Investigating the Dynamic Relationship between Exchange Rate and Trade Balance in Egypt: ARDL Bounds Testing Approach

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Abstract: - Exchange rate policies are among the most important economic tools in the country for their impact on the balance of payments in general and the balance of trade. This study used the autoregressive distributed lag (ARDL) model to estimate the long-term relationship between the exchange rate and the trade balance deficit while clarifying the impact of potential determinants during the period 1990 to 2021 in Egypt. The data for trade balance and its economic determinants (exchange rate, foreign direct investment, and money supply) was obtained from the World Bank. The results indicated that the best model was ARDL (2,1,2,3). The exchange rate is found to have a significant negative effect on the trade balance, confirming the perceptions of the economic theory. The money supply is positively and significantly related to the trade balance while there is no significant effect of foreign direct investment in the long term on the trade balance deficit. Economic adjustments between the four variables occur in the short run (after about 14 months only). The study recommends continuing the policy of liberalizing the exchange rate while working on expanding the production base to increase exports.

Keywords: - ARDL model; Exchange rate; trade balance; foreign direct investment; money supply.

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1 Introduction

Economic policies play a fundamental role in shaping the country's economic growth. One of the most important policies is the exchange rate, which is the number of units sacrificed from the local currency to obtain several units of foreign currency. The exchange rate is considered the most important price in any economy as it affects all other prices. The exchange rate is highly affected by government policy. The exchange rate largely determines the inflation rate. The exchange rate policy is a powerful and effective tool to influence the trade balance. The higher the value of the domestic currency against the foreign currency, the higher the prices of domestic goods which increases the trade balance deficit due to the gap between exports and imports. On the other hand, with the depreciation of the local currency against the foreign currency, domestic commodity prices are relatively low, and exports are increasing, resulting in a lower trade balance deficit.

Changes in exchange rates constitute countries' monetary policies. From 1990 to 2021, Egypt experienced dramatic changes in the exchange rate policy, which affected the trade balance. In 2003, the dollar's unavailability at official rates led to the adoption of a flexible exchange rate regime which caused a cumulative depreciation of about 68 percent against the US dollar from 2000 to 2004. In 2004, the Central Bank of Egypt (CBE) launched the interbank foreign exchange market, causing the pound to rise by 4 percent in one quarter. In the same period, higher interest rates and stabilization of the foreign currency increased in saving in the local currency, [1]. In 2005-2006, CBE intervened

through open market operations using traditional treasury bills, new notes, and certificates of deposits with maturities of up to two years. The monetary transmission mechanism improved, and market interest rates have become more responsive to the main policy rates. Inflation also decreased in conjunction with these changes. In 2008, the pound fell about 6 percent after the collapse of Lehman Brothers. While the exchange rate in 2009 rose almost to its pre-crisis level with the continued capital inflows and official reserves.

In 2011, a dramatic change occurred in the political landscape, which was characterized by uncertainty and widespread turmoil. Financial fragility increased, as well as fiscal deficit, inflation, and debt, prompting the Central Bank to introduce new mechanisms (Foreign Exchange Auctions) in 2012. The pound fell 13 percent, and the exchange rate rose from LE 5.80 pounds to LE 7.26 in the period (2011-2015). September 11 attacks, the Iraq war, and other events in the Middle East have deteriorated the exchange rate and increased the public debt burdens of approximately 203,100 million pounds in 2012/2013. The external debt reached 46 billion dollars in 2015, and the total public budget deficit was 12% of the GDP. Several measures were taken, namely, the floating of the Egyptian pound in 2016, the liberalization of the exchange rate, and the devaluation of the currency to eliminate the black market and bring in foreign direct investment, and despite that, the results were disappointing. Moreover, the Corona pandemic appeared in 2019, causing a negative impact on the country's economy and affecting the trade balance. In this context, our study aims to investigate the dynamic causal relationship between the trade balance, exchange rate, foreign direct investment (FDI), and money growth in Egypt during the period from 1990 to 2021.

