in which the symmetry of positive shock coefficient and negative shock coefficient was tested, in other words, is the relationship between the independent variable with the dependent variable linear or nonlinear, and the results, as in the table, that the P-value in the long and short –rum is significant and less than 5%, which is (0.0001) for the long –run and (0.0000) for the short- run, which means the asymmetry of negative and positive shocks of the independent variable, i.e. the nonlinear relationship between the dependent variable and the independent variable**.** To ensure that the data used is free of any structural changes, Peseran conducted two tests through which the structural stability of the model parameters is tested in the short and long term, where the first test represents the cumulative sum test (CUSUM) for residuals, and the second test is the cumulative sum of squares (CUSUM), where the structural stability of the estimated coefficients of the two models is achieved if the graph of the CUSUMSQ and CUSUM tests falls within the boundary Critical at 5% morale level.



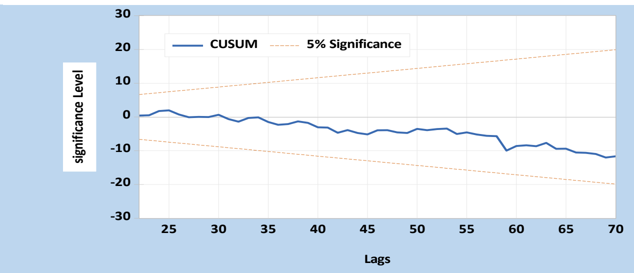




**Figure 4:** Cumulative sum of squares of residuals and Cumulative total of residuals for ARDL model

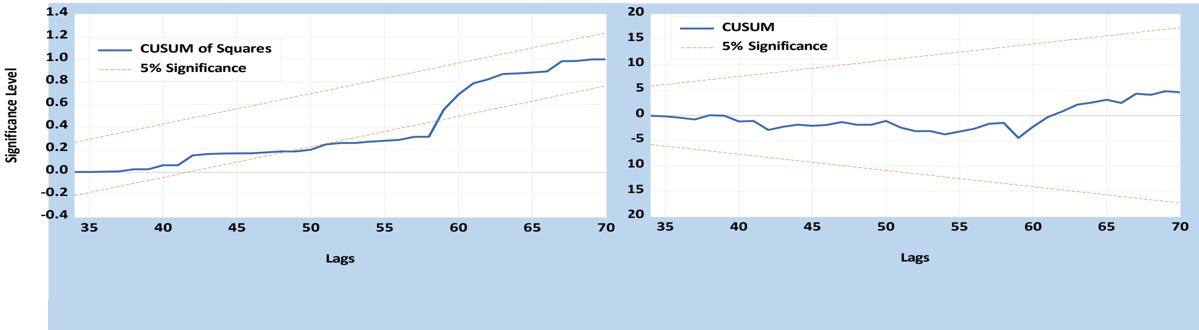



**Figure 5:** Cumulative sum of squares of residuals and Cumulative total of residuals for NARDL

Through the graphs shown above, noted that the cumulative sum of CUSUM residuals is within the critical zone for the two models, which confirms the stability of the two models at the significance level of 5% . While the results showed that there was a structural change in the two models that occurred using the second test, the difference in results between the two tests leads us to adopt the results of the cusumq test, which show that there are structural changes that have occurred in the relationship between money supply variables and bank deposits.

**Table 10:** Comparison of the results of the two models

| method | ARDL Model | NARDL Model |
|---|---|---|
| ECT(-1) | - 0.369547 | -0.279564 |
| P value(ECT) | 0.0000 | 0.0000 |
| Adjustment speed ratio | %37 | %28 |
| Adjustment time period | 2 month | 3.5 month |
| $R^2$ | 0.550203 | 0.691520 |
| Durbin-Watson stat. | 2.069584 | 2.007266 |
| Correlation LM Test | Lack of autocorrelation | Lack of autocorrelation |
| Heteroskedasticity test | The presence of a heterogeneity problem | The presence of a heterogeneity problem |
| Residual Normality Tests | Normal distribution | Normal distribution |
| Structural stability test | stable | stable |

