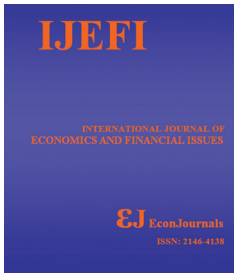

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The Relation between Central Bank Independence and Inflation Rate in Egypt: An Empirical Analysis during 1998-2019

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ABSTRACT

This paper examines the relation between granting central banks more independence represented in both its manifested legal charter as well as actual practices adopted and inflation in Egypt during the period from 1998-2019. To do so, this paper first looks at the evolution of different central bank independence (CBI) measures and adopts the most comprehensive relevant one. Consequently, it runs a regression model adopting an autoregressive distributed lag (ARDL) model, regressing the dependent variable inflation on its determinants of legal CBI, actual CBI, M2 and openness, to capture such relation in both the short and long term time dimensions in the case of Egypt. The paper further provides an interpretation of computed outcomes, where it presents robust evidence of an inverse relation between inflation and CBI in Egypt in the period under study in its legal and actual form and in both the short-run and the long-run.

Keywords: Central Bank Independence, Central Bank of Egypt, Inflation, Autoregressive Distributed Lag, Unit Root Test
JEL Classification: E31, E42, E58, E370

1. INTRODUCTION

During the last decades, monetary authorities were increasingly delegated greater independence from political authority in many countries, to allow monetary policy to achieve its macroeconomic goals of fostering economic growth and employment (Gourinchas, 2010) through stabilizing inflation level[1]. This trend is based on widespread belief that central bank independence (CBI) will allow it to effectively diminish "inflationary bias" from induced political pressures (Rogoff, 1985). Such political pressures resulting in inflationary bias stems from several reasons; the most important of which include: increasing the seigniorage revenue, the balance of payments motivation, and increasing employment (Eijffinger and Hann, 1996). Recent acceleration in more monetary policy independence is advocated by both theoretical and empirical foundation. Theoretically, there is wide consensus that governments can strengthen its commitment to price stability and, therefore, less variability in its inflation level through granting its central banks higher levels independence (Cukierman et al., 1992). Empirically, there are several empirical studies evidencing that, on average, inflation rate is lower at countries enjoying a high degree of CBI, and similar or higher growth rates of per capita income (Kamaly and Farrag, 2005), (Cargill, 2013). Therefore, economic literature includes many studies attempting to tackle different perspectives of CBI ranging from its emergence, measures, and supporting evidence.

Most studies provided theoretical base for the emergence and importance of CBI, while only a few studies attempted to measure it, and even fewer endeavored to assess its impact on macroeconomic variables such as economic growth, and

1 For the purpose of this paper, CBI is defined as the ability to design, articulate and execute monetary policy to achieve its main objective of price stability.

inflation rate. Moreover, studies mainly focused on measuring legal CBI as opposed to actual CBI through relying on indicators as representation for behavioral independence for instance the governor's turnover ratio and his political vulnerability indicator. Moreover, empirical evidence studies were mainly conducted in developed countries with relatively clearer legal charter which allows measuring CBI in an easier and more objective manner.

Of a particular note, Egypt, as a developing country, was excluded from the scope of analysis of most previous studies. Egypt's case appeared in only five studies endeavoring to measure its degree of CBI. The first study was a cross country analysis, including Egypt among the studied sample presented by (Cukierman et al., 1992). The study evaluated the degree of legal and actual CBI for the period from (1950-1989). The second study presented by (Ewiss, 2003) concentrated on computing Egypt's degree of legal CBI before and after law 88 for year 2003. The third study undertaken by (Kamaly and Farrag, 2005) focused on measuring both legal and actual CBI since the establishment of the Central Bank of Egypt (CBE) in 1961 until 2003, hence capturing discrepancies between the legal and actual degree of independence conferred to the CBE. The study pinpointed the indicators that required attention to reinforce CBE's independence. The fourth study conducted by (Awad, 2008) tried to examine the actual independence degree conferred to the central bank of Egypt CBE in light of the legal independence granted to it by the legislation promulgated in 2005. It found that the legal degree of independence granted to the CBE did not confer actual independence. Finally, the last study by (Emam, 2018) aimed to quantify both legal and actual CBI degree over the period (1997-2017) where it designed two comprehensive measures one for measuring legal CBI and the other for actual CBI. The two measures where constructed to measure the degree of CBE's independence and incorporates same variables allowing comparisons between legal and actual CBI.

This study builds on previous studies and goes beyond previous work in that it explores the relation between CBE's Independence and inflation outcomes. The study assesses the relation by capturing both legal and actual CBI, covers the period (1998-2018). The study mainly aims at scrutinizing the impact of increasing monetary policy's effectiveness, through granting independence to the CB to design, formulate and execute its monetary policy away from governmental intervention, will lead to lower inflation rates. This can be done by measuring the degree of CBI and estimating its impact on inflation and other macroeconomic outcomes. The study tried to answer the following basic research questions: is there an inverse relation between CBI and inflation rate? To what extent is the CBE legally and actually independent? Is there an inverse relation between CBI and inflation rate in Egypt? To what extent is Egypt's monetary policy efficient in maintaining inflation at optimal levels?

The rest of this study is arranged in the following order. After the introduction, the second section discusses the literature review that presented different measures to quantify CBI. Section three shows data sources and methodology. Section four runs the econometric model and shows its results, while the last section shows the conclusion.

2. LITERATURE REVIEW

The greatest challenge in examining CBI is measuring it. This literature review focuses on the theoretical and empirical studies that developed indices to measure CBI. It is important to differentiate between legal CBI and actual CBI. Legal CBI reflects the level of independence granted to the central bank by law. Focusing only on central bank laws and related legislations is necessary but not sufficient reflection of CBI since laws can be incomplete without explicit limitations of authority among CB and political authority under all aspects. Moreover, actual practice might really deviate from legislated laws supposing that such laws were quite explicit. Consequently, the need for actual CBI measures aroused. This section will illustrate main CBI indices under each category.

The first quantitative index for legal CBI was designed by (Bade and Parkin, 1977) where they built a scale for CBI ranging from (1-4) for 12 countries referring to lowest and highest level of independence respectively. It focused on measuring the political and financial independence of a central bank using three main indicators. The first indicator assesses the CB and the government's relation regarding the monetary policy's selection, designation and execution. The second indicator is concerned with the procedures of appointment of board members of the central bank. The third indicator reflects the degree of control exercised by the government over the CB[2]. The study concluded that there is a direct link between CB's authority in managing monetary policy and its ability to independently appoint the members of its board. Moreover, a CB cannot independently appoint its board members if it is deprived of the power to manage its monetary policy. Additionally, a CB that possesses the authority of managing its monetary policy implies the non-existence of government representation in its board of members. On the other hand, the "financial independence" is taken to depend on the institutional framework of financial and budgetary relationship amongst the CB and the government based on three factors; whether CB's financial statements are independent from the government, the authority responsible for determining CB's board salaries and whether the government approval for CB's dividends distribution is required. They concluded that a CB that can decide to distribute dividends independently from any governmental intervention enjoys financial independence.