2 Literature Review

The real exchange rate is one of the widely used economic indicators. The real exchange rate is the nominal exchange rate that accounts for the inflation differences between countries. Its importance lies in international trade as it describes commercial competitiveness. Real exchange rate movements affect many economic variables; in this context, many studies investigated the economic impacts of exchange rates. In [2], the author measured the main economic factors that affected the bilateral trade balances of Thailand and Malaysia with the US and Japan. The study estimated an unrestricted VAR model using quarterly data from 1980 to 1996 and demonstrated a stable long-run relationship between trade and three macro determinants (exchange rate, domestic income, and foreign income). In [3], the author aimed to measure the effect of exchange rate volatility on the aggregate demand for Pakistani exports during the period (1979-2005) using ARDL analysis. The study showed that foreign economic activity had a positive impact on exports, while the real exchange rate and its fluctuations had negative effects on total Pakistani exports. In [4], the author examined the relationship between trade balance, exchange rates, income, and money supply in Malaysia. The study used the autoregressive distributed lag (ARDL) approach to investigate the long-run relationship between the trade balance and the previous determinants and found that income and money supply affected the trade balance in contrast to the exchange rate. In [5], the authors used the VAR-Error correction models to measure how the exchange rate affected the trade balance in Ghana and revealed that long-run stable relationship between the exchange rate and Ghanaian exports and imports. In [6], the authors investigated the effects of real exchange rates on the trade balance in 10 East African countries using the ARDL procedure. the study findings indicated that real exchange depreciation notably improves the trade balance for four countries, the trade balance with respect to the real exchange rate is inelastic and the J-curve relationship did not hold for trade balance. In [7], the author examined the underlying relationship between the balance rate and trade balance in Morocco and concluded that the changes in exchange rates have insignificant effects on foreign trade. While, [8], tested the J-curve hypothesis and investigated the dynamics of the bilateral trade balance in Egypt, the study found that the J-curve hypothesis did not apply in the case of Egypt, especially in the long term. In [9], the study evaluated the extent to which the exchange rate affected stock returns on the Shenzhen Stock Exchange from 2008 to 2018. based on the ARDL model's results, the study showed that the exchange rate had a negative and significant effect on stock returns. In [10], the authors estimated the relationship between the exchange rate and the trade balance in tourism in Turkey using a nonlinear ARDL approach. The study found that the depreciation of the euro boosts the number of tourist arrivals to Turkey but is not important for the balance of tourism in Spain. The relationship between exchange rate fluctuations and high current account deficits has received great attention during

the last decades. Existing research recognizes the important role played by exchange rate policies on the trade balance. In [11], the authors examined the effect of currency devaluation in Ethiopia on its trade balance during the period (1998-2020) using the ARDL framework. The study found that devaluation substantially improves the trade balance in the short and long term, both domestic and foreign income are positively correlated with the improvement in the trade balance while money supply and government expenditure are negatively correlated with the trade balance. In [12], the authors studied the dynamic causal relationships between the inflation rate and foreign exchange rate, money supply, and gross domestic product (GDP) in Egypt during the period (2005-2018) using the ARDL bound testing approach and found that the exchange rate and growth in the money supply significantly affect the inflation rate in Egypt, in contrast to the gross domestic product, which did not have a significant effect on the inflation rate. In a similar study, [13], investigated the same relationship in Nigeria during the period (2005-2019) and found that CPI, GDP, and money growth affect the inflation rate in the long run. While, [14], focused on the missing values problem and its effect on the optimal order of the ARDL model. The study found that expectation–maximization method is more efficient in imputing missing data compared to other techniques (K-nearest neighbors, classification and regression tree, and random forest) and highlighted that gross domestic product, exchange rate, and inflation rate significantly affected the foreign direct investment.

Our study contributes to the previous literature by investigating the dynamic causal relationship between trade balance, exchange rate, foreign direct investment, and money growth in Egypt from 1990 to 2021, using the Autoregressive Distributive Lag (ARDL) approach.

3 Data and Methodology

3.1 Data Source

The trade balance data for Egypt and its economic determinants (exchange rate, foreign direct investment, and money supply) during the period 1990 to 2021 were obtained from the World Bank.

3.2 Research Method

Our study adopted the Autoregressive Distributed Lag (ARDL) approach to cointegration testing. The form of the ARDL (p, q) model is expressed as follow:

$$Y_t = C + \propto_1 Y_{t-1} + \ldots + \propto_p Y_{t-p} + \beta_0 X_t + \beta_1 X_{t-1} + \ldots + \beta_q X_{t-q} + e_t \quad (1)$$

where p is the number of lags of y (lag order of y) and q is the number of lags of x (lag order of x). We can rewrite (1) as follows:

$$Y_t = C + \sum_{i=1}^{p} \propto_i Y_{t-i} + \sum_{i=0}^{q} \beta_i X_{t-i} + e_t \quad (2)$$

The simple ARDL model assumes that we have one explanatory variable, hence, if we have k explanatory variables, the general ARDL $(p,q_1,q_2,\ldots,q_k)$ model is

$$Y_t = C + \sum_{i=1}^{p} \propto_i Y_{t-i} + \sum_{i=0}^{q_1} \beta_i X_{1t-i} + \ldots + \sum_{i=0}^{q_k} \beta_i X_{kt-i} + e_t \quad (3)$$

The assumptions of the ARDL model are as follows:

1. Linear in parameters
2. $E(e_t) = 0$
3. $Var(e_t) = \sigma^2$
4. Cov $(e_t, e_w) = 0$; $t \neq w$
5. Cov $(e_t, X_{tl}) = 0$; $\forall\, t, l = 1,2,3, \ldots, k$
6. e_t *is normally distribution*

3.3 Requirements of ARDL Cointegration Testing

Irrespective of whether the underlying variables are I(0) or I(1) or a combination of both, the ARDL technique can be applied. ARDL technique helps to avoid the pretesting problems associated with standard cointegration analysis which requires the classification of the variables into I(0) and I(1). The bound testing procedure for cointegration does not require pre-testing the variables for unit roots. The bound testing procedure is robust if there is a single long-term relationship between the underlying variables. If the Wald test establishes a single long-run relationship and the sample data size is small or finite, the ARDL error correction representation becomes relatively more efficient. On the other hand, if the Wald test establishes multiple long-run relationships, the ARDL approach cannot be applied, [15]. Hence, an alternative approach, [16], can be applied. That is, if the various single expression/equation of the underlying individual variable as the dependent variable shows a feedback effect (multiple long-run relationships) between the variables, then a multivariate procedure needs to be employed.

The null hypothesis of no cointegration is $H_0: \beta_1 = \cdots = \beta_4 = 0$, and the alternative hypothesis that cointegration exists, i.e., H_1: at least

one parameter not equal to zero, is achieved by the Wald test using F-test. The null hypothesis can be rejected when the value of the F-statistic is greater than the upper bound critical value. The conditional autoregressive distributed lag model can be conducted to estimate the long-run relationship. The second step in where ECT is known as the Error Correction Term which indicates the speed of adjustment parameter, the ECT shows how much of the disequilibrium is being corrected, that is, the extent to which any disequilibrium in the previous period is being adjusted in current point.

3.4 Estimation and Specification

According to [17], the error correction model of the ARDL model is:

$$\begin{aligned}\Delta \mathrm{BOT}_t =& \propto_0 + \sum_{i=1}^{p} \propto_{1i} BOT_{t-i} + \sum_{i=0}^{q_1} \propto_{2i} \Delta ER_{t-i} \\ &+ \sum_{i=0}^{q_2} \propto_{3i} \Delta FDI_{t-i} \\ &+ \sum_{i=0}^{q_3} \propto_{4i} \Delta M_{t-i} + \beta_1 BOT_{t-1} \\ &+ \beta_2 ER_{t-1} + \beta_3 FDI_{t-1} + \beta_3 M_{t-1} \\ &+ e_t \end{aligned} \quad (4)$$

Where BOT refers to the balance of trade, ER refers to the exchange rate, FDI refers to the foreign direct investment, and M refers to Money. The second stage of the bounds testing ARDL method involves approximating a restricted ECM. A principal feature of cointegrated variables is that their time paths are influenced by the extent of any deviation from long-run symmetry. if the system is to return to long-run equilibrium, the movements of at least some of the variables must respond to the magnitude of disequilibrium. The following equation specifies the conditional ECM:

$$\begin{aligned}\Delta \mathrm{BOT}_t =& \propto_0 + \sum_{i=1}^{p} \propto_{1i} BOT_{t-i} + \sum_{i=0}^{q_1} \propto_{2i} \Delta ER_{t-i} \\ &+ \sum_{i=0}^{q_2} \propto_{3i} \Delta FDI_{t-i} \\ &+ \sum_{i=0}^{q_3} \propto_{4i} \Delta M_{t-i} + vECT_{t-1} \\ &+ \varepsilon_t \end{aligned} \quad (5)$$

4 Empirical Application

4.1 Descriptive Statistics

Economic indicators confirm that the foreign exchange rate policies in the Egyptian economy have witnessed major stages. First, the nationalization phase and the state's intervention in economic life during the 1960s and the adoption of the policy of economic openness and open door during the 1970s. Second, the period of initial attempts at economic reform in response to external shocks in the 1980s. Third: the period of comprehensive economic reform, which included the launch of the economic reform and structural stabilization program in the early 1990s, and finally the so-called period of economic liberalization, so that the exchange rate is determined by the forces of supply and demand, and this period continues to date. To find out how the balance of payments is affected by the exchange rate float, we estimate the balance of trade as a function of the real exchange rate, Foreign direct investment, and Money. The study is based on real annual data for the Egyptian economy from 1990 to 2021 obtained from the World Bank. Table 1 provides some descriptive statistics of our data.

Table 2 shows that there is a positive correlation between every pair of independent variables: a moderate correlation between money and exchange rate, and a high correlation between foreign direct investment and exchange rate. Correlation coefficients are less than 0.8, indicating that there isn't a multicollinearity problem between the independent variables.