## 5. Conclusions:

Through the results we can summarized our conclusion , from the unit root test results for both variables, noted that, the both variables are nonstationary with zero level I(0), but stabilized with the first differences I(1), and there is not integrated with the second level. I(2). The cointegration test of the two models showed a cointegration 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. The symmetry test for the NARDL model showed an asymmetric long-run co-integration relationship. The existence of a statistically significant relationship between both Money Supply and bank deposits in both models.The coefficient of the error correction mechanism was negative in both models, and this achieves the condition of correcting the errors of a short-run model in the long -run, and its value was significant in the two models, but the speed of adjustment and the time period of the amendment were the more important in the ARDL model, as it reached (%37) in two months, while the speed of adjusting NARDL was (%28) in three and a half months. According to the amount of the adjustment percentage and the period required for the adjustment, the ARDL model is more accurate than NARDL.

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**Authors Declaration:**

Conflicts of Interest: None

-We Hereby Confirm That All The Figures and Tables In The Manuscript Are Mine and Ours. Besides, The Figures and Images, Which are Not Mine, Have Been Permitted Republication and Attached to The Manuscript.

- Ethical Clearance: The Research Was Approved By The Local Ethical Committee in The University.

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# تقدير نماذج السلاسل الزمنية غير المستقرة باستعمال ARDL وNARDL

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**مستخلص البحث:**
درست هذه الورقة العلاقة بين سلوك عرض النقود والودائع المصرفية في كل من أنموذجي الانحدار الذاتي للارتدادت الزمنية المبطاة الخطي (ARDL ) وأنموذج الانحدار الذاتي للارتدادت الزمنية المبطاة اللاخطي (NARDL). ان علاقة الانحدار بين اي سلسلتين زمنيتين غير مستقرتين تعاني من مشكلة الانحدار الزائف والنتائج قد تكون غير صحيحة ولا يمكن الاعتماد عليها، وللتغلب على هذه المشكلة كان الهدف من هذه الورقة هو ايجاد علاقة متزنة في الاجل الطويل بين متغيري الدراسة بأستعمال أسلوب التكامل المشترك من خلال التركيز على سلوك البواقي من أنموذج انحدار التكامل المشترك بألاعتماد على بيانات شهرية لسلسلة زمنية للمدة(2010-2015) وتم عمل اختبار استقرار السلسلة الزمنية من خلال اجراء اختبار جذر الوحدة (unit root test)بألاعتماد على اختبار فيليبس بيرون ( Philips-Perron) لمعرفة مدى استقرار المتغيرات ثم الكشف عن وجود خاصية التكامل المشترك (co-integration relationship) بأستعمال اختبار الحدود (Bounds Test ) وقد اظهرت الاختبارات عدم استقرار السلاسل الزمنية في المستوى I(0)واستقرارها بعد اخذ الفروق الاولى I(1) ,واظهر اختبار الحدود وجود التكامل المشترك في الانموذجين وكان أنموذج تصحيح الخطأ لانموذج ARDL هو الاكثر دقة بالرغم من تقارب اغلب نتائج الاختبارات للأنموذجين ولكن تفوق أنموذج ARDL على أنموذج NARDL بسرعة التعديل في الاجل القصير للعودة الى التوازن في الاجل الطويل حيث بلغت نسبتها ( 37% ) وبفترة زمنية شهرين لأنموذج ARDL بينما كانت النسبة لأنموذج NARDL تساوي( 28%) وبفترة زمنية ثلاثة اشهر ونصف تقريباً.
**نوع البحث:** ورقة بحثية.

**المصطلحات الرئيسة للبحث:** ARDL، NARDL ، التكامل المشترك ، فيليبس بيرون ، اختبار الحدود. عرض النقود.

*البحث مستل من رسالة ماجستير