Alesina in 1988 expanded (Bade and Parkin, 1977) index by adding a fourth indicator relating to monetary financing rules by assessing CB's obligation to extend credit to the government through buying Treasury bills. (Alesina, 1988) examined how CBI affected the extent of political impact on the economy as a whole and specifically monetary policy. In other words, an independent central bank can decrease inflationary bias thus diminishing monetary policy volatility and high inflation induced politically by the elections cycle.

2 The third indicator concerning financial independence is based on "bureaucratic" models, where CBs are perceived as bureaucratic bodies with the goal of maximizing their influence.

Grilli et al. (1991) constructed a more comprehensive index of legal CBI reflecting both "political" and "economic" independence. The index captured 15 indicators; eight of which reflect political independence whereas the remaining seven reflected economic independence. They adopted (Bade and Parkin, 1977) definition of political independence, as CB's ability to choose its policy objectives without political influence. Economic independence is well-defined as CB's ability to adopt monetary policy instruments without restriction. The greatest constrain levied on monetary policy conduct is the CB's obligation to finance budget deficit. In conclusion, the index formally introduced "economic independence" and placed more weight on the extended model of (Bade and Parkin, 1977) as presented by Alesina in 1988 on rules concerning monetary financing of government's deficits.

Cukierman et al. (1992) presented three indices for measuring CBI and its relation to inflation. The first index for measuring legal CBI consisted of sixteen indicators grouped into four clusters; two of which are concerned with the internal relations of the central bank which focused on (a) the appointment, dismissal and term of office of the central bank's governor, and (b) the central bank's objective. On the other hand, other clusters aimed to regulate the central bank's external relation with the government as evident in (c) the policy formulation cluster, which focus on monetary policy conflict resolution between the central bank and the government and the CB's participation in the budgeting process and finally the last cluster (d) limitation on central bank's lending to the public sector. The other two indices captured the spirit of the law by initiating two indices to measure actual independence-illustrated later; the governor's turnover index TOR and a questionnaire based index. Worth noting that the study implied major importance to the economic indicators expressed by the limitations on central bank's ability to extend credit to the government since it assigned 50% of the whole index weight to this cluster solely.

Eijffinger and Schaling, 1993 developed a new index of legal CBI. This index represents an expansion of the studies by Bade and Parkin (1977), Grilli et al. (1991), where political independence is well-defined as central bank's capacity to pick from the ultimate goals of the monetary policy, and is assessed by three indicators similar to those distinguished in the previous studies. The study's important contribution is the introduction of the concept of "twin authority" where monetary policy articulation authority is distributed among the central bank and the government. Eijffinger and Schaling, (1993) arrived at two conclusions; first, a "twin authority" central bank that has a government official on its board does not exist. Second, there does not exist any twin authority bank that is able to appoint some board members independent of the government. However, it is important to note that this index ignored the economic independence that was coined by Grilli et al.(1991).

Lybek (1999) tailored an index to cover the guidelines used by the IMF in determining legal CBI. He built upon (Briault et al., 1996)[3] and developed an index covering both independence and accountability. The index is based on twenty one indicators that include most of the previously used indicators in Grilli et al. (1991), Cukierman et al. (1992), (Eijffinger and Schaling, 1993), Bade and Parkin (1982), Alesina (1988), in one form or another but they are more detailed and comprehensive. The twenty one indicators can be grouped into four main clusters as follows; (a) objective independence, (b) political independence, (c) economic independence, and (d) accountability indicators.

Jacome, 2001 designed a legal CBI and accountability index. He expanded traditional indices using more or less same political and economic indicators determined by previous studies (Grilli et al., 1991) (Cukierman et al., 1992) yet with some adjustments. The index incorporates indicators of financial independence, accountability and transparency as determined by (Lybek, 1999) in addition to adding indicators concerning the central bank as a lender of last resort LOLR which is viewed as his ultimate contribution. In particular, this index included the following additional features; (a) in terms of political independence, it not only addressed governmental representation in the central bank's board, but extended to include private sector participation/ representation in the board on the notion that private sector participation (representing profit maximizing activities) in monetary, financial, and exchange rate decisions might hinder CB from achieving its primary long term goal of price stability. This is because CB decisions should prioritize long term objective, while profit maximizing private agents will favor short term policy decisions, (b) adding an indicator for the role of the CB as a lender of last resort implying that CBs will be responsible for the financial system's stability, (c) in terms of economic independence government interference in exchange rate policy formulation is penalized unless there is a clear law granting CB the upper hand in case of conflict, (d) concerning financial independence, the index gives high weight to assessing integrity of the CBs capital where CB can only transfer its excess profits to the government after having an sufficient legal reserves balance; and government will be responsible to cover any CBs losses resulting from any quasi fiscal operations conducted by the CB to support the government, (e) lastly, it includes criteria for CB accountability, comprising among other things, transparency in both demonstrating bank operations and disclosing its financial statements.

Jacome and Vazquez, 2005 built on the structure of Cukierman et al. (1992). It maintained the four general clusters being; criteria relating to central bank's governor, CB's independence in policy formation, CB's objective, and limitations on CB's lending while it changed some of their aspects. In addition to, adding a new category to measure CB accountability. Four main differences were coined; (a) it expanded it to include not only the appointment and dismissal of the governor but also the whole board, adopted a different perspective of assessing terms of office of the government and board instead of looking at merely the time frame, it considered the overlapping with the presidential tenure, to assure independence from political cycles. Further, emphasized restriction on the government to dismiss any of the board members not just the governor. (b) Regarding central bank's independence in formulating its monetary policy; it included the scope to ensure central bank's independence in formulating exchange

3 (Briault, Haldane, & King, 1996) were the first to introduce indicators concerning the accountability and transparency in their accountability index which focused on monetary policy arguing that it can reduce inflation bias arising from uncertainty.

rate policy. (c) Economic independence; it added two indicators lender of last resort and an indicator for safeguarding CB financial independence. (d) Finally, it added the indicator for accountability through requiring CBs to report regularly their policy targets and achievements. Additionally, it favors the obligation to publish central bank's financial statements regularly especially in case the financial statements are audited by a certified independent auditor and disclosures follow international accounting standards.

Smaghi (2008) was the first to shed light on the practical problems arising upon assessing the effectiveness of CBI, where previous studies all focused on the theoretical and formal aspects of CBI. In his study, four categories of CBI were coined; First, functional independence defined as CB's freedom and independence in setting its policy instruments to achieve its objectives. Second, intuitional independence defined as the overall institution's independence within the various organs of the government's constellation. Third, personal independence concerned with the nomination and dismissal of the CB's board and governor though might be responsibility of the government but has to follow some common criteria such as term of office, professional qualification, political affiliation and collegiality. Lastly, financial independence.