4.2 Stationarity

The study, [17], showed that cointegration analysis does not apply in cases of integrated variables of different orders i.e., some series is I(1) and others series is I(0). The ARDL cointegration procedure is applicable and although the ARDL cointegration technique does not require pre-testing for unit roots, [16], the stationary condition of all chains should be examined as an initial step to avoid the ARDL model crash in the presence of integrated stochastic trend of I(2), A series is said to be stationary if its mean, variance, and structure don't change over time. In terms of the unit root concept, a non-stationary time series are stochastic process with unit roots or structural breaks. However, the unit roots are major sources of non-stationarity. The presence of a unit root implies that a time series under consideration is non-stationary while it lacks

entails that the time series is stationary. Dickey and Fuller introduced the stationarity test (based on the unit root in time series, [18]. A logic behind the unit root test is that if a non-stationary series (X) must be differenced d times to be stationary then this series has d unit roots at its level and must be integrated of order d, it can be written as I (d). The null hypothesis (H_0) of the Dickey-Fuller (DF) test is "series has a unit root" versus the alternative hypothesis (H_1) which is "the series is stationary". The DF test assumes the white noise of the disturbance term, so if there is autocorrelation in the dependent variable it leads to autocorrelation in the error term which causes the invalidity of the DF test. In 1981, Dickey and Fuller developed the DF test to augmented Dickey–Fuller test (ADF) by taking p lag values into consideration, [19]. The same null hypothesis and critical values table are used as the DF test. Table 3 indicates that the ADF test confirmed that the included variables are stationary at I(0) (stationary at their level) and I(1) (integrated of order 1).

4.3 Model Selection

We estimated the ARDL model with automatic lag selection using E-views version ten. ARDL (2,1,1,3) model was selected depending on the least Akaike information criterion (AIC), as shown in Figure 2.

Table 4 shows that there are significant effects of the lags of some of the macroeconomic variables on the balance of trade. We found a highly significant effect on the exchange rate and the first leg of the exchange rate. The first lag of money supply growth has a significant effect. Additionally, the first, second, and third lags of foreign direct investment have a significant effect on the balance of trade. The second lag of balance of trade has no significant effect on the balance of trade, in addition to the insignificance of money, second lag of money. in addition to the insignificance of foreign direct investment. The time series plots of the variables from 1990 to 2021 are presented in Figure 1.

Table 1. Descriptive statistics of the variables from 1990 to 2021

Variable	Mean	Standard Deviation	Maximum	Minimum	Jarque-Bera	p-value
Balance of Trade (BOT)	-6.4450	2.9464	-1.3600	-13.4899	0.5792	0.7485
Exchange Rate (ER)	6.7756	4.6838	17.7825	1.5500	11.9024	0.0026
Foreign direct investment (FDI)	3.9E+09	3.6E+09	1.2E+10	-4.8E+08	2.0295	0.1983
Money (M)	83.9469	7.9921	98.1361	69.7155	2.0033	0.3672