Pisha (2011) established a new index for measuring legal CBI based on the requirements for CBI as instructed by the European Monetary Union EMU for the pre-accession and integration of any country. Therefore, sometimes called "Eurozone index." The index is based on work presented by Smaghi (2008), where 26 indicators each covering a different aspect of legal CBI were grouped into the same four categories of (Smaghi, 2008). Functional CBI is based on two main aspects; (a) The central bank's primary objective, and (b) its secondary objective. Institutional independence is based on three aspects; (a) central bank's independence in monetary policy formulation of its primary objective, (b) its independence in its secondary objective, and (c) the degree of central bank's independence from any governmental interference. Personal CBI based on eleven indicators categorized into four main groups related to the term of office, professional qualifications, political affiliations and collegiality. Indicators include government term of office, governors and board reappointment possibilities, responsibility of re-appointing the governor, nomination of the governor and board members, composition of the central bank's board, tenure of the board's term of office, responsibility of proposing the board members, governor and board dismissal options, and incompatibility clause for board members. Financial and budgetary CBI based on seven indicators grouped into two main categories; first limitation on government spending where two indicators are coined (a) direct credit prohibition/limitation and (b) indirect credit prohibition/limitation. Second, budgetary CBI where five main indicators where proposed; (a) Budget and net worth ownership, (b) budget management, (c) allocation of profits, (d) central bank's residual to statutory reserves and (e) coverage of potential losses.

Dincer and Eichengreen, 2014 provided new measures of transparency supplementing the literature for new measure of CBI. Their measure extended the criteria developed by Cukierman et al. (1992) adding other aspects to the sixteen indicators to reach twenty four indicator as emphasized by subsequent literature to Cukierman et al. (1992). The added indicators include limitations on the re-appointment of the central bank's board and governor, government representation on the board as proposed by Bade and Parkin (1982), (Eijffinger and Schaling, 1993), (Grilli et al., 1991) and (Jacome and Vazquez, 2005) and government involvement in the formation of exchange rate policy as emphasized by (Jacome and Vazquez, 2005). The twenty four indicators were aggregated into five clusters; first cluster includes five indicators concerned with the appointment of the governor. Second cluster consists of four indicators focusing on policy formulation. Third cluster reflects one indicator regarding the objective of the monetary policy. The forth cluster embraces four indicators analyzing limits on lending. Lastly, the fifth cluster comprises six indicators depicting central bank's board members.

Emam, 2018 constructed two new comprehensive indices for measuring CBI in Egypt between (1997 and 2017); one covering the legal attributes-which is analyzed here- and the other covers actual CBI attributes-will be illustrated later. The index is constructed into ten clusters; each cluster was divided into several indicators; with a total of thirty three indicators as follows. The first cluster, addresses one indicator favoring setting price stability as the CB's main objective. Second cluster reflects two indicators related to policy formation; (a) monetary policy formulation responsibility, and (b) the final authority in conflict resolution. The third cluster includes five indicators assessing central bank governor's independence from any political pressures focusing on terms of office, his re-appointment possibilities, the appointment and dismissal procedures, and an incompatibility clause. The forth cluster comprise of six indicators addressing central bank's board term of office, re-appointment possibilities, appointment and dismissal procedures, incompatibility clause and the composition of the central bank's board (i.e., governmental or private representation in the board). The fifth cluster embraces eight indicators focusing on limitations on monetary policy financing limitations where the index favored prohibiting direct and indirect credit to the government in terms of amount, maturity, interest rate, potential borrowers, participation in the primary market for government debt. The sixth cluster holds one indicator favoring limiting playing the role of lender of last resort. The seventh cluster consists of four indicators assessing central bank's financial independence in terms of ownership of central bank's capital, its ability to determine its internal budget and its top official's salaries in addition to its ability to freely allocate its profits for internal use without government's intervention. The eight cluster, is made up of three indicators concerned with accountability such criteria include who the central bank should appear before/ account to, who is responsible for auditing central bank's financial statements and the periodic disclosure of central banks financial statements. The ninth cluster involves two indicators evaluating the degree of transparency the central bank is obliged to adopt by looking into its obligation to publish reports on monetary variables and inflation reports, as well as disclosing any policy changes to the people. Finally, the tenth cluster holds one indicator assessing who is in charge of formulating and executing the exchange rate policy. Each of the above indicators takes a value ranging from zero to one depending on its degree of independence from the

lowest to the highest respectively. The index follows a two-step aggregation process. On one hand, the thirty three indicators are aggregated into ten clusters. On the other hand, the ten clusters are further grouped to produce a single index computing the amount of CBI. Each cluster has equal weights to reduce the degree of subjectivity; where each group's criteria were added up to one. Hence, the index will result into a value ranging from zero to a maximum of ten reflecting the highest degree possible for CBI.

The study by (Emam, 2018) incorporated indicators enjoying a large degree of consensus among economists into a unified index, was based on information written in the legal documents covering CB; hence, it represents a fairly objective measure. That's why her numerical results for CBI will be used to conduct the econometric model in this study.

All the above measures focused mainly on legal CBI whose major defect arises from inability to reflect actual relation between CBs and governments in reality. This may be the case since laws are usually incomplete in unambiguously addressing all authority limits between the central bank and external intervention, leaving room for interpretation. In addition to the fact that even if adopted laws are quite explicit, many deviations can occur in actual practice. Consequently, some advocates called for the need for different indices that capture actual CBI. The economic literature is fairly limited in addressing actual CBI as opposed to that addressing legal CBI. Below are the main attempts in this regards.

Cukierman et al. (1992) were the first to introduce the concept of actual CBI. They developed two measures for actual CBI; the first by looking into the actual frequency of change of the governor, and the second was built on the replies to a questionnaire that they directed to experts in different countries. Their turnover of central bank governors' TOR measure favored low turnover based on the following assumptions; (a) if political authorities can frequently choose a new governor, then it follows that they will elect those who will do their will, (b) the high turnover rate may be a reflection of the frequent firing of the governors who defy the governments will, (c) governments may be inclined to appoint a governor with reputation of some independence i.e., to use up the governors reputation, to have a bigger chance in temporarily stimulating output and then fire him, (d) if the governor's tenure is shorter relative to the government's tenure, then the governor can be a target for political pressures and hence discouraged from adopting long term policies. Their second index addressed seven indicators based on nine questions sent to experts in twenty three countries. The indicators looked at governor's and board of members term of office, actual limitations on lending in practice, the actual degree to which central bank's will supersedes in any conflict with the political authorities, CB's budget determination, the setting of salaries of central bank's top officials, the monetary stock or interest rates[4] targets relative importance, price stability's relative importance and the magnitude to which the CB is allowed to extend credit to cover budget deficits.

4 Money stock target enhances price stability, since the bank can adhere to them when faced by governmental pressures. A target for the nominal interest rate, will limit the bank's ability to respond to inflation upsurges.

Cukierman and Webb (1995) developed a new measure for actual CBI by looking at the political vulnerability of central bank's governor. Such political vulnerability was assessed by examining the likelihood of replacing the governor just after a political change of government. To this end, they introduce the terms of "political period" and "non-political period." In the presence of heavy political influence, there is high propensity for the governor to lose office in periods immediately after political transition "political periods," than in non-political periods.

Emam (2018) established another comprehensive index for measuring actual CBI in the same manner of her legal CBI measure. The index is built up in the same methodology of her legal CBI measure, but here five more indicators were added being; the existence of an explicit target for inflation, politically inspired dismissals for the governor and board, release inflation and monetary variables forecasts along with used models and finally disclosing minutes of Monetary Policy Committee MPC minutes.

3. METHODOLOGY AND THE DATA

The key question this study investigates is whether there is an inverse relation between increasing CBI and inflation rate by applying it to the Egyptian case. To answer this question, the study runs regression models, regressing the dependent variable inflation on the independent variables being: legal CBI, actual CBI TOR, M2 and openness, to assess the relationship.

We used the consumer price index as proxy for inflation rate, M2 as a proportion to GDP, trade percentage to GDP as a proxy for openness, legal and actual CBI as derived by (Emam, 2018). For the purpose of empirically assessing CBI in Egypt, this study is based on 22 years of data from 1998 to 2019. The sample was chosen due to the availability of needed variables, especially because data on both legal and actual CBI in Egypt are not available. To overcome the problems associated with small samples, quarterly data has been used resulting in a large sample of 88 observations for each variable. The data has been obtained from different sources; quarterly data for CPI and M2 were derived from the International Financial Statistics IFS published by the International Monetary Fund IMF data. Nevertheless, only yearly data for openness was found in the World Development Indicators published by the World Bank data which were then transformed into quarterly data using e-views applying interpolation technique of second degree since openness takes a curved shape as per Graph 1.

Moreover, legal CBI and actual CBI TOR values were transformed into quarterly data in the same manner.

To provide an initial view at the data involved in the regression models under study, Table 1 presents descriptive statistics of the indicators adopted in the regression models. The presented key figures include the following: mean, median, standard deviation, minimum and maximum values. Table 1 is produced to provide an overall description of the data involved in the model and assists in data screening to pinpoint arbitrary figures. The summary statistics for selected variables is presented as follows:

Table 1: The descriptive statistics of all indicators

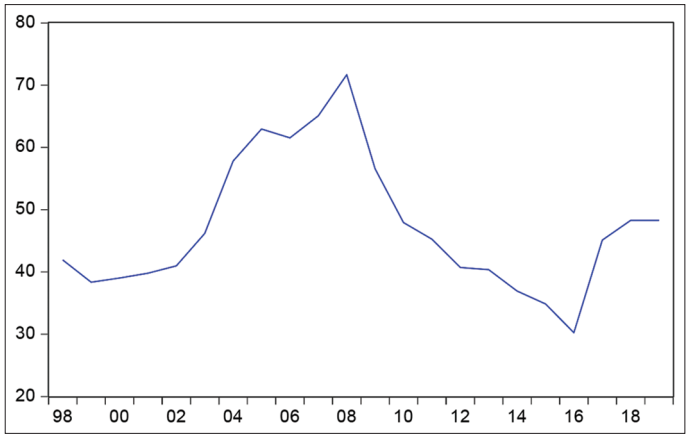
Statistics	CPI	LCBI	M2	OPENNESS	TOR
Mean	109.3386	5.258887	1103143	47.26637	5.871615
Median	84.27539	5.867608	799990.5	44.61433	6.697870
Maximum	292.2613	6.310529	3137740.	72.89246	7.504987
Minimum	42.47898	2.285338	211560.0	28.92763	1.455166
SD	72.72001	1.186677	903224.7	10.78525	1.812635
Jarque-Bera[5]	20.94218	16.11045	16.49560	7.687102	14.09562
Probability	0.000028	0.000317	0.000262	0.021417	0.000869
Observations	88	88	88	88	88

The following conclusions are drawn from the above table:

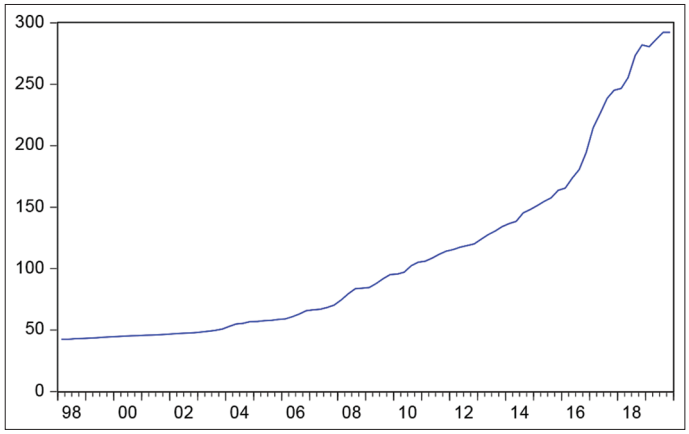
- Mean of the inflation rate represented in CPI is 109.339 with a median of 84.275, standard deviation of 72.72, minimum value of 42.479 and maximum value of 292.26. By looking at the p-value for Jarque-Bera test, it is obvious that inflation rate is not normally distributed at 95% level of confidence.
- Mean of the legal central bank independence represented in LCBI is 5.26 with a median of 5.87, standard deviation of 1.19, minimum value of 2.285 and maximum value of 6.31. By looking at the p-value for Jarque-Bera test, it is obvious that LCBI is not normally distributed at 95% level of confidence.
- Mean of the money supply in the economy as a percentage of GDP represented in M2 is 1103143 with a median of 799990.5, standard deviation of 903224.7, minimum value of 211560 and maximum value of 3137740. By looking at the p-value for Jarque-Bera test, it is obvious that M2 is not normally distributed at 95% level of confidence.
- Mean of the openness variable is 47.27 with a median of 44.61, standard deviation of 10.79, minimum value of 28.93 and maximum value of 72.89. By looking at the p-value for Jarque-Bera test, it is obvious that openness is not normally distributed at 95% level of confidence.
- Mean of the actual central bank independence represented in TOR is 5.87 with a median of 6.70, standard deviation of 1.81, minimum value of 1.46 and maximum value of 7.50. By looking at the p-value for Jarque-Bera test, it is obvious that TOR is not normally distributed at 95% level of confidence.

Moreover, the below Graph 2 depicts that inflation rate increased throughout the years under study.