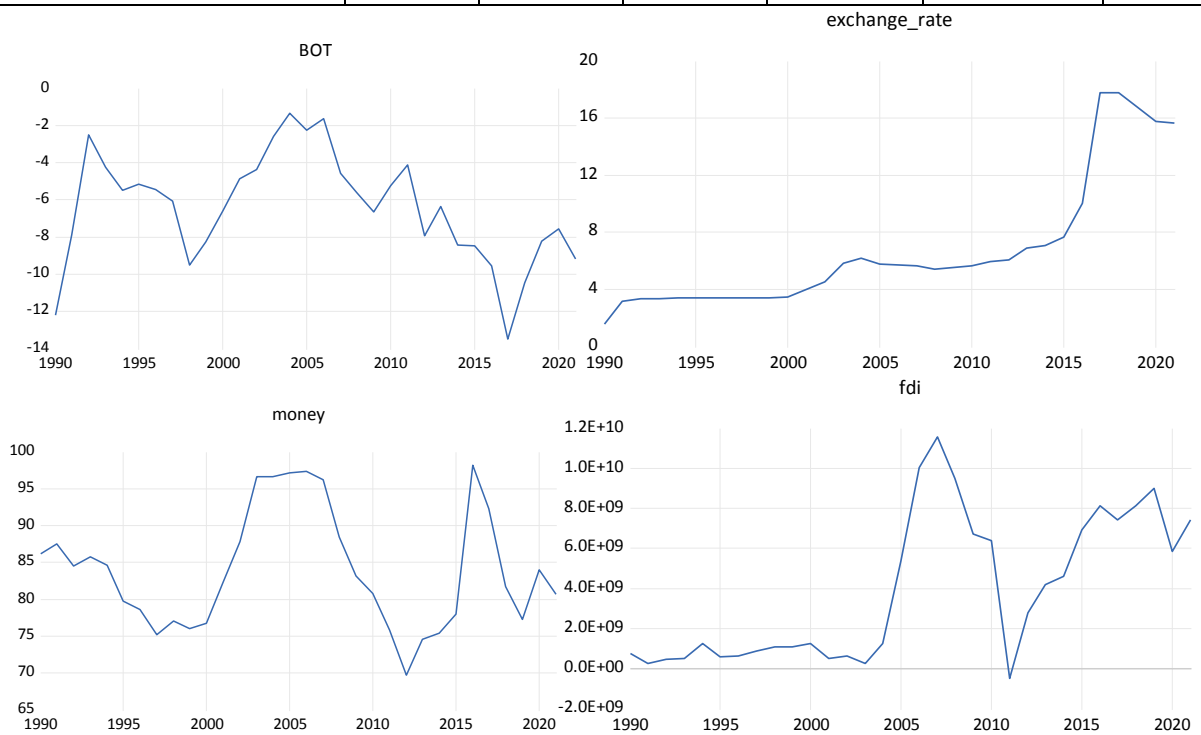

Fig. 1: Time series plots of the variables from 1990 to 2021

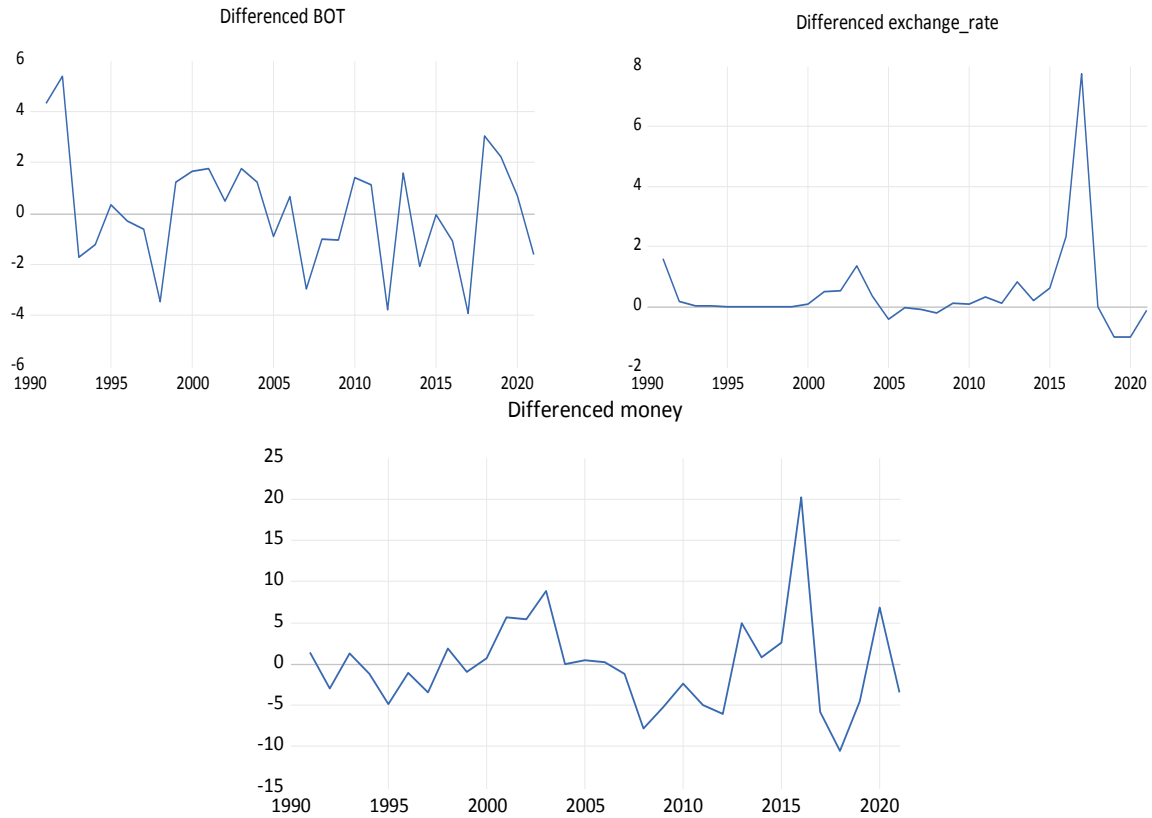

Fig. 2: Time series plots of the variables from 1990 to 2021 after taking differences

Table 2. Correlation matrix of independent variables

Variable	ER	FDI	M
Exchange Rate (ER)	1		
Foreign direct investment (FDI)	0.6032	1	
Money (M)	0.0528	0.2983	1

Table 3. Results of Augmented Dickey-Fuller Test

Series	Integrated Order
Balance of Trade (BOT)	I (1)
Exchange Rate (ER)	I (1)
Foreign direct investment (FDI)	I (0)
Money (M)	I (1)

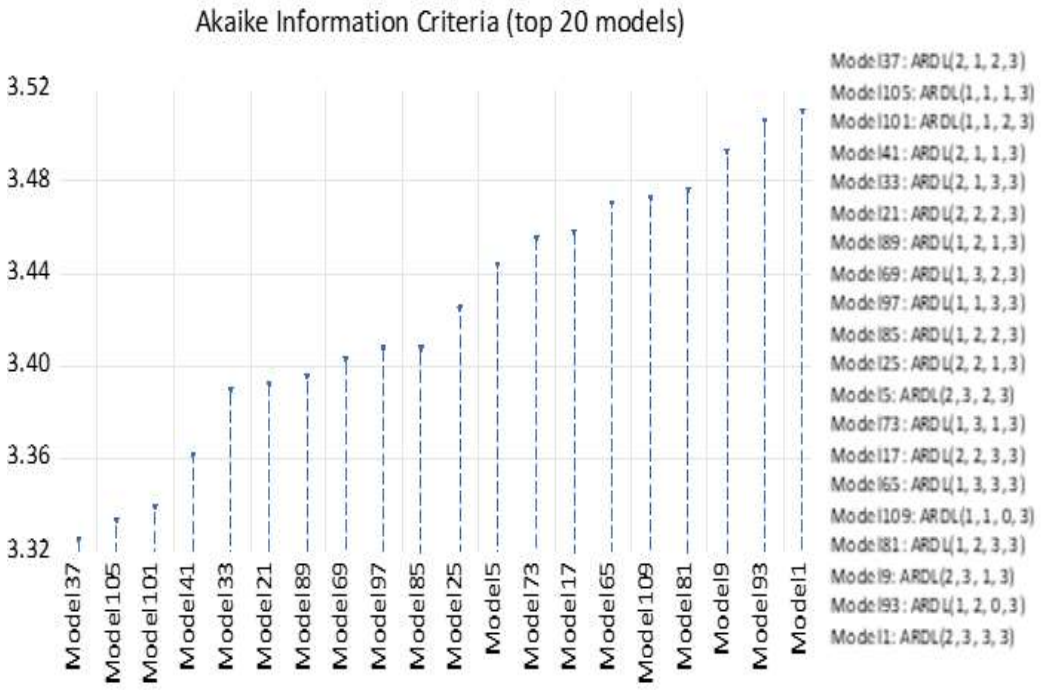

Fig. 3: Model Selection-summary graph of AIC

Table 4. The results of the ARDL (2,1,2,3) model

Variable	Coefficient	Std. Error	t-Statistic	Significant
BOT(-1)	0.323076	0.111623	2.894339	**
BOT(-2)	-0.188907	0.143647	-1.31576	NOT SIG
ER	-1.253976	0.231131	-4.802102	***
ER(-1)	1.007773	0.220375	4.572991	***
M	0.082761	0.049513	1.671500	NOT SIG
M(-1)	0.230282	0.110430	2.085317	*
M(-2)	-0.101506	0.082768	-1.226403	NOT SIG
FDI	-1.04E-10	1.22E-10	0.855963	NOT SIG
FDI(-1)	1.84E-10	8.39E-11	2.188447	**
FDI(-2)	-6.54E-10	1.38E-10	-4.745025	***
FDI(-3)	5.97E-10	1.47E-10	4.060022	***
Constant	-20.93543	3.385374	-5.657634	***

Note: *** significant at 0.01, ** significant at 0.05, * significant at 0.1

Table 5. Bound test of ARDL (2,1,2,3) model

Test Statistic	Value	Significant level	I(0)	I(1)
F-statistic	8.2915	10%	2.72	3.77
K	3	5%	3.23	4.35
		2.5%	3.69	4.89
		1%	4.29	5.61

Note: Null Hypothesis: No levels of relationship

Table 6. The results of the ARDL (2,1,2,3) model in the long run

Variable	Coefficient	Std. Error	t-Statistic	Significant
ER	-0.2844	0.0610	-4.6626	***
M	0.2443	0.0435	5.6163	***
FDI	2.56E-11	1.53E-11	0.1673	NOT SIG
EC=BOT-(-0.2844EXCHANGE RATE +0.2443MONEY+2.56E-11FDI)				