Graph 1: Openness



Graph 2: CPI



4. ECONOMETRIC RESULTS

To investigate the existence of a link between Central bank independence CBI and inflation rate in the Egyptian economy, the study regressed inflation on two indices of central bank independence; one reflecting legal independence while the other assessed its actual independence, M2 as a proportional to GDP and level of openness in the country. The following simple regression model is studied.

$$\text{Inflation (CPI)} = a + b\,\text{LCBI} + c\,\text{M2} + d\,\text{openness} + f\,\text{TOR} + e \quad (1)$$

Where, Inflation is measured by consumer price index (CPI), LCBI is the legal index for CBI of CBE, M2 is Money supply as a proportion to GDP, Openness is the summation of exports and imports as a proportion to GDP, TOR is the CBE governor's turnover, and e: is the error term.

To estimate the above relationship, time series models will be put in use due to the data's nature. Since several time series exist, Autoregressive moving average ARMA models cannot be used. Instead, Vector autoregressive VAR models will be adopted. As a first step, assessing the stationarity of the underlying time series is essential. Unit root tests are used to statistically analyze the level of stationarity in any series.

Augmented Dickey-Fuller ADF test is used to assess the stationarity in a given series, where the null hypothesis of ADF is unit root is present in the series. In other words, the null hypothesis is data is non-stationary. The null hypothesis is not rejected if p-value is bigger than 5%. Rejecting the null means the series is

5 The Jarque–Bera test is conducted to estimate the goodness of fit to assess if the sample data is characterized by a skewness level similar to a normal distribution. The test statistic is always positive. The further it is from zero, the more it indicates that data is not normally distributed.

stationary, whereas not rejecting the null hypothesis indicates a non-stationary series.

Differencing[6] is a mean used to change a non-stationary series into a stationary one. A series is integrated of first order and denoted by I(1) in case the time series becomes stationary after differencing one time. Correspondingly, it can be deduced, that a time series is integrated of order two and demoted by I(2), in case it has to be differenced twice to make it stationary. Needless to mention that stationary series do not need to be differenced, and are denoted by I(0).

Worth noting that difference signifies short run changes only in the time series but ignores completely long term information. To study the existence of a probable long run relationship, conducting co-integration tests[7] is essential.

Table 2 shows Augmented Dickey-Fuller unit root tests results of the understudied variables.

The unit root test on quarterly series of CPI, M2, openness, LCBI and TOR at the level of data and in the converted time series after taking differences[8] and including intercept were carried based on the Augmented Dickey-Fuller test. The stationarity test conducted (ADF) reveals that all five variables are non-stationary at the data level. The level series of CPI, M2 and openness converts to stationary ones at first difference. Nevertheless, LCBI and TOR remain non-stationary at first difference. However, both LCBI and TOR become stationary at second difference.

Now we will have to assess any probable long run relationship so there is a need to test for co-integration. To recap, the main aim is to examine the short and long term relationships between inflation and its determinants. This can be done using co-integration analysis and error correction model. It is essential to properly choose the appropriate technique to be used to test for co-integration to arrive at unbiased results. Therefore, co-integration test and error correction model are used within the an ARDL framework because Johansen co-integration test cannot be used if the variables of interest are not all I(1). That is, it is not applicable for mixed order of integration for the variables of interest or all of them are not non-stationary. Since the above variables depicit mixed order of integration and are non-stationary, therefore, an alternative method is needed, hence, autoregressive distributed lag ARDL model will be put in use.

An autoregressive distributed lag (ARDL) models can be used if the models are of mixed orders or some of them are non-stationary. It takes several lags sufficient enough to capture the data generating process in a general-to-specific modeling framework.

Deriving a dynamic error correction model (ECM) from ARDL can be done using a simple linear transformation. Also, the ECM is used to integrate short-term with long-term equilibrium without dropping long-term information and circumvents complications that can occur as a result of non-stationary time series data such as spurious relationship (Shrestha and Bhatta, 2018).

To demonstrate the ARDL modeling approach, let us consider the following simple model:

$$y_t = \propto + \beta x_t + \delta z_t + e_t \quad (2)$$

The ARDL model error correction version is illustrated as follows:

$$\Delta y_t = \alpha_0 + \sum_{i=1}^{p} \beta_i \Delta y_{t-i} + \sum_{i=1}^{p} \delta_i \Delta x_{t-i} + \sum_{i=1}^{p} \gamma_i \Delta z_{t-i} + \lambda_1 y_{t-1} + \lambda_2 x_{t-1} + \lambda_3 z_{t-1} + u_t \quad (3)$$

Analyzing the above equation, equation (3), it is obvious that the first part of the equation encompassing the model's short run dynamics depicted by β, δ, and γ. Whereas, the second part of the equation focuses on the long run relationships as reflected by λ_s. The null hypothesis in the equation is $\lambda_1+\lambda_2+\lambda_3=0$, which demonstrates non-presence of long term relation.

Before running the ARDL model, it is vital to check for correlation[9] among the independent variables. For a correlation relation to

6 Non-stationary data that is characterized by long run trend can be transformed into a stationary one through a) including time variable in the regression or b) running one of the popular techniques to extract trends and cycles from the single series such as Hodrick Prescott (HP) filter. For more information look at (Shrestha & Bhatta, 2018).

7 Co-integration is a form of test conducted to examine the level of non-stationary in a given series whose variance and mean fluctuate over time. i.e., co-integration is used in estimating the long-run parameters or the system's equilibrium using unit root variables.

8 The appropriate lag lengths were determined based on the Schwartz Bayesian criterion, also p-value are calculated using MacKinnon (1996) one-sided p-values.

9 Correlation analysis is a statistical method utilized to assess the relationship robustness among two quantitative variables. A high correlation denotes strong relation between two or more variables, while a weak correlation implies that the variables are hardly related.

Table 2: Augmented Dickey-Fuller unit root tests results

Variable	ADF	p value
CPI	−0.104	0.9941
ΔCPI	−5.300239	0.0002
M2	−0.282357	0.99
ΔM2	−7.311634	0
LCBI	−2.26389	0.4486
ΔLCBI	0.078444	0.9966
Δ^2 LCBI	−9.007841	0
TOR	−2.263975	0.4485
ΔTOR	0.266228	0.9982
Δ^2 TOR	−8.890764	0
Openness	−2.371087	0.3915
Δopenness	−4.281224	0.0057

*10%, **5%, ***1% significance, ADF t-stat. reported. Note: an intercept is included in the DF test. The suitable lag lengths were chosen according to the Schwartz Bayesian criteria, also P-value are calculated using MacKinnon (1996) one-sided P-values.