Table 7. The results of the error correction model

Variable	Coefficient	Std. Error	t-Statistic	Significant
Constant	-20.9354	3.3854	-6.1841	***
D(BOT(-1))	0.1889	0.1158	1.6310	NOT SIG
D(ER)	-1.2540	0.2200	-5.6986	***
D(M)	0.0828	0.0400	2.0691	*
D(M(-1))	0.1015	0.0530	1.9153	NOT SIG
D(FDI)	-1.0E-10	9.2E-11	-1.1370	NOT SIG
D(FDI(-1))	5.7E-11	9.9E-11	0.5776	NOT SIG
D(FDI(-2))	-6.0E-10	1.1E-10	-5.3897	***
COINTEQ(-1)	-0.8658	0.1386	-6.2465	***

*Note: *** significant at 0.01, ** significant at 0.05, * significant at 0.1*

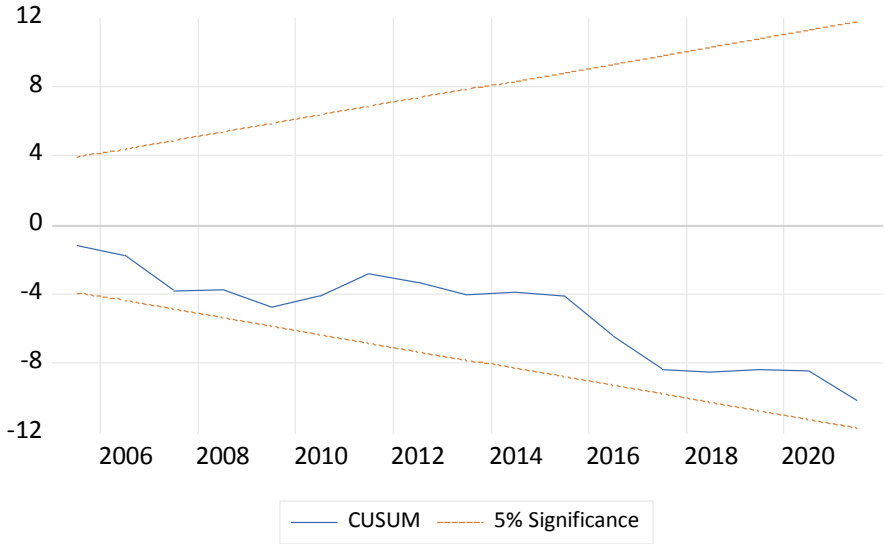

Fig. 4: CUSUM stability test of ARDL (2,1,2,3) model

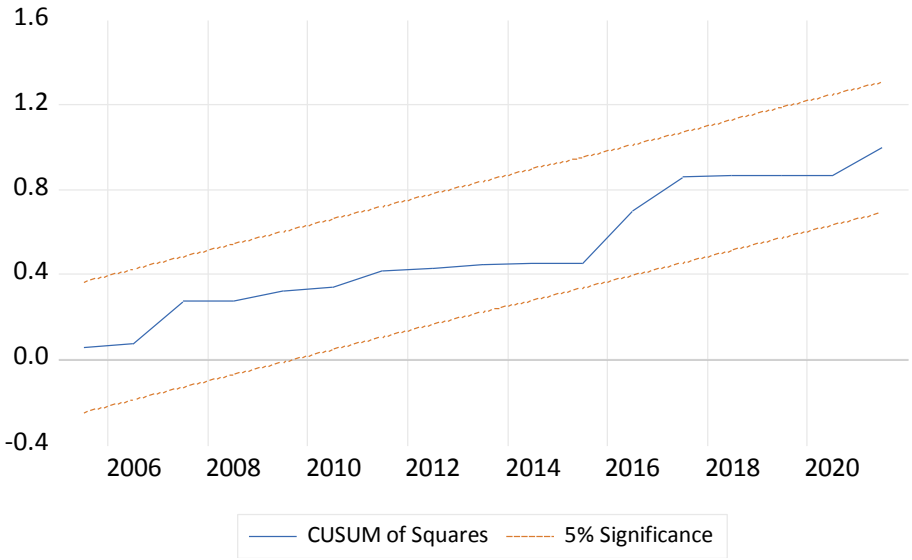

Fig. 5: CUSUM of squares stability test of ARDL (2,1,2,3) model

Table 8. Serial correlation and heteroskedasticity tests for the residuals of ARDL (2,1,2,3) model

Test	Chi-squared value	p-value
Lagrange multiplier (LM) for serial correlation	0.115556	0.7383
Heteroskedasticity (white test)	0.465456	0.9002