Table 3: Checking for correlation among independent variables

	LCBI	M2	OPENNESS	TOR
LCBI	1			
M2	0.654571***	1		
OPENNESS	0.120504	−0.209052*	1	
TOR	0.998432***	0.694950***	0.091878	1

*10%, **5%, ***1% significance

exist, the absolute value of the correlation coefficients should be >0.7. Table 3 shows correlation coefficient results among the independent variables understudy.

From the above table, it is obvious the existence of a strong correlation between legal central bank independence LCBI and actual central bank independence TOR. Consequently, the estimation of two models will be conducted to overcome this problem and avoid multicollinearity.

The first model:

$$Inf = a + b\ LCBI + c\ ln\ (M2) + d\ openness + e \quad (4)$$

The second model:

$$Inf = a + b\ TOR + c\ ln\ (M2) + d\ openness + e \quad (5)$$

Starting with the first model:

$$Inf = a + b\ LCBI + c\ ln\ (M2) + d\ openness + e \quad (6)$$

First: Applying ARDL Bounds test for co-integration for the first model.

The presence of a co-integration relationship of the dependent variable inflation and its determinants will be tested using ARDL Bounds tests for co-integration. The bounds test is chiefly based on the joint F-statistic under the null hypothesis of no co-integration. For a given significance level, two sets of critical values can be determined (Persaran et al., 2001). The first set of critical values are created supposing that all the ARDL model variables are stationary at level of data, whereas the second set of critical values are computed based on the notion that those variables are integrated of first order. In the first level, the null hypothesis is there is no co-integration between variables, in other words, there is not any long term relation between the variables understudy. In the second level, the null hypothesis is there is at least one long term relation among variables. The null hypothesis of no co-integration is not rejected when the F-statistic is lower than the lower bounds value, whereas it is rejected in case the value of the test statistic is greater than the upper critical bounds value. Table 4 shows outcomes for the relation between the dependent variable inflation and its determinants as denoted by the bound test for co-integration.

From Table 4 below results, a long run relation between the variables understudy is evident upon regressing the dependent variable inflation on its determinants since its F-statistic value of 5.58 is lower than the upper-bound critical value 5.605 at 95% level of confidence, besides it is also lower than the upper bound critical value 5.61 at the 99% confidence. This indicates that the null hypothesis referring to the existence of at least one long term relation among variables is not rejected.

Second: The ARDL long-run model for inflation.

Once co-integration is established, the long run relationship between inflation and its determinants can be estimated using the

Table 4: Bound test for co-integration relation

K	Bounds test critical values of the F-Stat.: intercept and no trend (Case II)					
	90% confidence*		95% confidence**		99% confidence***	
3	I (0)	I (1)	I (0)	I (1)	I (0)	I (1)
	2.72	3.77	3.23	5.605	4.29	5.61
	Calculated F-Statistic: F inflation (inflation, LCBI, M2,openness)					5.58***

*10%, **5%, ***1% significance

Table 5: ARDL long run coefficient outcomes

Variables	Coeff.	Standard Err.	T-stat.	Probability
LCBI	−74.133088	14.668173	−5.05401	0
LNM2	138.641066	24.896992	5.568587	0
OPENNESS	0.811414	0.443574	1.829263	0.0714
C	−1341.590501	405.27	−3.31036	0.0014

ARDL long-run model, where its outcomes are shown in Table 5. Model was estimated applying 4 lag periods based on Akaike's Information Criteria AIC[10] for the dependent variable (inflation) which is consistent with the quarterly data's nature, while only one lagged period for the independent variables taking into account the small sample size.

From the above table, the following conclusions can be interpreted;

- There is a long term inverse relation between legal central bank independence and inflation rate at 95% confidence level as evident by a P < 5%. In other words, increasing legal CBI by 1% will result in decreasing inflation rate by 74% in the long run with other variables remain unchanged.
- A positive relationship for logarithm of the money supply in the economy represented by LNM2 and inflation rate in the long run with 95% confidence level as evident by a P < 5%. In other words, increasing money supply by 1% will result in increasing inflation rate by 139% in the long run based on the assumption that former variables are unchanged.
- There is a positive relationship for openness of the economy and inflation rate in the long run with 90% confidence level as evident by a p < 10%. In other words, increasing openness by 1% will result in increasing inflation rate by 81% in the long run assuming that other variables remain unchanged.

Third: The ARDL short-run model for inflation.

After estimating the long term co-integrating model, it is time to move to the next step by including the short-run parameters in the ARDL modeling framework. Accordingly, the ARDL model will continue to retain the lagged values of all level variables (a linear combination is denoted by the error-correction term[11], ECMt-1). Table 6 reflects the estimated outcomes of the error-correction model of inflation for the Egyptian case using the ARDL method.

10 The Akaike information criterion (AIC) is a test that evaluates the level of lost information by the model whereas the less amount of information lost by a given model, the better quality it possesses.

11 An error correction model (ECM) are mainly used in time series models characterized by long term stochastic trends i.e., cointegrated. These models predict the time dimension effect in both the long and short term of a series on another.

The model is chosen based on the Akaike's Information Criteria AIC.

From Table 6, the following conclusions can be interpreted;

- There is a short term inverse relation between legal CBI and inflation rate in the short run at 95% confidence level as evident by a P < 5%. In other words, increasing legal CBI by 1% will result in decreasing inflation rate by 101% in the short run with other variables remain unchanged. This conclusion is consistent with the one derived when estimating long run relationships, though it is evident that legal central bank's independence impact on inflation rate in Egypt is higher in the short run than in the long run.
- A positive relationship for the money supply in the Egyptian economy represented by LNM2 and inflation rate in the short run with 95% confidence level as evident by a p-value of <5%. In other words, increasing money supply in the Egyptian economy by 1% will result in increasing inflation rate by 11% in the short run assuming that other variables remain unchanged. This interpretation is also in line with its long term relationship, yet, it should be noted that money supply effect on inflation is higher in the long-run than in the short-run.
- A positive relationship for openness of the economy and inflation rate in the short run with 95% confidence level as evident by a p-value of <5%. In other words, increasing openness by 1% will result in increasing inflation rate by 0.5% in the short run assuming that other variables remain unchanged. This interpretation is consistent with its long term relationship in the case of Egypt, yet, it should be noted that openness effect on inflation is much higher in the long term than in the short term.
- The estimated coefficient for the error correction term denoted by $ECM^{(\tau-1)}$ of 8% means that around 8% of the deviations from the long term relationship is being adjusted in its respective quarterly short term.

After estimating first models results, of regressing the dependent variable inflation and its determinants being; legal central bank independence, money supply and openness in the economy of Egypt in both the short and the long intervals. It is important to conduct diagnostic test to verify the robustness of the estimated coefficients. One of the important tests to be conducted is the residual diagnostic test. Residual diagnostic test concerned with minimizing errors or residuals of the regression model will be implemented to ensure that the error term is white noise (independently and identically distributed, i.i.d). Table 7 reflects diagnostic test applied.

The below two tables; Tables 7 and 8 reveal that there is no autocorrelation since Durbin Watson statistic value is close to the value 2. Moreover, looking at Q-statistics for residuals confirms the non-existence of autocorrelation since p-value is bigger than 0.05. This result is also supported by Graph 3 where residuals are randomly scattered in addition to the fact that actual and fitted values are almost identical. Furthermore, it is evident from Table 7 that R-square value of 0.999254 which is very close to one indicating the model's robustness.

Table 6: Error-correction model of inflation

Variables	Coeff.	Standard Err.	T-stat.	Probability
D(CPI(-1))	0.244709	0.107081	2.285271	0.0252
D(CPI(-2))	−0.30678	0.10014	−3.06355	0.0031
D(CPI(-3))	0.137365	0.098289	1.397562	0.1664
D(LCBI)	−101.189	51.89034	−1.95005	0.055
D(LNM2)	11.38573	4.350935	2.616845	0.0108
D(OPENNESS)	0.50847	0.131155	3.876857	0.0002
ECM(t-1)	−0.08212	0.022604	−3.63316	0.0005

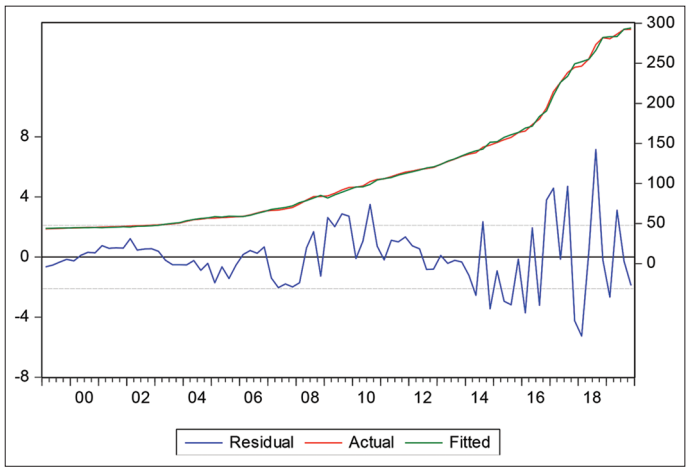
Table 7: Robustness tests

R-squared	0.999254	Mean dep. vari	112.5095
Adj. R-squared	0.999163	S.D. dep. vari	72.93268
Standard Error of reg.	2.109719	Akaike inf. Crit. AIC	4.442330
Sum sq. residual	329.3676	Schwarz criteria	4.731713
Log likelihood	−176.5779	Hannan Quinn crit.	4.558659
F-stat.	11013.03	Durbin Watson DWstat.	1.777881
Probability (F-stat.)	0.000000		

Table 8: Q-statistics for residuals

	AC	PAC	Q-Stat	Probability*
1	0.105	0.105	0.9606	0.327
2	−0.002	−0.013	0.9609	0.618
3	0.126	0.129	2.3709	0.499
4	0.012	−0.016	2.3840	0.666
5	0.045	0.050	2.5657	0.767
6	−0.070	−0.099	3.0171	0.807
7	0.175	0.204	5.8741	0.555
8	−0.160	−0.243	8.3167	0.403
9	0.040	0.162	8.4725	0.487
10	0.044	−0.088	8.6630	0.564
11	−0.134	−0.036	10.449	0.491
12	−0.016	−0.072	10.476	0.574

Graph 3



4.1. The Second Model

Now we revert back to our second model, which is concerned with assessing the impact of actual CBI on inflation rate, expressed as follows:

$$Inf = a + b\ TOR + c\ ln\ (M2) + d\ openness + e \quad (7)$$

First: Applying ARDL Bounds tests for co-integration for the second model.

The presence of a co-integration relationship of the dependent variable inflation and its determinants being; actual central bank independence TOR, money supply and openness, will be tested using ARDL Bounds tests for co-integration. As previously illustrated, the null hypothesis of no co-integration is rejected when the value of the test statistic is greater than the upper critical bounds value. Table 9 shows outcomes of the bound test conducted for assessing the co-integration relation of the dependent variable inflation and its determinants.

From Table 9, it is easy to conclude the existence of long term relation between the different variables understudy assuming inflation is the dependent variable since its F-statistic value of 5.58 is lowers than the upper-bound critical value 5.605 at the 95% confidence, similarly it is also lower than the upper bound critical value 5.61 at the 99% confidence. Hence, it is evident that the null hypothesis demonstrating the existence of at least one long term relation among variables is not rejected.

Worth noting that Table 9, assessing co-integration relations between inflation and actual CBI TOR among other independent variables, is identical to Table 4 assessing the co-integration relations between inflation and legal CBI among other independent variables. This is a result of the high correlation between legal and actual CBI, as it is an almost perfect relation.

Second: The ARDL long-run model for inflation.

Once co-integration is established, the long run relationship between inflation and its determinants can be estimated using the ARDL long-term model, where its outcomes are illustrated in Table 10 below. Model was estimated applying 4 lag periods based on Akaike's Information Criteria AIC for the dependent variable (inflation) which is consistent with the quarterly data's nature, while only one lagged period for the independent variables taking into account the small sample size.

From Table 10, it is easy to derive the following conclusions

- An inverse relation is evident between actual CBI and inflation rate in Egypt in the long run at 95% confidence level as evident by a p-value of <5%. In other words, increasing TOR by 1% will result in decreasing inflation rate by 53% in the long run with other variables remaining constant. It is worth noting that higher coefficient resulted in considering the relation between legal CBI and inflation. In other words, first model's results were more effective indicating a deviation between legal framework for CBI and actual practices adopted.
- A positive relationship for logarithm of the money supply in the economy represented by LNM2 and inflation rate in Egypt in the long run with 95% confidence level as evident by a p-value of <5%. In other words, increasing money supply by 1% will result in increasing inflation rate by 142% in the long run assuming that other variables remain unchanged.
- It is fair to conclude a long term positive relation between openness of the economy and inflation rate in Egypt with 95% confidence level as evident by a p-value of <5%. Put differently, increasing openness by 1% will result in increasing inflation rate by 77% in the long run assuming that other variables remain unchanged.

The above results are consistent with those derived when estimating the legal central bank's independence on inflation.

Third: The ARDL short-run model for inflation.

As previously stated, upon estimating the long-run co-integrating model, then it is time to add to the ARDL modeling framework the short-term parameters. Accordingly, the ARDL model will include the lagged values of all level variables (a linear combination symbolized by the error-correction term, ECMt-1). Applying the ARDL technique, Table 11 illustrates the estimated error-correction model outcomes for the Egyptian inflation model. The adopted model is chosen on the grounds developed by Akaike's Information Criteria AIC.