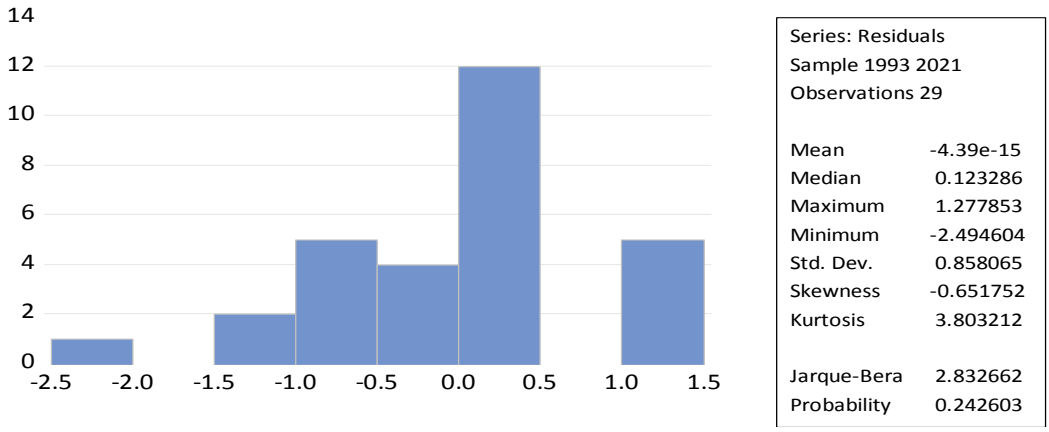

Fig. 6: Histogram and Jarque-Bera normality test for the residuals of ARDL (2,1,2,3) model

4.4 F-Bounds Test

As mentioned before, the bound test determines whether there is a long-run relationship. There are 3 cases according to the value of the F-statistic. First case: if its value is lower than I(0), we don't reject the null hypothesis and conclude that there is no long-run relationship. Second case: if its value is greater than I(1) we will reject the null hypothesis and indicate that there is a long-run relationship. The last case: if its value lies between two bounds we cannot judge. We are in the second case as the value of the F-statistic is greater than the upper bound, concluding that there is a long-run relationship at different levels of significance 1%, 5%, and 10%. See Table 5.

Table 6 shows that the long-run variables have significant effects on the balance of trade. We have a highly significant effect on exchange rates and money, however, FDI is an insignificant variable.

4.5 Error Correction Model

There is cointegration, so the error correction model is specified as follows: ECT shows how much of the disequilibrium is being corrected, i.e., the extent to which any disequilibrium in the previous period is being adjusted at the current point. A positive coefficient indicates a divergence, while a negative coefficient indicates convergence. If the estimate of ECT equals 1, then 100% of the adjustment takes place within the period, or the adjustment is

instantaneous and full. If the estimate of ECT equals 0.5, then 50% of the adjustment takes place each period/year. While if ECT equals 0, this shows that there is no adjustment, and a long-run relationship cannot be confirmed. From Table 7, the ECT is a negative sign and highly significant indicating convergence. We can conclude that 86% of adjustment from the short run to the long run occurs every year, i.e., the adjustment occurs after 1.25 years.

4.6 Diagnostics Tests

Another essential step in estimating the model is to check the model's adequacy before predicting, [20], [21], [22], [23]. Therefore, we checked model stability and diagnosed the residual performance. CUSUM is used to check the stability and accuracy of the estimated model. Figure 3 and Figure 4 confirm that the estimated model satisfies the stability condition as there is no root outside the significance level. The CUSUM of squares stability test of the ARDL (2,1,2,3) model is presented in Figure 5.

The LM test is used for checking the serial correlation of the residuals and the white test is used to inspect the no heteroscedasticity problem. There is no longer a serial correlation between residuals as we don't reject the null hypothesis (Ho: there is no serial correlation). Also, there is no heteroscedasticity problem since we don't reject the null hypothesis of no heteroscedasticity at level 0.05. Moreover, The Jarque-Bera (JB) test is used for checking the normality of the residuals, [24]. JB test indicates the residuals are normally distributed. Estimates of the Chi-square and p-values of the tests are produced in Table 8. The histogram and Jarque-Bera normality test for the residuals of the ARDL (2,1,2,3) model is presented in Figure 6.

5 Conclusion

This study estimated one of the most advanced dynamic models, auto-regressive distributed lag, and investigate the dynamic causal relationship between the trade balance, exchange rate, foreign direct investment (FDI), and money growth in Egypt during the period from 1990 to 2021. The model overcomes the problem of mixed stationary and non-stationary series as it can handle series that integrate from different orders. Moreover, it overcomes the serial correlation that occurs in the least square regression method. The trade balance has a long-run equilibrium relationship with its determinants (exchange rate, money, and Foreign direct investment), and the best ARDL model to describe this relation is ARDL (2,1,2,3). According to our results, the exchange rate is found to have a significant negative effect on the trade balance, The money supply is positively and significantly related to the trade balance while there is no significant effect of foreign direct investment in the long term on the trade balance deficit. We also conclude that 86.5% of adjustment from short run to long run is taken place each year.

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