From Table 11, the following conclusions can be interpreted;

- A short term inverse relation exists between actual central bank independence and inflation rate at 90% confidence level as evident by a p-value of <10%. In other words, increasing TOR by 1% will result in decreasing inflation rate by 85% in the short run with other variables remain unchanged. This conclusion is consistent with the one derived when estimating long run relationships, though it is evident that actual central bank's independence impact on inflation rate in Egypt is higher in the short-run than in the long-run.

Table 9: Bound test for co-integration relation outcomes

K	Bounds critical values of the F-Stat.: intercept and no trend (Case II)					
	90% confidence*		95% confidence**		99% confidence***	
3	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
	2.72	3.77	3.23	5.605	4.29	5.61
	Calculated F-Statistic: F inflation (inflation, TOR, M2,openness)					5.58***

*10%, **5%, ***1% significance.

Table 10: ARDL long-term coeff.

Variables	Coeff.	Standard Err.	T-stat.	Probability
TOR	−53.482	10.27456	−5.20528	0
LNM2	141.5452	29.78449	4.752314	0
OPENNESS	0.770298	0.43256	1.780788	0.0014
C	−1441.75	472.4528	−3.05162	0.0032

Table 11: Error-correction model of inflation

Variables	Coeff.	Standard Err.	T-stat.	Probability
D(CPI(-1))	0.249172	0.106455	2.340634	0.0219
D(CPI(-2))	−0.308489	0.100241	−3.077483	0.0029
D(CPI(-3))	0.13926	0.098177	1.418459	0.1603
D(LNM2)	11.944675	4.625424	2.582396	0.0118
D(OPENNESS)	0.501637	0.132261	3.79279	0.0003
D(TOR)	−85.255714	46.07852	−1.850227	0.0683
CointEq(-1)	−0.084388	0.021558	−3.914472	0.0002

- A positive relationship for the money supply in the Egyptian economy represented by LNM2 and inflation rate in the short run with 95% confidence level as evident by a p-value of <5%. In other words, increasing money supply in the Egyptian economy by 1% will result in increasing inflation rate by 12% in the short run assuming that other variables remain unchanged. This interpretation is also in line with its long term relationship.
- A positive relationship for openness of the economy and inflation rate in the short run with 95% confidence level as evident by a p-value of <5%. In other words, increasing openness by 1% will result in increasing inflation rate by 0.5% in the short run assuming that other variables remain unchanged. This interpretation is consistent with its long term relationship in the case of Egypt, yet, it should be noted that openness effect on inflation is much higher in the long term than in the short term.

Graph 4

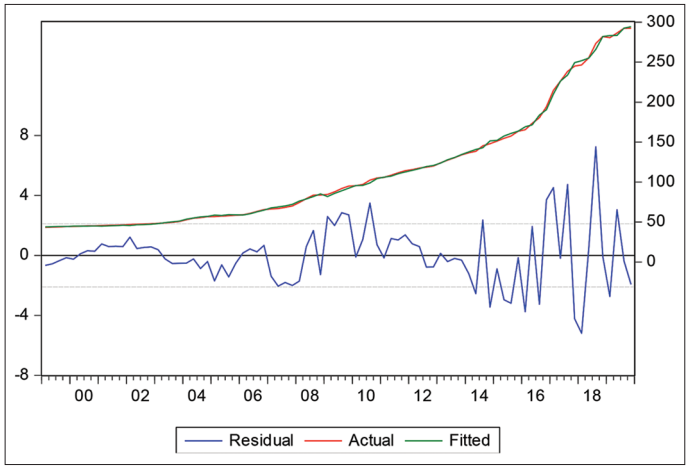


Table 12: Robustness tests

R-sq.	0.999254	Mean dep. vari	112.5095
Adj. R-sq.	0.999163	S.D. dep. vari	72.93268
Standard Error of reg.	2.110242	Akaike inf. Crit. AIC	4.442826
Sum sq. residual	329.5310	Schwarz crit.	4.732209
Log likelihood	−176.5987	Hannan Quinn crit.	4.559155
F-stat.	11007.56	Durbin Watson DWstat	1.782631
Probability(F-stat.)	0.000000		

Table 13: Q-statistics for residuals

	AC	PAC	Q-Stat	Probability*
1	0.102	0.102	0.9112	0.340
2	−0.002	−0.013	0.9116	0.634
3	0.125	0.128	2.3075	0.511
4	0.013	−0.014	2.3229	0.677
5	0.051	0.057	2.5646	0.767
6	−0.068	−0.099	2.9960	0.809
7	0.179	0.208	5.9915	0.541
8	−0.160	−0.245	8.4260	0.393
9	0.036	0.157	8.5487	0.480
10	0.042	−0.091	8.7172	0.559
11	−0.139	−0.039	10.628	0.475
12	−0.018	−0.074	10.659	0.558

- The estimated coefficient for the error correction term denoted by $ECM^{(\tau-1)}$ of 8% means that around 8% of the deviations from the long run relationship is being corrected/adjusted in its respective quarterly short term.

After estimating second models results, of regressing the dependent variable inflation and its determinants being; actual central bank independence, money supply and openness in the case of Egypt in both the short-run and the long-run. It is important to conduct diagnostic test to verify the robustness of the estimated coefficients. Table 12 reflects diagnostic test applied.

The above Tables 12 and 13, reveal that there is no autocorrelation since Durbin Watson statistic value is close to the value 2, recording 1.78. Moreover, looking at Q-statistics for residuals confirms the non-existence of autocorrelation since p-value is bigger than 0.05. This result is also supported by Graph 4 where residuals are randomly scattered in addition to the fact that actual and fitted values are almost identical. Furthermore, it is evident from Table 12 that R-square value of 0.999254 which is very close to one indicating the model's robustness.

5. CONCLUSION

The economic literature embraces various studies examining the motives behind and consequences that follow increasing monetary policy's discretion mainly through delegating more independence to central banks. This paper defines CBI as the ability to design, articulate and execute monetary policy to achieve its main goal of maintaining price stability, despite the fact that it may come at the expense of other more politically advocated goals. This paper aims at finding linkages between CBI and inflation rate applying it to the Egyptian case during 1998-2019. This paper is the first-to the best of my knowledge- to apply autoregressive distributed lag (ARDL) model, regressing the dependent variable inflation on its determinants of legal CBI, actual CBI, M2 and openness. ARDL is an effective way to capture such relation in both the short and long-term time dimensions in the case of Egypt given sample data characteristics.

There is large consensus that the greater the independence level granted to a given central bank, the lower the respective country's inflation rate. The adopted ARDL technique outcomes support this conventional view by pinpointing significant effect of CBI (using indices for both its legal and actual independence) on inflation rate in the Egyptian case in both examined time dimensions. This paper concludes that the legal CBI is more significantly affecting inflation level than actual CBI, hence implying the need to adopt further institutional reforms that increases actual CBI. Moreover, it is deduced that CBI's effect in the short run is higher than in the longer dimension.

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